

Papua LNG Project – Downstream

Nearshore Marine Baseline

ExxonMobil PNG Antelope Limited



Reference: 754-MELEN300733_R03

16 June 2023

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QUALITY INFORMATION

Revision history

Revision	Description	Date	Author	Reviewer	Approver
Rev A	Draft report	28/03/2023	Ivan Steward Erica Colley Sarah Gregory	Kristen Hall	Kristen Hall
Rev B	Revised draft report	03/05/2023	Ivan Steward	Kristen Hall	Kristen Hall
Rev C	Revised draft report	19/05/2023	Ivan Steward	Kristen Hall	Kristen Hall
Rev D	Revised draft report	29/05/2023	Ivan Steward	Kristen Hall	Kristen Hall
Rev 0	Final report	16/06/2023	Ivan Steward	Kristen Hall	Kristen Hall

Distribution

Report Status	No. of copies	Format	Distributed to	Date
Rev 0	N/A	Word and PDF	EMPNGA	16/06/2023

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ACRONYMS/ABBREVIATIONS

Acronyms/Abbreviations	Definition
ADCP	Acoustic doppler current profiler
AoI	Area of influence
ASS	Acid sulphate soil
AWS	Automatic weather station
BOD	Biological oxygen demand
BTEX	Ethylbenzene xylenes
CALM	Catenary anchor leg mooring
CO	Collapsed
COD	Chemical oxygen demand
CR	Critically Endangered
CTD	Conductivity, temperature, and depth profiling instrument
DCPPS	Dirio Central Province Power Station
DGV	Default guideline value
DD	Data Deficient
DW	Dry weight
EOO	Extent of occurrence
EIS	Environmental Impact Statement
EMPNG	ExxonMobil PNG Limited
EMPNGA	ExxonMobil PNG Antelope Limited
EN	Endangered
FEED	Front End Engineering Design
GIS	Geographical information system
GPS	Global positioning system
GV	Guideline value
IFC	International Finance Corporation
IUCN	International Union for the Conservation of Nature
LNG	Liquified natural gas
MPA	Marine Protected Area
MPN	Most probable number
NAGD	National Assessment Guidelines for Dredging
nMDS	Non-metric multidimensional scaling
NT	Near Threatened
PAH	Polynuclear aromatic hydrocarbon
PCB	Polychlorinated biphenyl
PCR	Polymerase chain reaction

Acronyms/Abbreviations	Definition
PFC	Projective foliage cover
PLEM	Pipeline end manifold
PNG	Papua New Guinea
PNGX	Papua New Guinea Expansion Project
Ppt	Parts per thousand
PRL	Petroleum Retention License 15
PS	Performance Standard
QA/QC	Quality assurance/quality control
RPD	Relative percentage difference
SDC	Stream Day Capacity
SPREP	Secretariat of the Pacific Regional Environment Programme
SQG	Sediment quality guideline
TPH	Total petroleum hydrocarbons
TRH	Total recoverable hydrocarbons
TSS	Total suspended solids
VU	Vulnerable
WMO	World Meteorological Organisation
WQ	Water quality

1. INTRODUCTION

Tetra Tech Coffey was commissioned by ExxonMobil PNG Antelope Limited (EMPNGA) to prepare an environmental impact statement (EIS) for the Papua LNG Project – Downstream (the Project). This nearshore marine baseline environmental characterisation report has been prepared by Tetra Tech Coffey part of the EIS for the Project.

ExxonMobil PNG Limited (EMPNG) is the operator of the PNG LNG Project, an integrated development that is commercialising the gas resources of Papua New Guinea. The Papua LNG Project is a gas development project for the Papua LNG Project Joint Venture participants, which are:

- TotalEnergies EP PNG Limited (TotalEnergies, an affiliate of TotalEnergies SA)
- ExxonMobil PNG Antelope Limited (EMPNGA) and ExxonMobil PNG Elk Limited
- Pac LNG Assets Limited, Pac LNG International Limited, Pac LNG Investments Limited, Pac LNG Overseas Limited and Pac LNG Holdings Limited (affiliates of Santos Limited)
- JX Nippon Oil and Gas Exploration Pty Ltd.

EMPNGA is the Project proponent and the ExxonMobil affiliate responsible for the construction of the Project. Niugini LNG Operating Company Limited (NLOC) is the ExxonMobil affiliate responsible for the Project once it has been constructed and commissioned.

The Papua LNG Project will involve producing and processing the gas and condensate from the Elk and Antelope gas reserves in Petroleum Retention License 15 (PRL-15), located in Gulf Province, Papua New Guinea and piping them overland, then offshore in the Gulf of Papua, to the existing Papua New Guinea Liquefied Natural Gas Project (PNG LNG Project) producing and exporting facility (LNG Plant) located in Caution Bay (Central Province) approximately 20 km north-west of Port Moresby.

The existing PNG LNG Project commercialises gas reserves in the Hela, Western and Southern Highlands provinces of Papua New Guinea. The gas is transported to the LNG Plant via pipeline, where it is liquefied and exported by ship to international gas markets. The LNG Plant also currently supplies gas to the NiuPower Port Moresby Power Station and the Dirio Central Province Power Station (DCPPS) for the domestic electricity market.

The Papua LNG Project involves two components:

- The Papua LNG Project – Upstream (referred to as the Upstream component).
- The Papua LNG Project – Downstream (the Downstream component, hereafter referred to as ‘the Project’, and the component addressed in this document).

Environmental and social studies for the proposed expansion of the LNG Plant were initially carried out in 2019. This included nearshore marine scopes of work in the vicinity of the proposed LNG Plant jetty expansion in Caution Bay and previous iterations of potential pipeline routes located to the north of the LNG Plant jetty, as proposed at the time of the 2019 field surveys. Further surveys were conducted in 2022 to address gaps in the previous data due to project design changes, particularly the addition of a proposed catenary anchor leg mooring (CALM) buoy option and alternative or updated pipeline routes.

The Caution Bay marine environment is also characterised in the 2019 Papua LNG Project – Upstream Environmental Impact Statement (EIS) (TotalEnergies EP PNG Ltd, 2019; Report No. 01215B_23_v5). Specific information regarding fisheries resource utilisation in Caution Bay is provided in a separate study completed by Tetra Tech Coffey (2020a).

This report describes the existing biological and physical characteristics of the Caution Bay nearshore marine environment focussed on areas potentially influenced by the marine infrastructure and activities (preferred and alternate option locations) proposed for the Project. In addition, some alternative pipeline option locations that

overlap the current Upstream component design, and that were previously surveyed during earlier investigations for the Project, are included in the characterisation. The nearshore marine environment of Caution Bay typically includes those waters not extending beyond depths of 30 m.

This report includes a review of data obtained from prior studies associated with the PNG LNG Project, and data collected during targeted field surveys and sampling completed in both 2019 and 2022. Section 3 describes the desktop study and field methods used to characterise the environment, with results and discussion presented in Sections 4 to 8.

2. PROJECT DESCRIPTION

The Downstream component of the Papua LNG Project (Figure 2.1) incorporates the expansion of the LNG Plant's existing onshore and marine facilities in Caution Bay, including the installation of new LNG processing trains (SMR technology). New LNG processing trains are proposed onshore, which will expand the capacity of the LNG Plant by an additional 4 million tonnes per annum (mtpa) Stream Day Capacity (SDC). An additional 2 mtpa will be routed to the LNG Plant trains to utilise latent capacity. Additional marine infrastructure is also proposed, including:

- New offshore feed pipelines to the landfall and a pipeline tie-in point (Upstream construction and operation component of the Papua LNG Project).
- A dual subsea export pipeline system and associated Pipeline End Manifold (PLEM) to connect to the export pipelines (Upstream construction component and Downstream operations component of the Papua LNG Project).
- The installation of a Catenary Anchor Leg Mooring (CALM) buoy connecting to the PLEM and export pipelines (Downstream construction and operations component).

An additional LNG export berth in the form of an extension of the existing LNG Plant jetty was previously considered as a potential alternative to the CALM buoy at the time the 2022 surveys were conducted, along with previous pipeline route alignment options that were surveyed in 2019. While no longer part of currently proposed infrastructure for the Papua LNG Project, these components were also assessed and the characterisation information obtained during field surveys is included in this report.

Figure 2.2 shows the proposed areas within the existing LNG Plant lease area where the new onshore facilities will be developed. The proposed marine facilities associated with the Project are shown in Figure 2.3. A summary of the Project components is provided in Table 2.1.

Table 2.1 Project components

Project component	Description
Additional LNG trains	New LNG processing trains and supporting systems including: • Inlet gas receiving and treatment • Dehydration/mercaptan removal • Mercury removal • Heavy-hydrocarbon separation (which contains benzene, toluene, ethylbenzene, and xylenes (BTEX)) • Liquefaction • Stabilisation • Refrigeration system • Fractionation system (naphtha)

Project component	Description
Expansion of existing utilities	Existing LNG Plant shared utilities to be expanded will include: • Hot oil system • Service and instrument air system • Nitrogen system • Freshwater system • Desalinated water system • Potable water system • Diesel oil storage and distribution system • Open and closed drain systems • Sanitary wastewater treatment systems
New utilities	Options for new separate utilities may include: • Integrated fuel gas system • Power generation system • Tempered water system • Highly demineralised water system for the Heat Recovery Steam Generators (HRSGs) • Flare system (wet and dry gas) • Thermal oxidizer
Product storage	Product storage will include: • New condensate storage tanks with a total storage capacity of up to 110,000 m³.
New marine facilities	Marine facilities will include: • CALM buoy and associated exclusion zones • Pipeline end manifold (Upstream construction component, Project operations component) • Naphtha and condensate export pipelines (Upstream construction component, Project operations component) ¹ • New feed pipelines² including a gas pipeline and a condensate pipeline (Upstream construction component and Project operations component), with landfall and tie-in to the pipelines at the LNG Plant. The pipelines will be located south of the existing LNG Plant jetty • Alternate shipping channel • Navigation and monitoring systems
Temporary facilities	Temporary construction facilities will be located within the LNG Plant lease boundaries and will include laydown areas, offices, workshops, and concrete batching plants.
Waste	Options being reviewed and assessed for waste facilities and management may include: • Temporary onsite storage and segregation of waste, with transport to and disposal at third party waste management facility • New engineered solid waste landfill within existing LNG Plant fence for disposal of non-restricted waste, with limited disposal of restricted waste by specialised service

¹ Construction of all pipelines and the PLEM will be undertaken by TotalEnergies EP PNG Limited, as will operation of the feed pipelines. The Project will be responsible for installation and operation of the CALM buoy and operation of the associated PLEM and export pipelines.

² The subsea pipeline construction activities are assessed in the 2019 Papua LNG Project – Upstream EIS with additional assessment to be provided in a subsequent EIS addendum.

Project component	Description
Logistics route	Most construction materials will be transported by truck from Motukea Port in Port Moresby to the LNG Plant site via the Lea Lea Road. Repairs or upgrades to the road, or relocation of overhead cables may be required to allow transport of large, heavy loads.
Workforce	Construction: Approximately 5,000 to 7,000 personnel at peak. Operation: Increase of approximately 50 operations and maintenance technicians with support staff anticipated to increase.
Accommodation	Construction: Up to 6,000 beds in construction camps. Operation: Up to 500 beds at the existing operations camp.

2.1 MARINE FACILITIES

Marine facilities at the LNG Plant site include an existing LNG Plant jetty extending approximately 2 km offshore into Caution Bay. The existing berth at the LNG Plant jetty provides a platform that allows LNG from the storage tanks to be loaded onto LNG carriers. The berth currently manages an estimated 110 to 120 LNG carriers (based on 164,000 m³ LNG carriers) and 10 to 12 naphtha tankers to moor at the berth annually. The expansion of the LNG Plant will increase ship traffic, with up to 60 to 70 additional LNG carriers and 10 to 12 additional condensate cargos per year.

At the time this report was being prepared and associated surveys were being conducted, two options (that is, the extension of existing berth at the LNG Plant jetty and the CALM buoy) were being considered for the expansion of the existing marine offloading facilities, to accommodate the increased LNG and non-LNG liquids production rates and subsequent increase in the number of vessels.

The CALM buoy option concept was selected as the preferred option for the expansion of the existing marine facilities to accommodate the increased LNG and non-LNG liquids production rates and subsequent increase in the number of vessels.

Additional upgrades to the existing berth are being considered to improve maintainability such as the installation of a maintenance crane and replacement of the existing condensate loading arm with an LNG loading arm.

2.1.1 Offshore pipelines

Two new feed pipelines (referred to as the Papua LNG pipelines), one each for gas and condensate, will be installed for the Papua LNG Project and constructed as part of the Upstream component. The onshore portion of these pipelines will traverse the existing LNG Plant lease boundaries.

Three options (Option 15A, Option 15C and Option 15F) located south of the existing LNG Plant jetty were considered for the Papua LNG pipelines nearshore routes (see Figure 2.3).

The Papua LNG pipelines will be laid on the sea floor by a pipelaying vessel and will be pulled ashore by equipment located on land. In water depths of 15 m or less, the pipe will be placed in an excavated trench, or laid by ploughing or jetting. The Papua LNG pipelines will be cement-coated to weigh them down and for protection from external influences. The subsea portion of the Papua LNG pipelines will connect to a short section of onshore Papua LNG pipeline that will then 'tie-in' to the LNG Plant.

2.1.2 CALM buoy and export pipelines

The CALM buoy concept has been selected for the expansion of the existing marine facilities to accommodate the increase in LNG and non-LNG liquids production and subsequent increase in the number of vessels. This concept will delink the non-LNG liquids (naphtha and condensate) from LNG offloading at the existing berth.

The concept includes a second shipping channel, additional navigational and monitoring systems, and approximately 7 km of dual subsea export pipelines for the naphtha and condensate.

The CALM buoy will be located at the 20 m depth contour and have a multi-product swivel and dedicated offloading hoses for each product. The buoy has an estimated hull diameter of 12 m and a height of 5 m. The mooring system will have six chains each with an estimated length of 400 m. Two under-buoy hoses will be installed, connecting the CALM buoy to the PLEM.

The location of the CALM buoy will require approximately 7 km of dual subsea export pipelines for the naphtha and condensate that will be constructed as part of the Upstream component, though these pipelines will be operated as part of the Project operations. Trenching will be required for all pipelines sited in less than 15 m water depth. The offshore pipeline construction activities up until the scope break are assessed in the 2019 Papua LNG Project – Upstream EIS with additional assessment to be provided in a forthcoming EIS addendum. During operations, the CALM buoy will be subject to a 500-m-radius exclusion zone restricting access to public vessels at all times, and a 1,200-m-radius exclusion zone that applies during offloading, for approximately two days, twice per month. An approximately 1,650-m-radius 'hazard to navigate zone' will also apply at all times to signify that caution is required, however public vessel access will not be restricted between the 1,200 m and 1,650 m radius areas.

Further optimisation of the final export pipelines routing and landfall location will be undertaken during the Front End Engineering Design (FEED).

2.1.2.1 PLEM design

The export pipelines will terminate at the PLEM. The PLEM will be designed to have piping for each product and allow for pigging. There will be pig launchers and receivers onshore and four remote actuated valves controlled by the CALM buoy hydraulic power unit. Operation of the PLEM will be managed as a component of the Project and is assessed in the EIS, while impacts associated with installation of the PLEM will be assessed as part of a forthcoming addendum to the 2019 Papua LNG Project – Upstream EIS.

2.1.2.2 Additional shipping channel route

An additional shipping channel exit is proposed for the CALM buoy to enable the second LNG carrier to approach the berth while the first carrier departs. The additional channel will reduce the minimum time between carriers by approximately one hour.

2.2 WORKFORCE AND ACCOMMODATION

An estimated peak construction workforce of between 5,000 and 7,000 people will be needed to construct the Project over the planned four-year period. The permanent operations and maintenance workforce is expected to increase by approximately 50 technician personnel to support the integrated LNG Plant. Support staff is anticipated to increase and will be evaluated throughout FEED.

The existing operations camp is sufficient to meet increased capacity from the Project and will not be expanded. The existing Camp A has approximately operational 500 beds, of which approximately 300 personnel represent the steady state requirement on site. This provides approximately 200 beds for overflow capacity for events such as major maintenance programs and unplanned events.

2.3 LOGISTICS ROUTE

Most construction material will be imported by ship via Motukea Port and trucked to site along the Lea Lea Road. The road may require repairs or upgrade, including relocation of overhead cables, to accommodate transport of large modules. Transport of construction and operations personnel from Port Moresby will also

occur along this road. The main entrance to the LNG Plant may also need to be upgraded, as will the existing bypass road outside the fence between Gate 1 and Gate 3.

Smaller sensitive equipment and time constrained shipments may be transported by air to Jacksons International Airport in Port Moresby and trucked to the LNG Plant.

2.4 COMMISSIONING AND OPERATION

Commissioning activities will be required to test the modified shared facilities and new facilities at the LNG Plant. These activities are expected to include testing the operation of individual components and systems, including flaring during start-up.

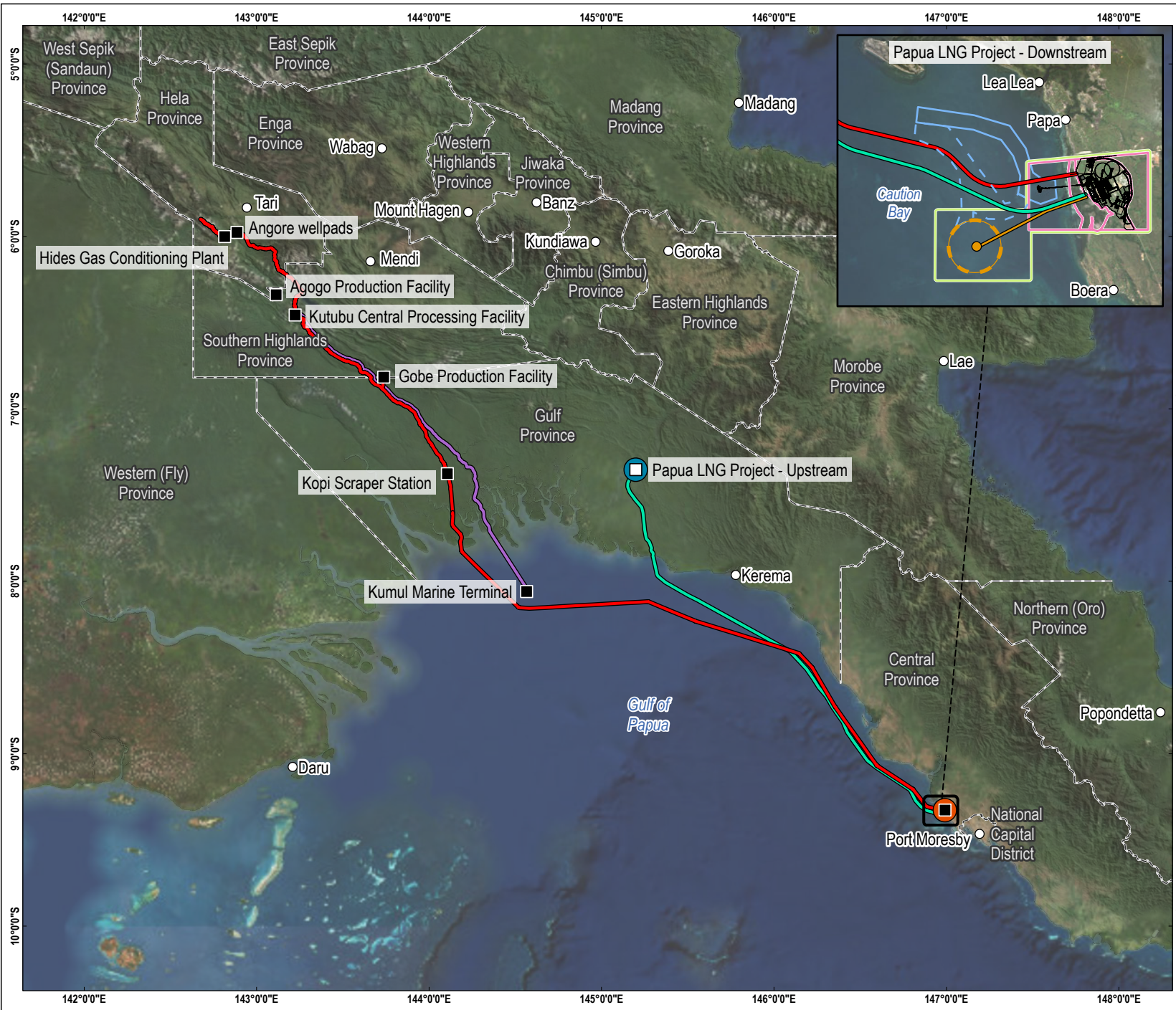
The operational and maintenance procedures are expected to be similar to those in place at the existing LNG Plant.

2.5 PROJECT SCHEDULE

Timeframes for key Project development milestones are shown in Table 2.2 below.

Table 2.2 Project timeframes

Key milestone	Timeframe
Environmental surveys and approval process	2022 to 2023
Front-end engineering design	2023
Detailed engineering design	2024
Construction	2023 to 2027
Commissioning and start-up	2027 to 2028



LEGEND

- Papua LNG Project - Downstream
- Papua LNG Project - Upstream
- Existing facility
- Province capital
- PNG LNG pipeline
- Proposed Papua LNG pipelines
- Santos oil pipeline
- Existing and proposed plant layout
- PPFL2 boundary
- APPFL boundary
- Province boundary
- Current navigational channel
- Proposed navigational channel
- Proposed CALM buoy components
- CALM buoy
- Naphtha and condensate pipelines
- CALM buoy navigational area

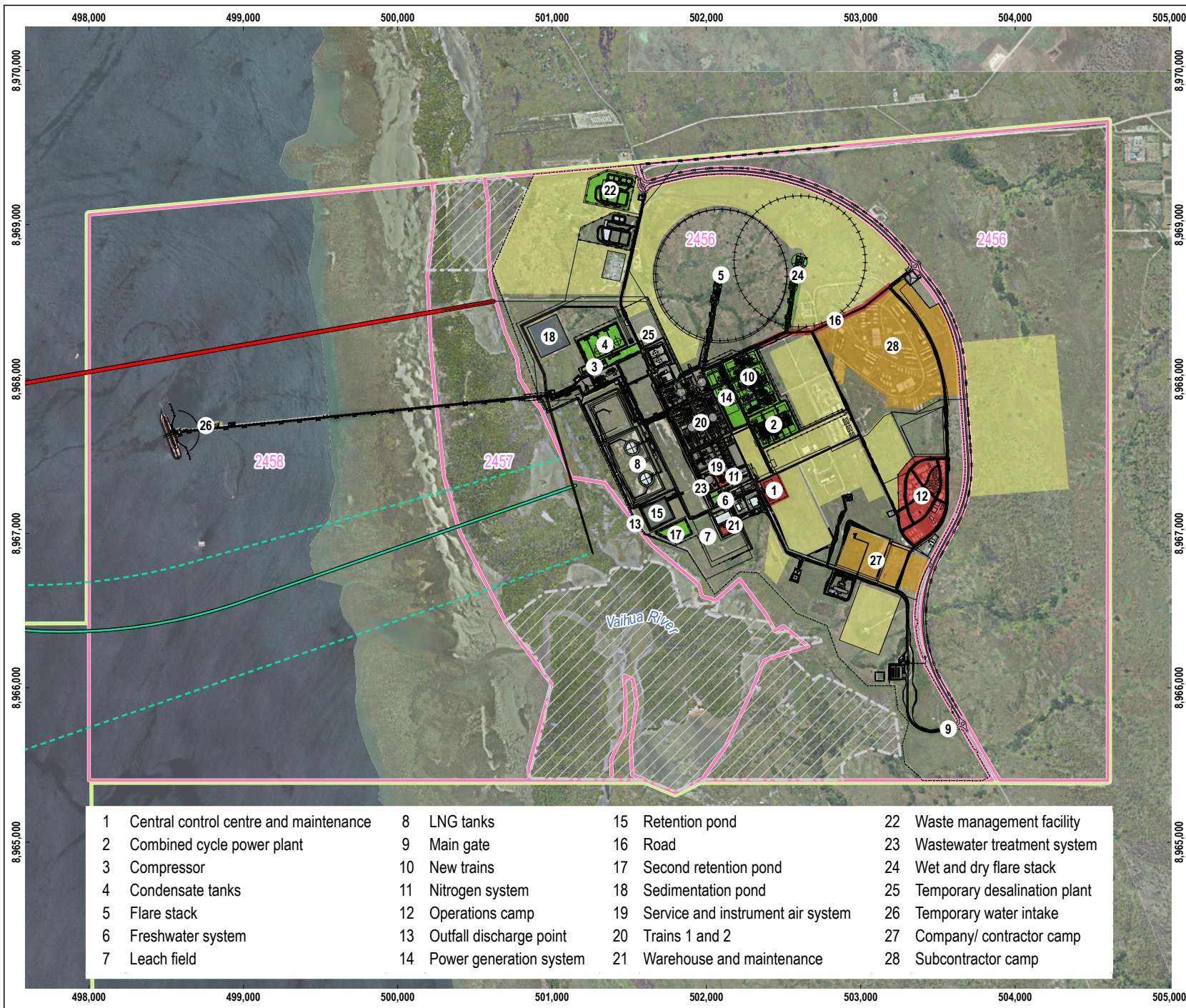
SOURCE
Infrastructure data from EMPNGA and Tetra Tech Coffey (indicative only).
Place names from NGIA.
Provinces from NSO.
Imagery from ArcGIS Online.

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PAGE SIZE: A4
PROJECTION: GCS WGS 1984

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PAPUA LNG PROJECT – DOWNSTREAM

FIGURE 2.1
Papua LNG Project – Downstream Project location





LEGEND

- PNG LNG pipeline
- Proposed Papua LNG pipelines route
- - - Proposed Papua LNG pipelines route alternate
- Existing and proposed plant layout
- Proposed new facility
- Proposed expanded/upgraded facility
- Temporary construction area
- Temporary camp
- PPFL2 boundary
- APPFL boundary
- Cultural heritage restricted area

SOURCE
Infrastructure, cultural heritage and lease boundary from EMPNGA.
Imagery from EMPNGA and Google Earth.



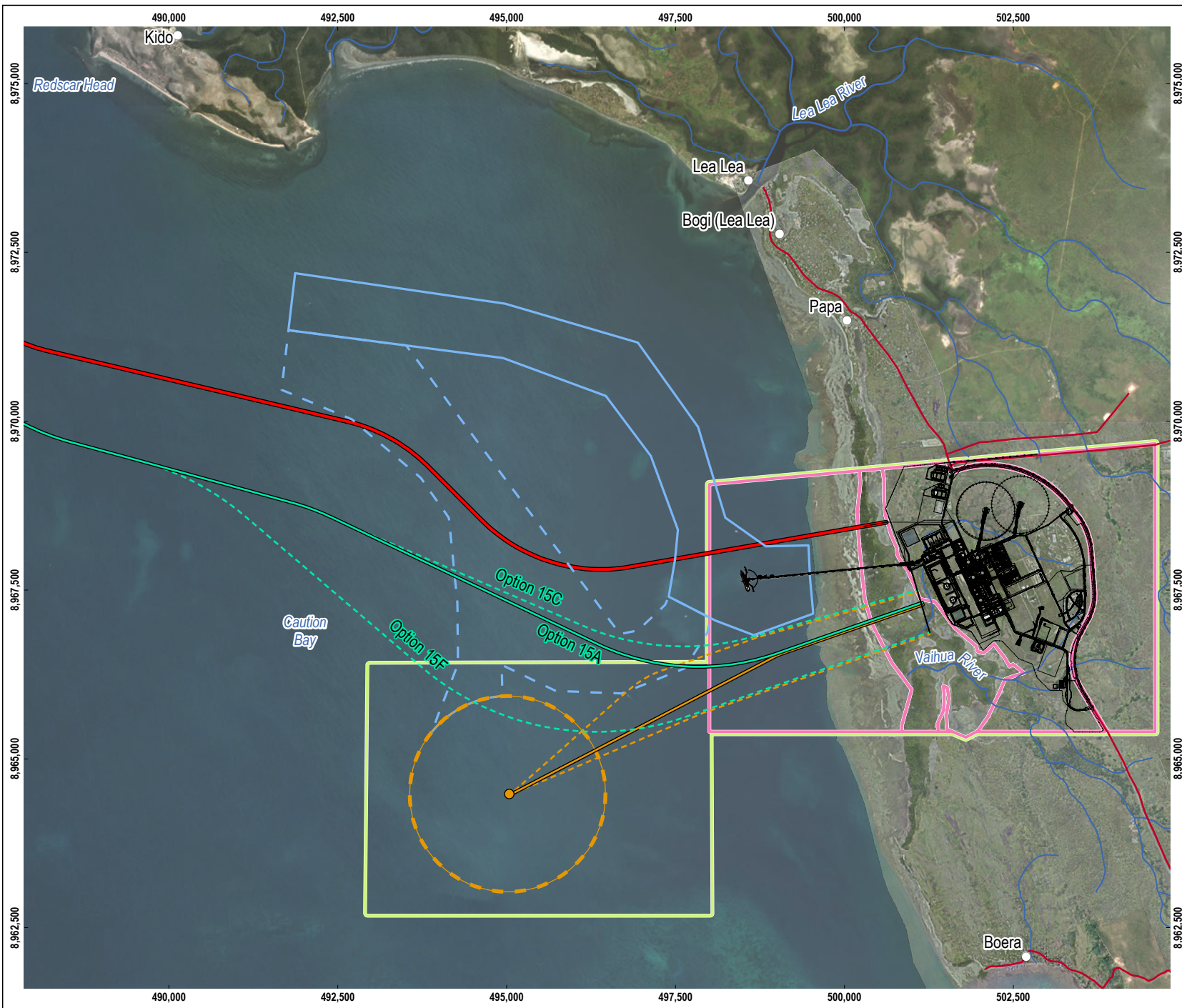
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PAPUA LNG PROJECT – DOWNSTREAM

FIGURE 2.2
Proposed onshore facilities for the Project

- | | | | |
|--|----------------------------|--------------------------------------|---------------------------------|
| 1 Central control centre and maintenance | 8 LNG tanks | 15 Retention pond | 22 Waste management facility |
| 2 Combined cycle power plant | 9 Main gate | 16 Road | 23 Wastewater treatment system |
| 3 Compressor | 10 New trains | 17 Second retention pond | 24 Wet and dry flare stack |
| 4 Condensate tanks | 11 Nitrogen system | 18 Sedimentation pond | 25 Temporary desalination plant |
| 5 Flare stack | 12 Operations camp | 19 Service and instrument air system | 26 Temporary water intake |
| 6 Freshwater system | 13 Outfall discharge point | 20 Trains 1 and 2 | 27 Company/ contractor camp |
| 7 Leach field | 14 Power generation system | 21 Warehouse and maintenance | 28 Subcontractor camp |





- LEGEND**
- Village
 - Road
 - Watercourse
 - PNG LNG pipeline
 - Proposed Papua LNG pipelines route
 - - - Proposed Papua LNG pipelines route alternate
 - Existing and proposed plant layout
 - PPFL2 boundary
 - APPFL boundary
 - Current navigational channel
 - Proposed navigational channel
 - Proposed CALM buoy components
 - CALM buoy
 - Naphtha and condensate pipelines
 - - - Naphtha and condensate pipelines alternate
 - CALM buoy navigational area

SOURCE
Infrastructure, roads, watercourses and lease boundary from EMPNGA.
Imagery from EMPNGA and Planet Labs.

0 1 2 km
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PROJECTION: WGS 1984 UTM Zone 55S

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PAPUA LNG PROJECT – DOWNSTREAM

FIGURE 2.3
Proposed marine facilities for the Project



3. METHODS

Methods for the nearshore marine baseline environmental characterisation are described in this chapter, with results included in Sections 4 to 7.

The Caution Bay marine environment relevant to the Project is characterised in this report through a combination of desktop review of existing information, and data obtained from targeted marine field surveys completed in 2019 and in 2022.

Existing sources of information are summarised in Section 3.1 and include baseline assessment and monitoring reports undertaken previously for the PNG LNG Project. Overall, these studies provide a comprehensive basis from which to characterise the marine habitats in Caution Bay.

For the Project, prior field survey and sampling programs were repeated where necessary to provide an updated baseline and the basis for impact assessment. The 2019, 2022 and 2023 field studies included:

- Intertidal aspects
 - Mangrove surveys
 - Macroinvertebrate sampling (2019 only)
 - Pore water sampling (2019 only)
- Marine aspects
 - Marine ecology survey
 - Water quality sampling³ (2019 only)
 - Sediment quality sampling
 - Macrobenthic infauna sampling

The nearshore marine study area is shown in Figure 3.1.

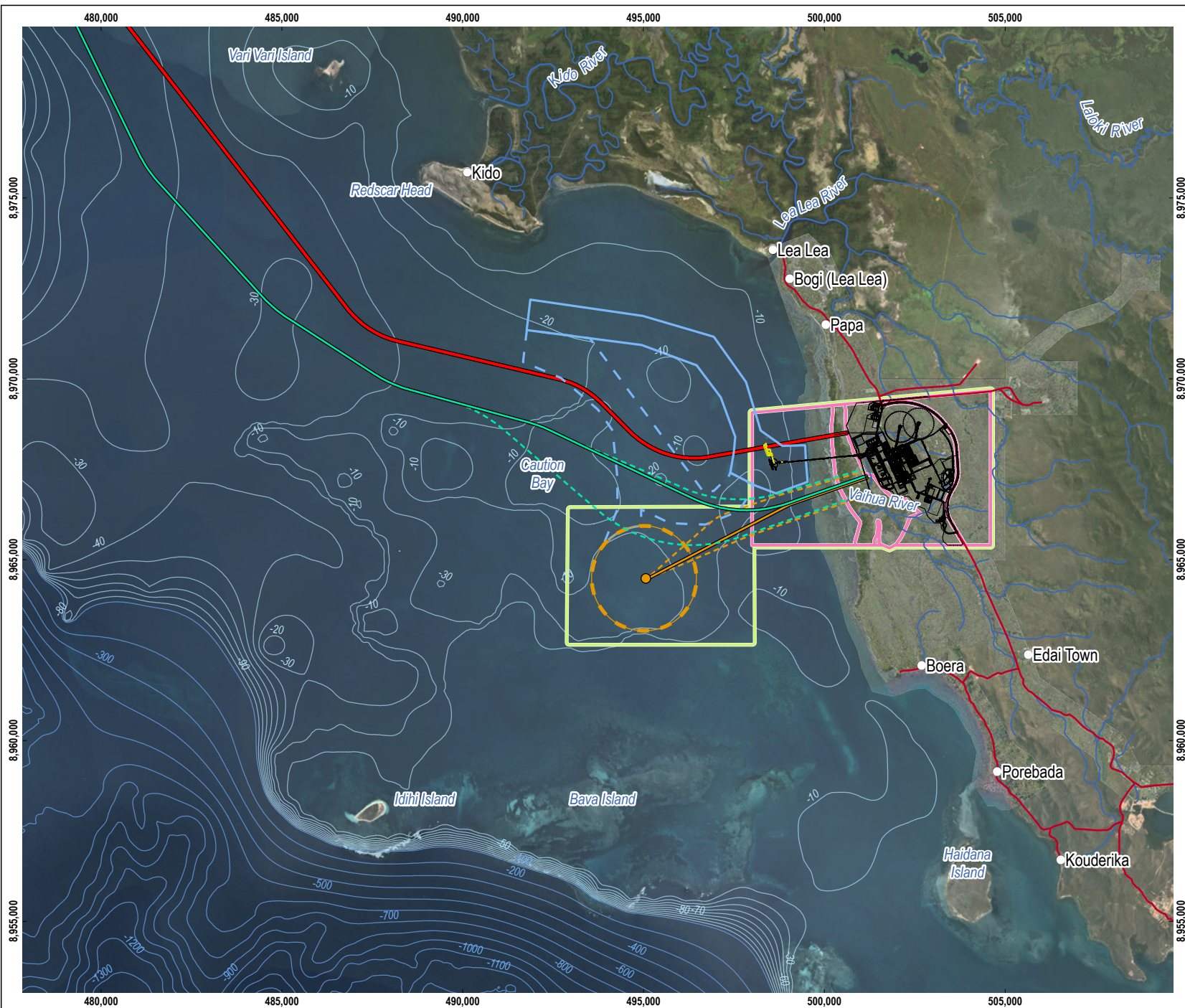
3.1 EXISTING SOURCES OF INFORMATION

Characterisation of the nearshore marine environment in Caution Bay was undertaken to inform the PNG LNG Project EIS in 2007 to 2008. Further monitoring occurred prior to, during, and after construction of the LNG Plant and PNG LNG pipeline to confirm that impacts described in the EIS had been correctly predicted and management measures were effective. Sediment transport and dispersion modelling was also carried out to predict the impacts from trenching and laying of the PNG LNG pipeline.

A summary of the available information and studies completed as part of the PNG LNG Project is provided in Table 3.1 and cover the period from 2007 to 2014. Water and sediment quality sampling occurred throughout the year, capturing data across all seasons. Mangrove and marine ecology surveys were undertaken between December and April, during the season of higher rainfall and less wind.

Sites where water and sediment quality sampling and marine ecology surveys (see Table 3.1) were undertaken for the PNG LNG Project are displayed in Figure 3.2 and Figure 3.3.

³ Due to the existing water quality data being collected within five years, assessed as being of satisfactory quality assurance, and providing a sufficiently representative spatial characterisation of conditions, additional water quality sampling was not conducted for the Project in 2022.



LEGEND

- Village
- Road
- Watercourse
- PNG LNG pipeline
- Proposed Papua LNG pipelines route
- - - Proposed Papua LNG pipelines route alternate
- Optional jetty extension
- Existing and proposed plant layout
- Bathymetry (10 m interval)
- Bathymetry (100 m interval)
- PPFL2 boundary
- APPFL boundary
- Current navigational channel
- Proposed navigational channel
- Proposed CALM buoy components
- CALM buoy
- Naphtha and condensate pipelines
- - - Naphtha and condensate pipelines alternate
- CALM buoy navigational area

SOURCE

Infrastructure, bathymetry, roads, watercourses and lease boundary from EMPNGA.
Imagery from EMPNGA and Planet Labs.



0 1 2 3 km
SCALE 1:150,000
PAGE SIZE: A4
PROJECTION: WGS 1984 UTM Zone 55S

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PAPUA LNG PROJECT – DOWNSTREAM

FIGURE 3.1

Nearshore marine study area



Other sources of existing information used to characterise the marine environment in this report include:

- Specialist reports prepared by EGS Survey Pty (EGS 2008) providing detailed bathymetry of Caution Bay which identified offshore coral bommies and rocky outcrops of the nearshore marine environment.
- Specialist report prepared by Global Environmental Modelling Systems (GEMS 2008) providing modelling of oceanographic conditions (i.e., current movements, sediment transport and coastal processes) in Caution Bay dredging program simulations.
- Additional information sourced from a broader literature review which have been referenced where relevant.

Table 3.1 Summary of existing marine data for the PNG LNG Project

Report name	Focus area
General characterisation and impact assessment	
Nearshore Marine Impact Assessment PNG LNG Project (Coffey Natural Systems 2008)	Objective: Characterise the nearshore marine environment and undertake an impact assessment to support the PNG LNG Project EIS. This report was appended to the EIS. This report also provides an overview of the oceanographic conditions and general climate of the area. Data collected: biological communities, habitats, water quality and sediment characteristics. Date collected: December 2007 and April 2008.
Sediment chemistry analyses	
LNG Facilities: Caution Bay Sediment Contamination Assessment (Coffey Natural Systems 2009)	Objective: To identify if any contamination existed in the areas where dredging was proposed to occur and that could subsequently pose a risk to the marine environment if disturbed. Data collected: Sediment quality. Date collected: July 2009.
Water quality and sedimentation	
PNG LNG Project. Marine Sedimentation & Water Quality Data Report April/May 2014 – Caution Bay (Coffey Environments 2014b)	Objective: To characterise the water quality and sedimentation conditions within Caution Bay before, during and after all activities associated with the construction of the LNG facilities. Data collected: Water quality and sedimentation. Dates collected: December 2009, February 2010, January 2011 and April/May 2014. Additional in-situ sampling of physical water quality parameters was conducted in August 2011, February 2012, October 2012, and February 2013.
Plume dispersal and deposition	
Caution Bay pipeline burial modelling (APASA 2010)	Objective: Determine the extent of the plume dispersal and deposition in Caution Bay, particularly exposure to reefs and seagrass areas caused by PNG LNG pipeline trenching and installation activities. Model run: 2010.
Marine ecology	
Marine Ecology Report 2010 Caution Bay (Coffey Environments 2010) Marine Ecology Report 2011 Caution Bay (Coffey Environments 2011)	Objectives: The objectives of these studies were to: • Characterise pre-construction conditions. • Document pre-construction marine ecological conditions in the region of the LNG Plant marine infrastructure (seagrass, coral reefs, sediment/benthos habitats, reef fish) against which future conditions could be compared.

Report name	Focus area
Marine Ecology Report 2012 Caution Bay (Coffey Environments 2012) Marine Ecology Report 2014 Caution Bay (Coffey Environments 2014a)	Survey at locations and at a frequency to verify that impacts are within the residual (temporal and spatial) impact predictions made in the EIS. Data collected: Video survey (scuba and towed underwater) data along transects and post-survey visual analysis of the video footage. Dates collected: December 2009, February 2010, January 2011, and April 2014.
Mangrove ecology	
Mangrove community assessment of the LNG facility: Caution Bay, Papua New Guinea (CQU 2011) PNG LNG Mangrove Survey Caution Bay, PNG: 2014 (Vision Environment 2014)	Objectives: The objectives of these studies were to: - Determine dominant mangrove community types. - Determine mangrove distribution density and canopy cover. - Map dominant communities adjacent to LNG facilities site. - Establish monitoring sites and indices of mangrove condition to monitor potential impacts associated with the construction of the LNG facilities construction including the LNG Plant jetty and PNG LNG pipeline. Data collected: Tree and seedling density, diameter at breast height and sum of live basal area per transect, canopy density, crab hole densities, mapping of mangrove coverage before and after construction using remote satellite imagery. Dates collected: February 2011 and March 2014.

3.2 FIELD SURVEY AND SAMPLING METHODS

This section describes the methods used during the field survey and sampling campaigns that were completed to characterise baseline environmental conditions in Caution Bay for the Project.

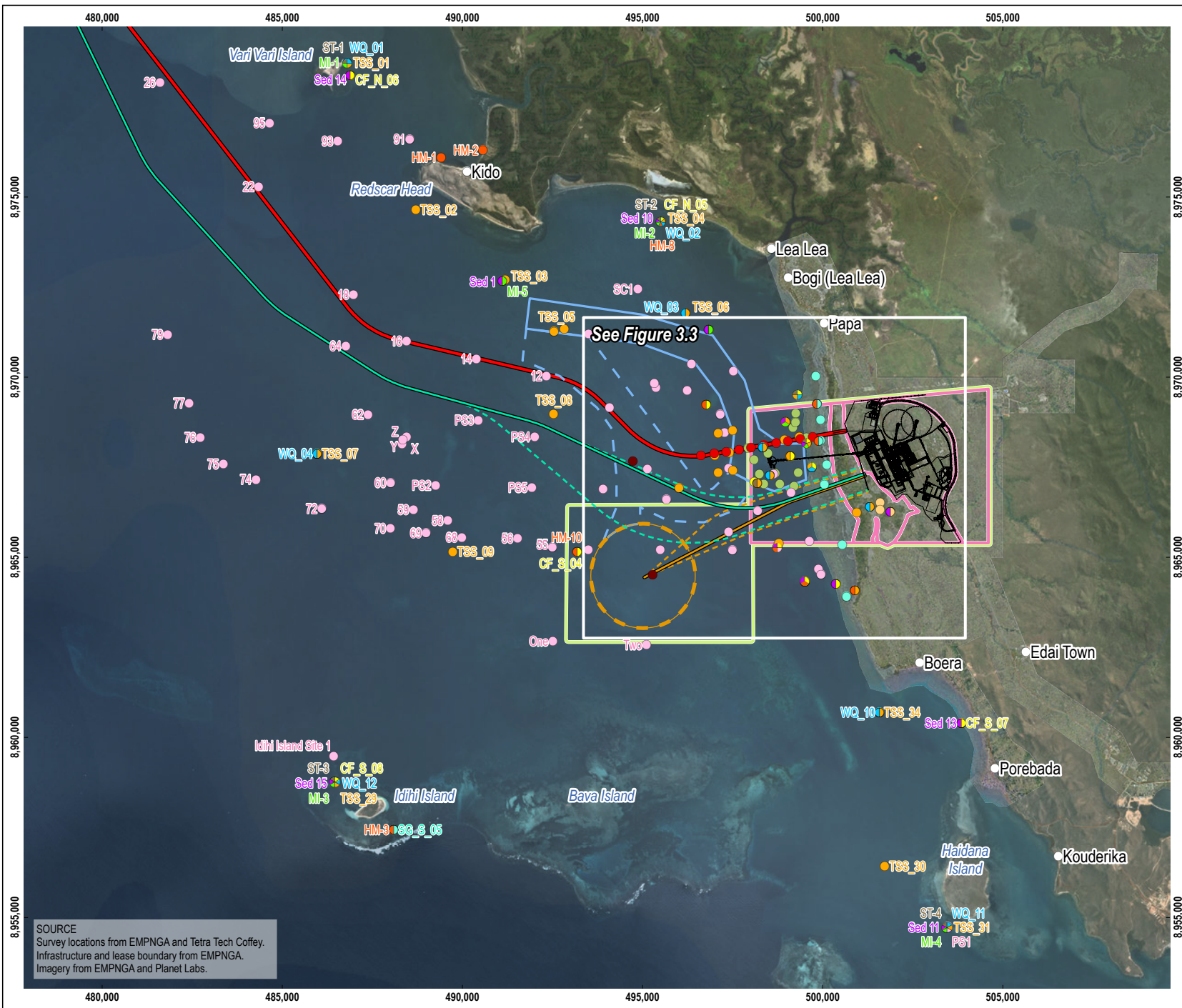
A suite of sites were investigated in 2019 to characterise the marine and coastal habitats in the footprint of and immediately surrounding proposed marine infrastructure locations.

The investigations primarily included mangrove surveys, marine sediment and infauna sampling, and video and hydrographic surveys of benthic habitats.

Additional Project-specific locations, specifically the CALM buoy sites, subsea pipelines (proposed and alternate) and a previously proposed potential jetty extension location option⁴, were then investigated in 2022, with an additional targeted mangrove study conducted in 2023.

The 2019 and 2022 sampling programs followed, as closely as practicable, the same methods and used the same equipment between surveys. These were also similar to the approach used during previous surveys e.g., for the PNG LNG Project, except where additional or divergent methods were identified and subsequently required. The methods applied to the various study scopes and surveys are discussed further in this section.

⁴ The jetty extension was a previously proposed potential Project option that was subsequently not selected or carried through as part of Project design. The results of the survey work are nonetheless retained in this baseline study to provide additional characterisation information.



LEGEND

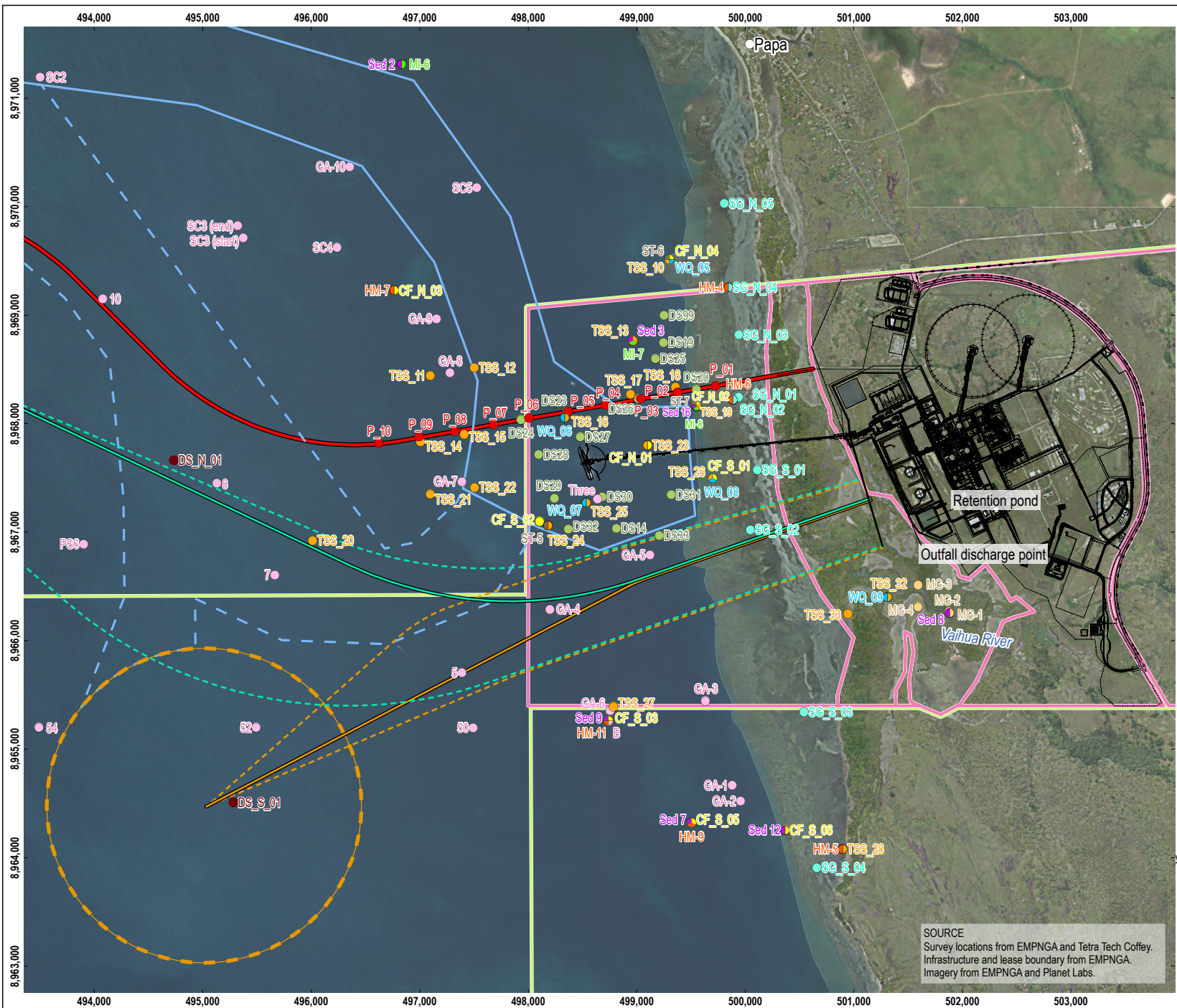
- Village
- PNG LNG pipeline
- Proposed Papua LNG pipelines route
- Proposed Papua LNG pipelines route alternate
- Existing and proposed plant layout
- PPFL2 boundary
- APPFL boundary
- Current navigational channel
- Proposed navigational channel
- Proposed CALM buoy components
 - Naphtha and condensate pipelines
 - Naphtha and condensate pipelines alternate
 - CALM buoy navigational area
- Marine survey location
 - Coral and fish video transect site
 - Dredge spoil video transect site
 - Pipeline video transect site
 - Seagrass video transect site
 - Water quality sampling site
 - TSS and CTD sampling site
 - Drop camera site
 - Habitat map site
 - Macrobenthic infauna sampling site
 - Mangrove transect site
 - Sediment sample site (pre-dredging)
 - Sediment quality site
 - Sediment trap site

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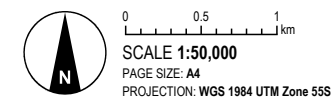
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FIGURE 3.2
PNG LNG Project marine survey locations pre-2019





- LEGEND**
- Village
 - PNG LNG pipeline
 - Proposed Papua LNG pipelines route
 - Proposed Papua LNG pipelines route alternate
 - Existing and proposed plant layout
 - PPFL2 boundary
 - APPFL boundary
 - Current navigational channel
 - Proposed navigational channel
 - Proposed CALM buoy components
 - Naphtha and condensate pipelines
 - Naphtha and condensate pipelines alternate
 - CALM buoy navigational area
 - Marine survey location
 - Coral and fish video transect site
 - Dredge spoil video transect site
 - Pipeline video transect site
 - Seagrass video transect site
 - Water quality sampling site
 - TSS and CTD sampling site
 - Drop camera site
 - Habitat map site
 - Macrobenthic infauna sampling site
 - Mangrove transect site
 - Sediment sample site (pre-dredging)
 - Sediment quality site
 - Sediment trap site



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 PAPUA LNG PROJECT – DOWNSTREAM

FIGURE 3.3
 PNG LNG Project marine survey locations
 pre-2019 (inset)



SOURCE
 Survey locations from EMPNGA and Tetra Tech Coffey.
 Infrastructure and lease boundary from EMPNGA.
 Imagery from EMPNGA and Planet Labs.

3.2.1 Intertidal ecology

Intertidal ecology was investigated via surveys that primarily focused on the mangrove habitats present along the coast in the vicinity of the LNG Plant and marine pipeline infrastructure.

For the 2019 surveys, previously completed mangrove surveys (undertaken in 2011 and 2014) were repeated as a baseline for the impact assessment. Additional mangrove transects were also completed to cover the options proposed previously for the Papua LNG pipelines landfall. Macroinvertebrate and pore water sampling was also undertaken at each mangrove transect.

As the 2019 (and prior) survey work had identified localised areas of dieback, but was unable to attribute cause to the dieback, further investigation was required. Further mangrove surveys were subsequently completed in 2022 and 2023 for the Project, to further establish the cause of mangrove dieback in the study area, primarily related to dieback in the vicinity of the retention pond at the LNG plant.⁵

3.2.1.1 2019 survey and sampling

Mangrove survey

The 2019 mangrove survey (Appendix C) was undertaken by subcontractors (Vision Environment) to Tetra Tech Coffey, and one Tetra Tech Coffey staff member.

The survey was conducted over eight days from 10 to 18 May 2019 and involved surveying previous and new mangrove transects near the LNG Plant, including proposed pipeline landfall sites. The global positioning system (GPS) coordinates for the sampling locations are listed in Appendix A and Appendix C, with transect and sampling locations shown in Figure 3.4.

The survey was undertaken in a similar manner to the mangrove surveys completed in 2011 and 2014. Eleven original 100- to 200-m-long transects were resurveyed and four new transects were surveyed providing additional coverage of the area including proposed pipeline landfall sites. New transect sites were selected at locations that were representative of habitat in the area and easily accessible for habitat characterisation.

Mapping of habitat areas and the dominant species composition of Caution Bay mangroves was undertaken using satellite imagery to assist in analysing the spatial extent of the mangrove area, identify community composition classes and density, and identify any changes to the area since previous surveys. Mapping of the survey area was undertaken using Geoeye images from 2018. Image processing, classification and change in vegetation analysis was carried out using ESRI® ArcGIS Pro™ 2019 Geographical Information System (GIS) software.

The survey included:

- Determining mangrove composition and relative canopy cover at 10 m intervals along each transect
- Establishing replicate 25 m² plots at 50 m intervals on each transect, and recording the following data:
 - Tree and seedling density (number per 25 m² replicate plot)
 - Diameter at breast height (DBH) and sum of live basal area per transect
 - Projective foliage cover expressed as percentage covered by foliage (canopy density), with four classifications: 0 to 5%, 5 to 25%, 25 to 50% and >50%

⁵ At the time this report was being prepared, additional investigations related to the potential causes of mangrove dieback were in progress separate to those of the Project. These were conducted by another mangrove specialist (Eco-Hilights) as part of the Upstream component of the Papua LNG Project. Some preliminary findings are included in this document, with the additional findings expected to be incorporated in a forthcoming addendum to the 2019 Papua LNG Project – Upstream EIS.

- Recording of crab hole densities
- Observing the extent and nature of mangrove timber harvesting as relative frequency of new versus regenerating areas.

Macroinvertebrate sampling

Macroinvertebrate sampling was undertaken by the mangrove survey team in 2019 and involved collection of one macroinvertebrate sample at each mangrove transect (see Figure 3.4).

Macroinvertebrate grab samples were collected from near the sediment surface using a petit ponar grab sampler. Samples were bagged and preserved in ethanol for later sorting. Field observations were recorded including sediment surface type and evidence of fauna (burrows, mounds, tracks etc.). Sample material and any obvious fauna were also photographed.

Samples were labelled and transported to Australia for the following analysis by a specialist benthic taxonomist:

- Identification to lowest known taxonomic level
- Counts of the numbers of individuals of each taxonomic group.

Pore water sampling

Pore water sampling was undertaken by the mangrove survey team in 2019 and involved the collection of one pore water sample from sediment in the intertidal area at each mangrove survey transect (see Figure 3.4).

Samples were collected in accordance with the Tetra Tech Coffey Marine Water and Sediment Quality Monitoring Manual prepared for the Project (provided in Appendix B). This included the collection of field duplicates, equipment rinsates and field blanks.

Water was collected using a pore water extracting device (PushPump) made from stainless steel tubing. Samples were collected by inserting the sampling end of the pore water device into the sediment to the desired depth and extracting pore water into laboratory-approved sampling containers using a syringe.

In-situ readings were obtained from the extracted pore water for pH, temperature, dissolved oxygen, conductivity, redox, salinity and turbidity.

Samples were kept refrigerated and placed in cooled eskies for transport to an accredited laboratory in Australia (ALS Limited), for analysis of the following parameters:

- total dissolved solids
- total suspended solids
- total and dissolved metals: antimony, arsenic, barium, boron, cadmium, chromium (as hexavalent), cobalt, copper, iron, mercury, manganese, nickel, lead, selenium, silver, tin, vanadium and zinc
- nutrients: total nitrogen, total kjeldahl nitrogen, nitrite, nitrate, ammonia, total phosphorus, reactive phosphorus
- potassium
- cyanide
- fluoride
- benzene, toluene, and ethylbenzene xylenes (BTEX), total petroleum hydrocarbons (including silica gel cleanup), speciated phenols and oil and grease
- chemical and biological oxygen demand

- sulphate and sulphide
- amines.

Analytical results were compared against the ANZG (2018) toxicant default guideline values (DGVs) for marine water, where available.

3.2.1.2 2022 survey and sampling

Mangrove survey

The 2022 mangrove survey was undertaken by Vision Environment (Appendix D), in a similar manner to the survey work completed in 2019. The main study area included the mangrove habitat adjacent to the LNG facilities that was surveyed in 2011, 2014 and 2019. The 2022 survey was completed over four days from 22 to 25 August and comprised an in-depth field investigation of the areas of potential mangrove dieback, to determine the extent and possible causes. Dieback was defined as trees with substantial or complete loss of foliage, desiccated trunks, stems and roots, and colour change from grey/brown to a white/bleached colour.

Visual estimation/observations of leaf defoliation (degree of leafless branches), discolouration (degree of leaf colour change from green), and dieback for each quadrat were determined and a scale used to determine the severity, with no change (<5%), slight (5 to 25%), moderate (26 to 50%), and severe (>50%). Remote sensing and spatial analysis were also used to assess land erosion and accretion.

Transects were between 70 m and 100 m in length and included three previously established transects (T8, T9, and T15) and four new transects (TA, TB, TC, and TD). The new transects were determined based on possible dieback areas identified via satellite imagery. Sampling locations are presented in Appendix D.

The 2022 assessment was conducted in a similar manner to the previous mangrove surveys and included:

- Determining mangrove composition and relative canopy cover at 10 m intervals along each transect
- Establishing three replicate 25 m² plots at the start, end and midway point on each transect, and recording the following data:
 - Tree and seedling species richness, density, and diversity indices (number per 25 m² replicate plot)
 - Projective foliage cover with four cover classifications: open (0-5%), sparse (6-25%), moderate (26-50%) and dense (>50%)
 - Live basal area
 - Recording of crab hole densities.

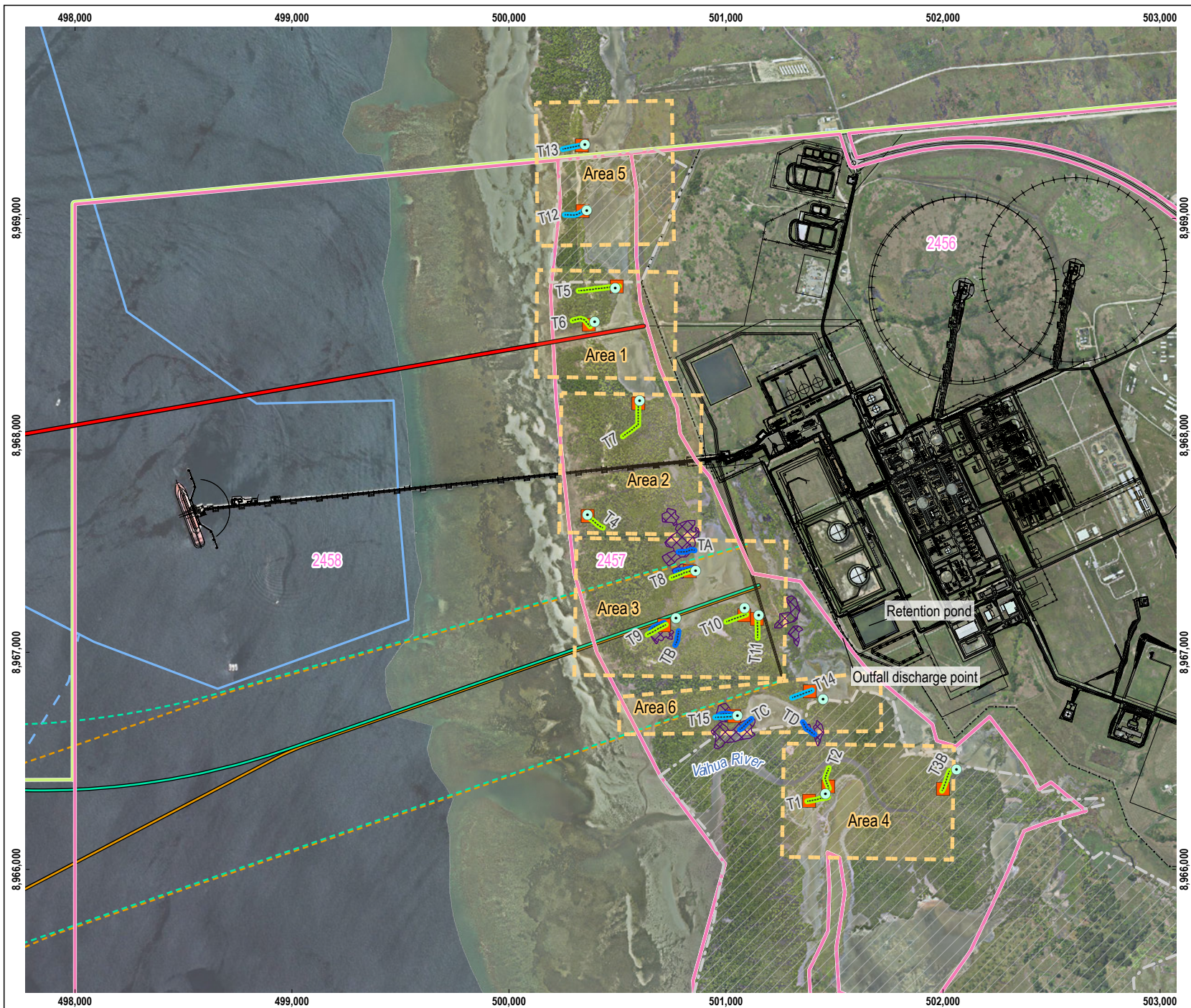
Water quality sampling

Water quality samples were collected from 25 sites where localised pooling and ponding of water was observed within the dieback areas in 2019 (Appendix C) and at adjacent discharge points. The samples were analysed for a range of parameters (temperature, pH, dissolved oxygen, salinity, and turbidity) using a multiparameter water quality meter.

The GPS coordinates for all sampling locations are listed in Appendix A and Appendix D and transect and sampling locations are shown in Figure 3.4.

2023 mangrove survey

Additional surveys were again undertaken by Tetra Tech Coffey subcontractors (Vision Environment), including habitat mapping and a water tracer study completed in February 2023, based on the 2022 field survey results, to determine if water discharged from the LNG Plant mixing pit was reaching dieback areas of interest, specifically those downstream of and in proximity to the LNG Plant mixing pit.



LEGEND

-  PNG LNG pipeline
-  Proposed Papua LNG pipelines route
-  Proposed Papua LNG pipelines route alternate
-  Existing and proposed plant layout
-  Cultural heritage restricted area
-  PPFL2 boundary
-  APPFL boundary
-  Current navigational channel
-  Proposed navigational channel
- Proposed CALM buoy components
 -  Naphtha and condensate pipelines
 -  Naphtha and condensate pipelines alternate
- Mangrove survey location
 -  Pore water sampling
 -  Macroinvertebrate sampling
 -  Mangrove transect (PNG LNG Project EIS/monitoring)
 -  Mangrove transect (2019)
 -  Mangrove transect (2022)
 -  Dieback area
 -  Mangrove transect area

SOURCE
Mangrove survey locations from Vision Environment
and Tetra Tech Coffey
Infrastructure, cultural heritage and lease boundary
from EMPNGA.
Imagery from EMPNGA and Google Earth.



0 500 m
SCALE 1:25,000
PAGE SIZE: A4
PROJECTION: WGS 1984 UTM Zone 55S

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FIGURE 3.4
Mangrove transect, macroinvertebrate
and pore water sampling locations

Approximately 10 grams of rhodamine water tracer powder was mixed with 10 litres of seawater, creating a final concentration of approximately 2 ppm over a 5 m³ volume of water. The water tracer was red in appearance and therefore readily identifiable among the mangrove forests and mudbanks.

Water tracer was released at two release points and as it moved downstream water quality parameters, including rhodamine concentrations, were used to track the tracer along its pathway. Additional water tracer was released further downstream when the dye became too dilute to detect visually.

Aerial drones (DJI Inspire 2 and DJI Mini 3) were used to capture images at 60 m altitude during water tracer movement. Between three to five ground control points were used for each image to aid in georectifying. GPS points were taken at the centre of each ground control point and used for image rectification.

Each image was georectified according to the ground control point and segmented by grouping pixels that had homogeneous spectral similarities using the ArcGIS Pro 'Segmentation' module (ESRI® ArcGIS Pro™ 2022). Segment training areas were then applied to each segment using the ArcGIS Pro Segment Training Manager module. Training areas were then converted into classification signatures (specific classes: mud, vegetation and water tracer) and used as part of an object-based supervised classification process. Support Vector Machine Learning Classification was used as a decision rule, based on the probability that a specific pixel value range belonged to a particular class, for the supervised classification. Final classification of mud, vegetation and water tracer classes were created using the ArcGIS Pro 'Classify' module.

The water tracer class was then separated using the ArcGIS Pro 'Reclassify' module and superimposed onto a mosaic of orthorectified images captured from the drones. The water tracer layers were visually assessed to determine final route and destination of the discharge water from the mixing ponds and reproduced as high-quality maps using ESRI® ArcMap™ 10.1 GIS software.

In addition to the 2023 surveys conducted by Vision Environment, related investigations of the mangroves adjacent the LNG Plant were in progress by a subcontractor for the Upstream component of the Papua LNG Project. Preliminary findings were reviewed to further characterise the mangrove community (see Section 3.2.1 and Section 5.1.3.3).

3.2.2 Marine ecology

The marine ecological setting for the Project was characterised by completing a series of towed underwater video transects and drop camera deployments, as well as the collection and analysis of sediment and infauna data. Relevant information previously collected for the PNG LNG Project was reviewed and supplemented by the additional survey data collected in 2019 and 2022.

Figure 3.5 shows the marine ecology survey locations for the 2019 and 2022 field surveys. Coordinates for each location are provided in Appendix A.

The 2019 marine surveys were undertaken by three Tetra Tech Coffey personnel during periods of suitable weather in April and August 2019. A small, manoeuvrable, tender (to the main survey vessel) with shallow draught was used to access most of the survey sites in April 2019, except those located in deeper water which were surveyed from aboard Collins Shipping 'MV Surveyor' (Plate 3.1). PNG Ports supplied a vessel for the August survey. Towed underwater video surveys of seafloor habitat to characterise the benthic environment was focused along prior coral and fish, seagrass, and trench spoil disposal sites, as well as Papua LNG pipeline route options, and the proposed LNG Plant jetty extension footprint. Previously surveyed reference sites located in similar environmental conditions but distant from the proposed infrastructure locations and the area(s) of potential impact were also surveyed in 2019.

Survey locations for coral and fish, seagrass, trenching spoil disposal and pipeline video survey sites were selected based on the 2014 monitoring survey locations. The 2014 locations had been refined following the evaluation of findings from marine surveys undertaken for the 2007-2008 study for the PNG LNG Project EIS and associated pre- and post-construction monitoring sampling programs that occurred between 2010 and 2014 (Coffey Environments 2010, 2011, 2012, and 2014a). Refinements were made based on observations of

ecosystem changes or in-situ confirmation of habitat-type delineations. The PNG LNG Project EIS marine ecology study was based on the sampling design described below, except for SCUBA diving that was also undertaken during the initial study as an additional method to characterise benthic habitats and fish communities. While there was overall similarity with the subsequent video results, direct quantitative assessment with the PNG LNG Project EIS baseline study was not possible due to the different methodologies as well as refinements in survey locations. Comparisons with previous data in this report therefore commences with the 2010 monitoring report (Coffey Environments, 2010).

The 2022 marine survey for the Project was undertaken between 4 September and 4 October and completed by two Tetra Tech Coffey personnel, during periods of suitable weather. A PNG Ports vessel was chartered (Plate 3.2) along with associated crew to support the survey. Locations for sediment sampling, benthic imagery collection and high-level hydrographic surveying were selected based on the current scope of the Project to adequately characterise the environment in the vicinity of proposed location options for the CALM buoy and dual subsea pipeline system, and alternative Papua LNG pipeline routes. A video transect was also completed for the proposed jetty extension alignment and video footage of the existing jetty piles was obtained to investigate the status of invasive species (i.e., determining presence or absence). Due to the substantial amount of prior information obtained previously in Caution Bay, rather than a broad scale characterisation effort, only locations within or immediately adjacent to the proposed preferred and alternate infrastructure locations were surveyed i.e., possible impact locations, except for the collection of one sediment sample at a reference location in the southwest of Caution Bay (see Figure 3.5).

Opportunistic observations of marine megafauna, including species of conservation concern such as turtles and marine mammals, and pelagic, demersal, and reef-associated fish were also made during surveys where such species were present.

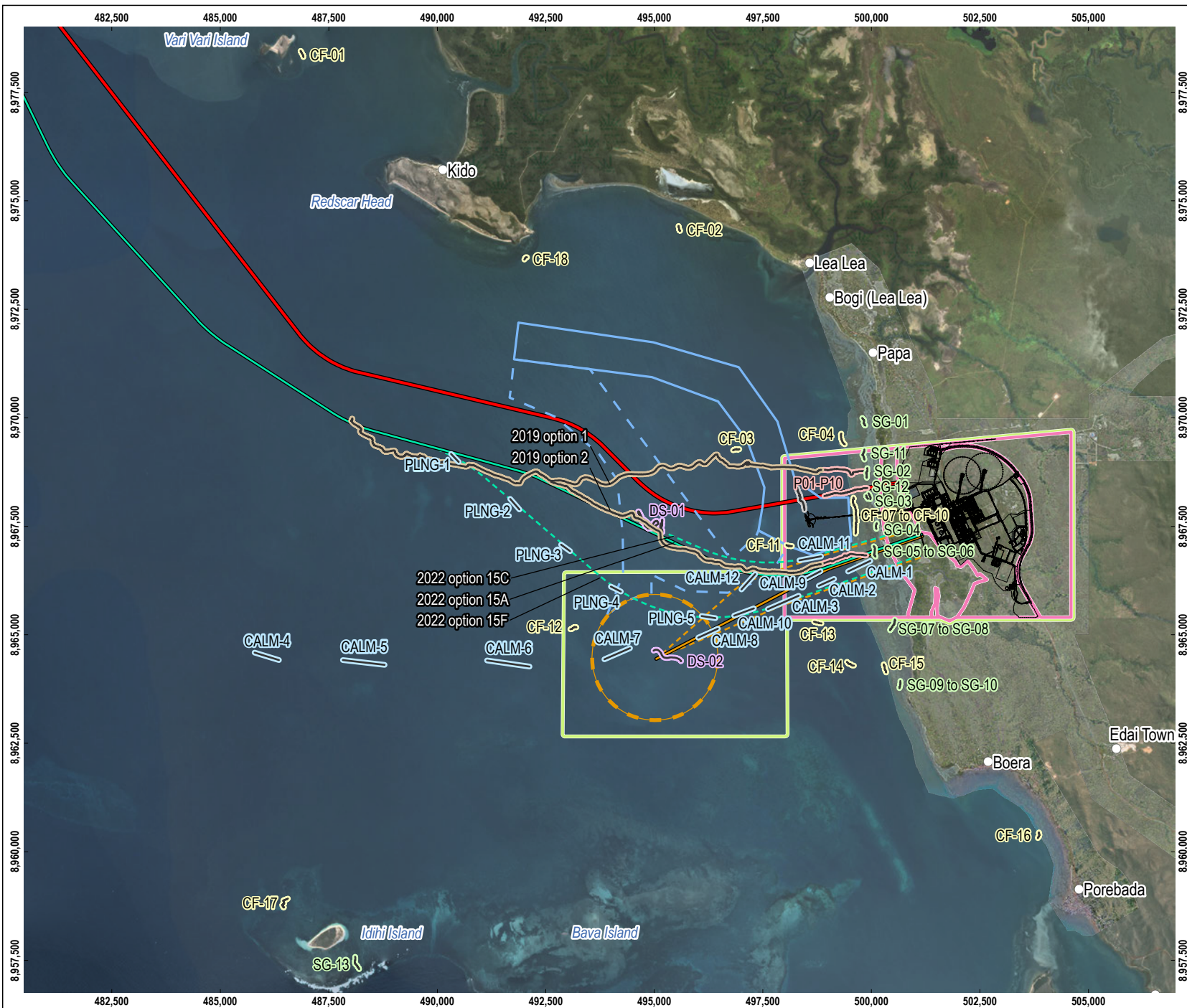
3.2.2.1 Towed underwater video transects

The towed underwater video camera and topside console used during the 2019 and 2022 surveys are shown in Plate 3.3. Towed video surveys have advantages compared to diver video operated and direct sampling techniques, and are widely used for the following reasons:

- Safety and greater spatial coverage compared to SCUBA diving.
- Adaptability to a range of environments, water depths and equipment types.
- Operability from a range of platforms (small dinghies to large vessels) with a relatively low number of operators required.

Towed underwater video camera, position fixing, recording and logging devices (i.e., GPS) were used to provide flexible, effective techniques for recording seabed and associated biological conditions at the range of habitats and depths selected for monitoring in Caution Bay.

The towed video equipment was designed to collect video records of ecosystem characteristics at the monitoring sites in Caution Bay. The equipment included two forward-orientated (at different angles) GoPro cameras mounted in a protective, weighted frame. These dual cameras provided differing perspectives of benthic, demersal, and pelagic features to capture as much information as possible for qualitative and quantitative analysis, provided for redundancy in the event of equipment failure, and compensated for changes in the orientation of the field of view (and the video data) because of factors including ocean currents, seabed relief, distance from the seabed and boat drift. The frame was designed to support the desired orientation and direction of the cameras and to provide stability for the equipment being towed above the seabed. An additional cabled GoPro camera was mounted on the frame to provide a 'live-feed' of real time imagery back to the onboard topside console, which informed the survey team of the position of the equipment and the habitat features being recorded along the transect.



LEGEND

- Village
- PNG LNG pipeline
- Proposed Papua LNG pipelines route
- - - Proposed Papua LNG pipelines route alternate
- Existing and proposed plant layout
- PPFL2 boundary
- APPFL boundary
- Current navigational channel
- Proposed navigational channel
- Proposed CALM buoy components
- Naphtha and condensate pipelines
- - - Naphtha and condensate pipelines alternate
- CALM buoy navigational area
- Marine survey transect
- Coral and Fish (CF)
- Dredge Spoil (DS)
- Seagrass (SG)
- LNG Plant jetty extension
- Pipeline (P)
- Pipeline option transect 2019
- Pipeline option transect 2022

SOURCE

Survey transects from Tetra Tech Coffey.
Infrastructure and lease boundary from EMPNGA.
Imagery from EMPNGA and Planet Labs.



0 1 2 3 km
SCALE 1:125,000
PAGE SIZE: A4
PROJECTION: WGS 1984 UTM Zone 55S

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FIGURE 3.5

Marine survey transect locations



The underwater video transect surveys were generally conducted by deploying the camera at each investigation location and positioning it between 0.5 m and 2 m above the seabed (depending on aspects such as slope, habitat type and visibility) and towing the equipment using a rope marked at 1 m intervals. During the transect, the video camera was manoeuvred to avoid contact with habitat features and maintain ideal orientation and distance above the seabed. Recordings were made of features and sightings in a field log and GPS device. Transect number, location, depth and time were also recorded.

The underwater camera system was coupled with use of a Lowrance HDS-7 Gen3 sonar with transducer to provide basic hydrographic data and monitor depth along the tow path, in order to identify locations where noteworthy bathymetric features and seabed irregularities such as reefs, habitat transitions, acute changes in seabed relief or potential rocky outcrops may be present.

Spatial data was captured using Avenza mapping software and recorded using a GPS overlay system built into the onboard live-feed camera console. The Avenza mapping software was also used for navigational purposes.

2019 coral and fish, and seagrass monitoring transects

Survey transects, typically 100 m in length, were completed in 2019 at existing i.e., previously established and surveyed, 'coral and fish' and 'seagrass' monitoring locations. For coral and fish sites, sampling depth typically varied between 5 m and 10 m. For seagrass sites, the video camera was towed approximately parallel to shore, in shallow waters typically between 0.5 m to 2.0 m depth.

A single, continuous 1-km-long camera tow was undertaken along the existing PNG LNG pipeline route, located approximately 530 m north of the existing LNG Plant jetty. A similar transect survey was undertaken during 2014 post-construction monitoring to assess the recovery of the seabed in this area, following disturbance. While monitoring of the route prior to 2014 involved surveying 10 separate transects that intersected the pipeline route at various depths perpendicular to shore, based on the 2014 method a single continuous transect was considered appropriate for 2019.

An approximately 800-m-long continuous transect from CF-07 (400 m north of the jetty) to CF-10 (400 m south of the jetty) was also completed in 2019, to repeat the surveying completed in 2014 (see Figure 3.5). This transect covered the area directly beneath the LNG Plant jetty to facilitate further visual assessment of seabed recovery processes.

The high-definition oblique video imagery taken in 2019 from 15 sites comprising predominantly coral habitat ('coral and fish' sites), and 10 sites comprising predominantly seagrass habitat ('seagrass' sites), were also analysed using a point-intercept technique, following the procedure used in previous surveys. Sections of video from the extended transect corresponding to the individual sites (CF07, CF09 and CF10) were extracted for quantitative analysis and comparison with results from other sites and from previous surveys. Still imagery was extracted from the video footage for point-intercept analysis (of sessile benthic biota). Fifty independent frames (still images) were extracted from each video transect for analysis (approximately one per 2 m of transect). Each image was analysed for the abundance of substrate and biotic features by superimposing five points that were located randomly within the area of each frame, ensuring that each point intersected seabed not open water. Only frames that showed a clear image of the seabed were used.

Data were summarised by category for graphical and multivariate analysis. Each point was classified using the same categories or sub-categories that identified the predominant seabed features identified from the video records (seabed types, benthic flora and fauna, substrates and seabed conditions) as previous surveys. These categories and subcategories were used in both point-intercept analysis (quantitative) and general analysis (qualitative) of video transects. Many flora and fauna can be identified to the level of genus or even species, although detailed taxonomic identification of small or cryptic fauna is typically not possible using towed video. Coral and fish observed from towed video records were identified to the lowest taxonomic level possible (typically to family or genus and occasionally species level) from video records.

Plate 3.1
MV Surveyor (2019 survey)



Photo credit: Tetra Tech Coffey

Plate 3.2
PNG Ports vessel (2022 survey)



Photo credit: Tetra Tech Coffey

Plate 3.3
Topside video viewing console and towed underwater camera



Photo credit: Tetra Tech Coffey

The proportion of each transect occupied by each category was calculated for each transect from the point-intercept data. The characteristics of the biological community at the 'coral and fish' and 'seagrass' sites were compared using multivariate analysis techniques. This is a standard technique used by ecologists and involves:

1. Preparing a Bray-Curtis dissimilarity matrix from the point-intercept data for the habitat and species categories at each site.
2. Using non-metric multidimensional scaling (nMDS) to find a representation of the dissimilarity matrix in two dimensions with a Kruskal stress value less than 0.2 (Clarke and Warwick 1994).

Non-metric multidimensional scaling is used to determine the degree of similarity or difference in sites' biological communities and represent these similarities and differences in a simple two-dimensional plot. Biological community variables explaining the similarities and differences are discussed with reference to the univariate data presented above. The R software analysis package Vegan was used for nMDS analysis.

2019 Papua LNG pipelines route survey

The nearshore portion of the Papua LNG pipelines route options within Caution Bay proposed at the time (preferred and alternative) were investigated in 2019 to determine the presence of sensitive habitats that may potentially be affected by construction of the pipeline and to identify other environmental features that may constrain the pipelines route. The nearshore portion of the preferred route was located to the south of the LNG Plant jetty and the alternative route was to the north of the jetty. A review of satellite imagery and navigational charts of the immediate area assisted in identifying noteworthy benthic features.

Drop camera deployments were conducted at a minimum of 200 m intervals along the proposed pipelines route and towed transects at locations where downscan and sidescan sonar data (generated using a Lowrance HDS-7 transducer) indicated noteworthy seabed features, including areas of rapidly changing gradient, coral bommies, or other complex benthic structures.

In areas of flat seabed habitat offshore, targeted drop camera deployments at set intervals were considered a more efficient sampling method to characterise habitats. Very slow speeds are required to successfully conduct camera tows and maintain suitable camera position and collect video records of usable resolution. Maintaining such speeds over extended distances is difficult.

2022 Project infrastructure route surveys

As with the 2019 pipelines route surveys, marine surveys within Caution Bay (see Figure 3.5).

were conducted in 2022 to determine environmental values and characterise subsea habitats in locations where infrastructure was proposed that were not previously assessed in 2019.

A qualitative habitat characterisation was undertaken to inform descriptions of predominant habitat type along the video transect, along with other incidental observations such as locations where changes in seabed relief were observed. As no earlier comparative data was available, this level of analysis was sufficient for characterising the marine environment along the proposed infrastructure footprint including identifying the distribution and types of habitats and ecological sensitivities, or potential pipeline route engineering constraints. Towed underwater video transects were conducted to characterise the benthic features and determine the presence of sensitive habitats that may potentially be affected by construction of Project facilities, and to identify other environmental features that may have implications for Project development. Video surveying focused on the following locations.

- Two potential CALM buoy locations and associated naphtha and condensate subsea export pipeline routes
- Papua LNG pipelines routes

- LNG Plant jetty extension

Continuous video transects were towed along the proposed pipeline routes, with focus targeted on sites where downscan and sidescan sonar data (generated using a Lowrance HDS-7 transducer) indicated noteworthy seabed features, such as areas of rapidly changing seafloor gradient, coral bommies, or other irregular or complex benthic structures. Drop camera deployments were conducted at the CALM buoy locations. Towed video was conducted along these routes at water depths between approximately 5 m and 45 m, with approximately 15 km of linear transects completed. Video transect surveying was also completed in the footprint of the proposed LNG Plant jetty extension (see Figure 3.5) to characterise the benthic features present in the area. Drop camera deployments were also conducted at five representative jetty pylon locations to investigate for the presence of invasive species.

3.2.2.2 Image quality analysis overview and considerations

For all transect surveys, the video records were used to identify the visible biological communities and inform a general qualitative habitat characterisation. Where relevant, ad hoc and incidental observations of other noteworthy features were also recorded. At some survey locations, repeat towed underwater video transects were completed due to variations in transect position or camera alignment that occurred because of waves/swell influencing the orientation of the vessel as it manoeuvred along the target transect line. The most representative and best quality video transect imagery was used during analysis to maximise data quality consistency between sites and surveys.

Key operational factors that affect the ability to collect ecological data and make taxonomic identifications using any visual survey technique (e.g., direct diver observation, photography, or videography) underwater include ambient water clarity, available light, proximity of observer/camera to the seabed and towing/swimming/current speed. These factors affect the ability to collect information directly or to subsequently discriminate and quantify ecological features from recorded images, including benthic species (such as corals) and fish species.

The towed video method may also under-estimate fish abundance and diversity due to small, cryptic (crevice-dwelling or camouflaged), nocturnal (e.g., soldierfish and squirrelfish, family: Holocentridae) or timid fish (those that flee the approaching boat or camera) typically not being seen. The results of the survey should therefore be considered in the context of the prevailing environmental conditions at the time of the surveys, the survey methods and characteristics of the ecosystem components being surveyed.

Descriptors of video image quality were assigned based on the factors discussed above (being consistent with those developed during 2014 surveys) and are summarised in Table 3.2.

Table 3.3 lists the seabed features and categories (seabed types, benthic flora and fauna, substrates and seabed conditions) that were identified from the video records obtained during the marine survey. These categories and subcategories were used for general analysis (qualitative) of video transects, while a consolidated set of these categories was used for point-intercept analysis (quantitative). While detailed taxonomic identification of marine flora and fauna is not always possible without ex-situ analysis, many flora and fauna are sufficiently distinctive to be identified to the level of genus. In some cases, the classifications of flora and fauna were estimated based on coarse morphological characteristics. In other cases, lower levels of taxonomic classification are used, supplemented by morphological classification.

Table 3.2 Video image quality classification

Video rating	Description
Very poor	Seabed only visible for part of the video footage. Very low resolution of seabed features.
Poor	Seabed visible for most of the video footage. Low resolution of seabed features (key seabed types and biota identifiable over most of transect).
Fair	Seabed visible for most of the video footage. Fair resolution of seabed features (seabed features clear). Key biota are identifiable over most of transect and minor biota identifiable in places.
Good	Seabed visible for most of the video footage. Good resolution of seabed features (seabed features clear). Key biota are identifiable over whole transect and minor biota easily identifiable over much of transect.
Very Good	Seabed visible for all of the video footage. Very good resolution of seabed features (seabed features clear), key biota and many minor biota easily identifiable over whole transect.

Table 3.3 Flora, fauna, and seabed classification categories

Category	Subcategory	Category	Subcategory
Flora and fauna			
Coral reef (live)	General coral	Hard coral	<i>Acropora</i> (branching)
Soft coral	<i>Lobophytum</i>		<i>Acropora</i> (corymbose)
	Soft coral (other)		<i>Acropora</i> (tabulate)
	<i>Sarcophyton</i>		<i>Euphyllia</i>
	<i>Sinularia</i>		<i>Faviid</i> (encrusting)
Fire coral	<i>Milleporidae</i>		<i>Faviid</i> (massive)
Lace coral	<i>Stylasteridae</i>		<i>Fungiidae</i>
Gorgonian	Sea whip		Hard coral (other)
	Sea fan		<i>Montipora</i>
Sponge	Erect sponge		<i>Mussidae</i>
	Encrusting sponge		<i>Pavona</i>
Echinoderm	Echinoderm (general)		<i>Pectiniidae</i> (foliose)
Seagrass	<i>Cymodocea</i>		<i>Pocillopora</i>
	<i>Enhalus acoroides</i>		<i>Porites</i>
	<i>Halimeda</i> sp.		<i>Seriatopora</i>
	<i>Syringodium isoetifolium</i>		
Macroalgae	Brown macro algae	Substrate	Base rock/base rock with sediment/base rock with algae
	Coralline algae		Dead coral reef
	Filamentous algae		Coral sand
	Green macro algae		Organic matter
	Red macro algae		Rubble/rubble with coralline algae/rubble with sediment
	<i>Padina</i>		Sediment

Category	Subcategory	Category	Subcategory
	<i>Sargassum</i>	Bioturbation	Burrow, large (fish)/burrow, small (invertebrate)
	<i>Caulerpa</i>		Burrow, small (invertebrate)/ mound
	<i>Halimeda</i>		Mound
	<i>Microphytobenthos</i>		Tube
Seabed			
Intact reef - low rugosity	Not applicable	Not applicable	Not applicable
Intact reef - moderate rugosity	Not applicable	Not applicable	Not applicable
Intact reef - high rugosity	Not applicable	Not applicable	Not applicable
Lightly damaged reef	Not applicable	Not applicable	Not applicable
Moderately damaged reef	Not applicable	Not applicable	Not applicable
Heavily damaged or destroyed reef	Not applicable	Not applicable	Not applicable

3.2.3 Marine water quality

The water quality sampling regime undertaken in 2007 and 2008 for the PNG LNG Project EIS and in 2011, 2012, 2013 and 2014 for ongoing PNG LNG Project monitoring was repeated in 2019 to provide a current nearshore marine baseline for the impact assessment for the proposed Project. Additional sampling sites were added in 2019 to cover two proposed options for the Papua LNG pipelines route.

Marine water samples were collected between 3 to 18 April 2019 alongside the marine ecology field survey. Water sampling of some sites and certain parameters was not able to be completed as the survey was cut short due to a medical issue with a crew member on board the vessel. For this reason, an additional survey was undertaken from 26 to 29 August 2019 to collect additional water quality samples.

3.2.3.1 Method

The GPS coordinates for sampling locations are provided in Appendix A and sites are shown in Figure 3.6 and Figure 3.7). Photographs of selected sites are presented in Plate 3.4 to Plate 3.12.

Water quality data was collected in-situ through use of a Seabird conductivity, temperature, and depth (pressure) profiling instrument (CTD) and a YSI Pro-DSS water quality meter. Samples were also collected at selected sites for later laboratory analysis.

The CTD was lowered to the seabed at selected sites at a rate of approximately 1 m/s to obtain measurements throughout the depth profile. The probe of the YSI meter was placed over the side of the vessel directly into the water at a depth of approximately 1 m and the readings recorded.

Water quality samples were collected in accordance with the Coffey Marine Water and Sediment Quality Monitoring Manual prepared for the Project, including the collection of quality assurance/quality control (QA/QC) samples (see Appendix B).

Samples were collected using a Niskin bottle at a depth of approximately 1 m and placed directly into laboratory-supplied sample bottles, with the sampler wearing powder-free latex gloves to minimise possible contamination. Samples were collected below the surface to avoid the surface microlayers at the air/water interface where contaminant concentrations may not be representative of the water column. Where possible, samples were collected up-current of the boat engine with the engine switched off to minimise potential contamination.

Water quality samples were either analysed for total suspended solids (TSS), or for a broader suite of water quality (WQ) parameters. Site IDs indicate whether each site was sampled for TSS or all WQ parameters (see Figure 3.6 and Figure 3.7).

Sites were distributed across the study area to characterise water quality in areas potentially impacted by project activities as well as reference sites at a distance from the proposed activities. Additional TSS sites were included to provide further coverage for this parameter, due to potential impacts from sedimentation during proposed pipeline trenching.

The physical parameters measured at each site included pH, temperature, salinity, dissolved oxygen, conductivity and turbidity. Where the water depth was greater than or equal to 10 m, two TSS samples were collected at each site; one at the surface (at approximately 1 m depth) and one in the midwater column. Where the water depth was less than 10 m, only one TSS sample was collected at the surface.

Both TSS and WQ samples were kept refrigerated on the survey vessel and placed in cooled eskies for transport to an accredited laboratory in Australia (ALS Limited).

WQ samples were analysed for the following parameters:

- Total suspended solids

- Total and dissolved (field-filtered) metals: arsenic, barium, boron, cadmium, chromium (as hexavalent), cobalt, copper, iron, mercury, manganese, nickel, lead, selenium, silver, tin, vanadium and zinc
- Nutrients: total nitrogen, total Kjeldahl nitrogen, nitrite, nitrate, ammonia, total phosphorus, reactive phosphorus
- Potassium
- Cyanide
- Fluoride
- BTEX, total petroleum hydrocarbons, speciated phenols and oil and grease
- Chemical and biological oxygen demand
- Sulphate and sulphide.

Samples collected at WQ sites near the discharge point of the LNG Plant retention pond (WQ_06, WQ_07, WQ_08 and WQ_14 (see Figure 3.7) were analysed for faecal coliforms, enterococci, *Escherichia coli* and amines. A sample from a reference site (WQ_05) was also tested for these parameters. Coliforms were tested by CSIRO laboratories and hand delivered to the laboratory to meet the required 24-hour holding time.

The date, GPS location, depth of sample, tide cycle and ocean/weather conditions were recorded onto datasheets for each site and later transferred to a digital database. Standard operating procedures were followed including instrument calibration, sample labelling, preservation, chain of command and documentation to meet customs requirements (see Appendix B).

3.2.4 Sediment quality

Sediment sampling was conducted in 2019 and 2022 to characterise benthic sediments at representative locations within the Project marine infrastructure footprint sites, and at control sites.

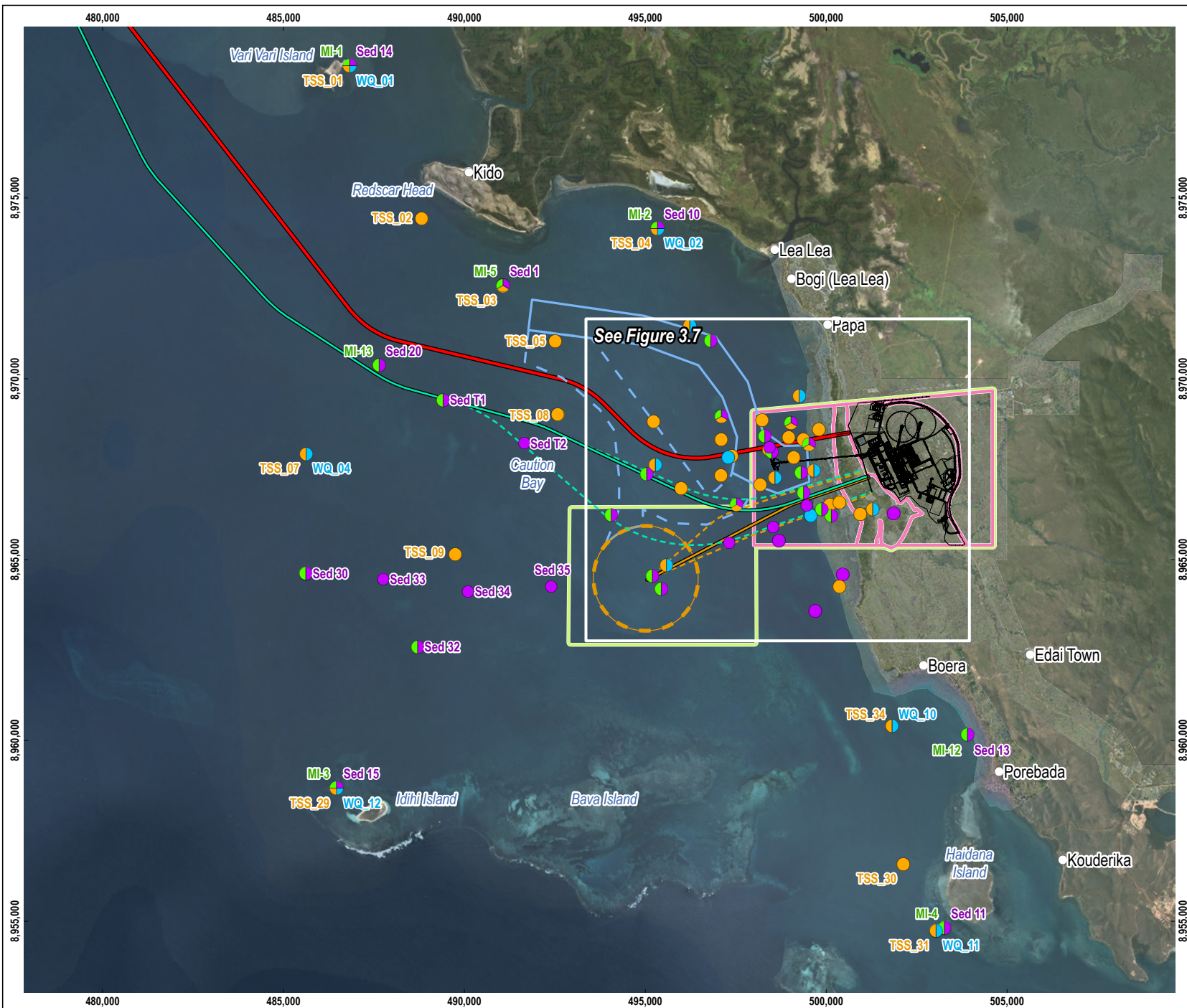
All samples were collected in accordance with the Tetra Tech Coffey marine water and sediment quality monitoring methods prepared for the Project, including the collection of QA/QC samples (see Appendix B).

At each sampling location, three sub-samples of sediment were collected from the surface of the seabed using a Petite Ponar grab sampler. Any unrepresentative materials (e.g., twigs, whole shells, stones, anthropogenic debris, visible biota) were removed using stainless steel forceps.

A composite of the three samples was prepared in a clean stainless-steel mixing bowl to obtain consistency throughout the whole sample and a sub-sample taken for laboratory analysis of physicochemical parameters. Mixing of the sediment was performed as quickly and efficiently as possible as prolonged mixing can alter the particle size distribution and cause oxidation of the sediments.

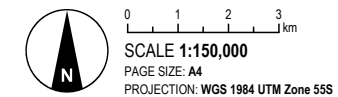
Sediment samples were labelled and photographed. Physical descriptions of colour, texture, odour and other conspicuous characteristics such as the occurrence of plant matter and/or coral fragments were recorded.

GPS coordinates for each sediment sampling site are provided in Appendix A and sampling locations are shown on Figure 3.6 and Figure 3.7.



- LEGEND**
- Village
 - PNG LNG pipeline
 - Proposed Papua LNG pipelines route
 - - - Proposed Papua LNG pipelines route alternate
 - Existing and proposed plant layout
 - PPFL2 boundary
 - APPFL boundary
 - Current navigational channel
 - - - Proposed navigational channel
 - Proposed CALM buoy components
 - Naphtha and condensate pipelines
 - - - Naphtha and condensate pipelines alternate
 - CALM buoy navigational area
 - Marine survey location
 - Macrobenthic infauna site
 - Sediment quality site
 - Water quality sampling site
 - TSS and CTD sampling site

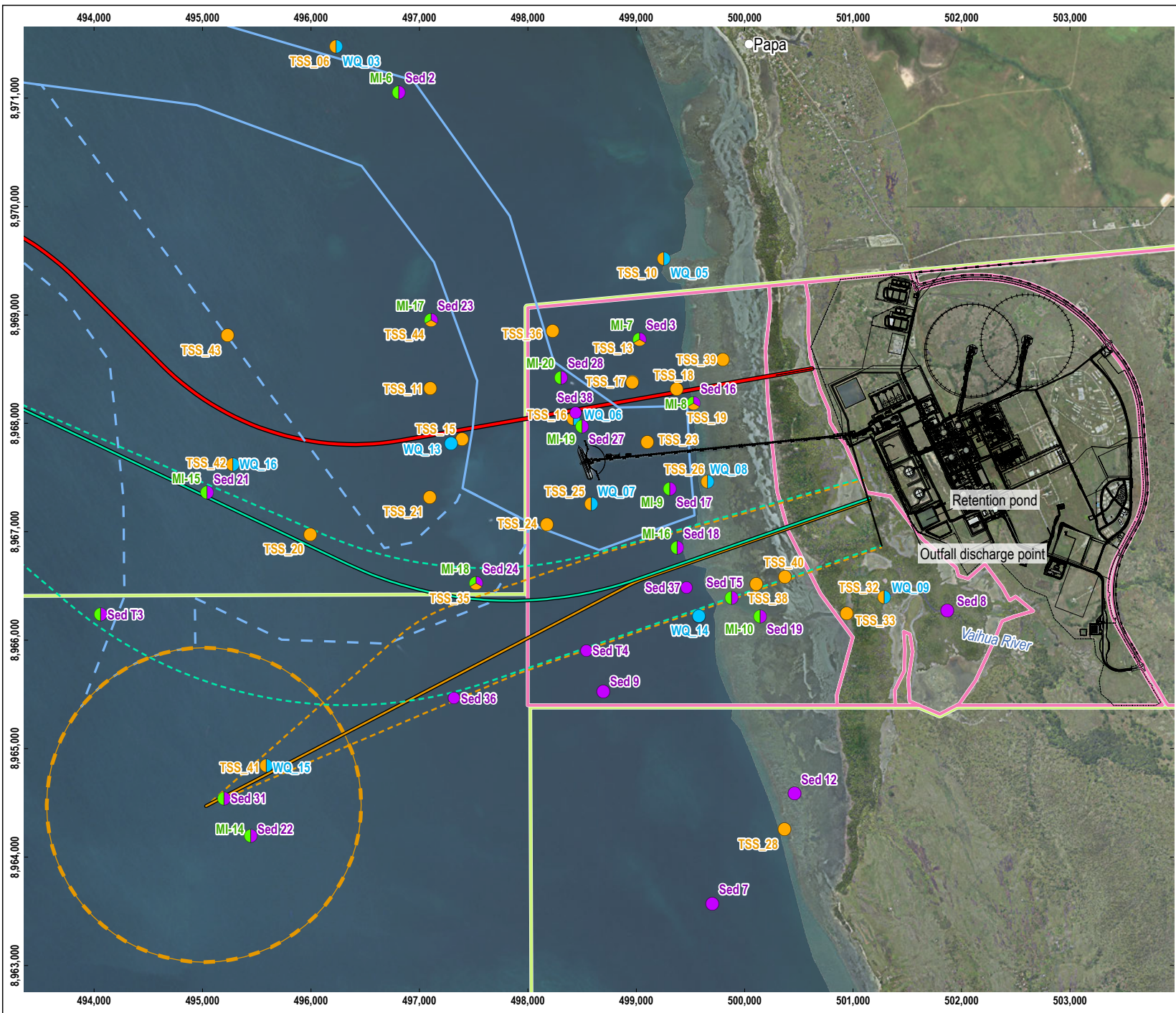
SOURCE
 Survey locations from Tetra Tech Coffey.
 Infrastructure and lease boundary from EMPNGA.
 Imagery from EMPNGA and Planet Labs.



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FIGURE 3.6
 Water quality, sediment quality and macrobenthic infauna sampling locations (2019, 2022)





- LEGEND**
- Village
 - PNG LNG pipeline
 - Proposed Papua LNG pipelines route
 - - - Proposed Papua LNG pipelines route alternate
 - Existing and proposed plant layout
 - PPFL2 boundary
 - APPFL boundary
 - Current navigational channel
 - - - Proposed navigational channel
 - Proposed CALM buoy components
 - Naphtha and condensate pipelines
 - - - Naphtha and condensate pipelines alternate
 - CALM buoy navigational area
 - Marine survey location
 - Macrobenthic infauna site
 - Sediment quality site
 - Water quality sampling site
 - TSS and CTD sampling site

SOURCE
 Survey locations from Tetra Tech Coffey.
 Infrastructure and lease boundary from EMPNGA.
 Imagery from EMPNGA and Planet Labs.

0 0.5 1 km
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FIGURE 3.7
 Water quality, sediment quality and macrobenthic infauna sampling locations (2019, 2022) (inset)



Plate 3.4
Vaihua Island and water quality
sample site WQ_01



Photo credit: Tetra Tech Coffey

Plate 3.5
Water quality sample site WQ_04

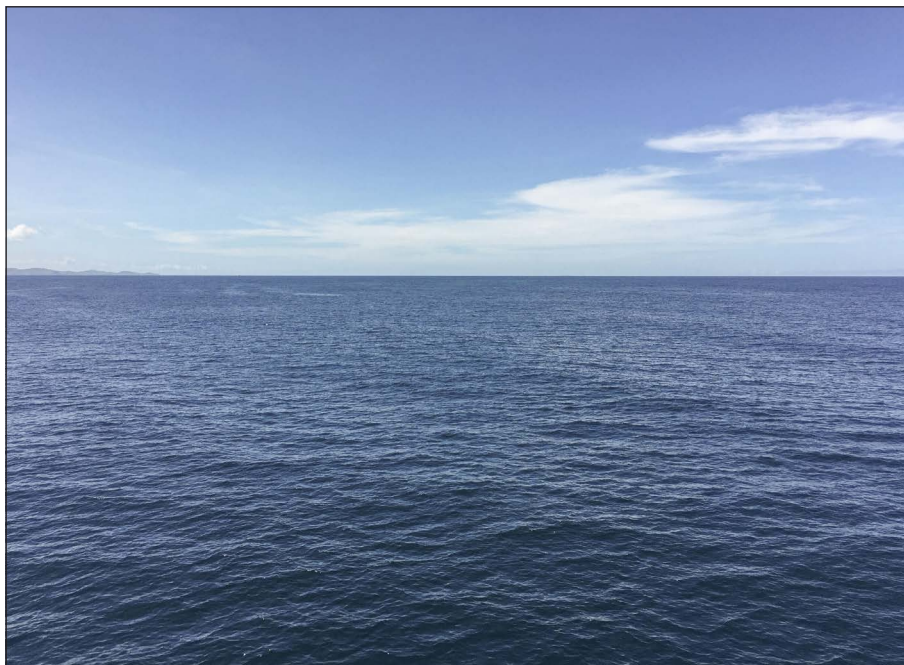


Photo credit: Tetra Tech Coffey

Plate 3.6
Viewpoint near WQ_06 toward LNG Plant jetty



Photo credit: Tetra Tech Coffey

Plate 3.7
Viewpoint near TSS_39 toward LNG Plant



Photo credit: Tetra Tech Coffey

Plate 3.8
Viewpoint near TSS_19 toward LNG Plant jetty



Photo credit: Tetra Tech Coffey

Plate 3.9
Water quality sample site TSS_33



Photo credit: Tetra Tech Coffey

Plate 3.10
Water quality sample site WQ_09



Photo credit: Tetra Tech Coffey

Plate 3.11
Water quality sample site WQ_10



Photo credit: Tetra Tech Coffey

Plate 3.12
Water quality sample site WQ_12



Photo credit: Tetra Tech Coffey

3.2.4.1 2019 sediment sampling

Sediment sample sites were selected based on previous locations sampled for the PNG LNG Project EIS and at proposed infrastructure locations. This included various locations within 2 km of the LNG Plant jetty, and in the vicinity of the Papua LNG pipelines route options. Reference sites were also included outside of the areas of potential impact.

Sediment sampling was undertaken in 2019 alongside water quality sampling from 3 to 18 April. Sampling of some sites and certain parameters was not able to be completed as the survey was shortened due to a medical issue with a crew member on board the vessel. For this reason, an additional survey was undertaken from 26 to 29 August 2019 to collect additional sediment quality samples.

Samples during the 2019 survey were kept refrigerated on the survey vessel and placed in cooled eskies for transport to an accredited laboratory in Australia (ALS Limited), for analysis of the following parameters:

- pH
- Particle size distribution
- Carbon content (organic, inorganic, and total)
- Total metals in the <2, µm fractions: arsenic, barium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, silver, tin, vanadium and zinc
- Nutrients: Including total nitrogen and total phosphorus
- Selected samples on the pipelines route options and in the vicinity of the LNG Plant jetty (Sed 3, Sed 16, Sed 18, Sed 19, Sed 21, Sed 22, Sed 27 and Sed 28) were also analysed for:
 - Total polychlorinated biphenyls (PCBs)
 - Organochlorine pesticides
 - Total petroleum hydrocarbons (with silica gel clean-up)
 - Polynuclear aromatic hydrocarbons (PAHs)
 - Radionuclides
 - Tributyltin.

3.2.4.2 2022 sediment sampling

In 2022, a total of fifteen sediment samples were obtained from representative locations inside the proposed Project infrastructure footprints, including the CALM buoy location options and associated naphtha and condensate pipeline routes, Papua LNG pipeline route and LNG Plant jetty extension area. One control site sample was also collected. Sampling coincided with the video transect survey between 4 September and 4 October 2022. Sampling locations are shown on Figure 3.5.

Samples collected during the 2022 survey campaign were kept refrigerated on the survey vessel and placed in cooled eskies for transport to an accredited laboratory in Australia (Eurofins Environment Testing Pty Limited), for analysis of the following parameters:

- pH
- Particle size distribution
- Carbon content (organic, inorganic, and total)
- Total metals in the <2, µm fractions: arsenic, barium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, silver, tin, vanadium and zinc
- Nutrients: including total nitrogen and total phosphorus

- PCBs
- Organochlorine pesticides
- Total recoverable hydrocarbons (with silica gel clean-up)
- PAHs.

3.2.5 Macrobenthic infauna

Macrobenthic samples were collected concurrently with sediment samples in 2019 and 2022 to assess the associated benthic infauna assemblages (see Figure 3.6 and Figure 3.7 and Appendix A for site coordinates).

For the purposes of this characterisation, macrobenthic infauna are defined as those multicellular animals living in the substrate or sediment on the seabed that are retained on a 500 µm sieve.

3.2.5.1 Method

Composite sediment samples were obtained by homogenising three subsamples collected from the surface of the seabed to a sediment depth of up to 15 cm, using a Petite Ponar grab sampler. Samples were labelled and fixed with formalin before being rinsed then preserved with ethanol prior to shipping from the sampling area, for later sorting and analysis by benthic taxonomy specialists. For the 2019 survey, samples were shipped to Australia for extraction, sorting and analysis by Dr John Moverley. In 2022, infauna analysis was conducted by Benthic Australia Pty Limited.

The samples were processed under international standard ISO 16665:2014(E) (International Organization for Standardization 2014), as follows:

- Samples were sieved on a 0.5 mm (500 µm) sieve.
- Fine sand (< 1 mm) and organic material were sorted under a dissecting microscope.
- Only animals that live in or on the sediment were counted. Only whole animals or unique segments like heads or mouth parts were counted.
- Taxa advised to be excluded by ISO 16665:2014(E) were recorded in the sample log but not included in the results.
- Identification was made to the lowest known taxonomic level (Family).
- Counts were made of the numbers of individuals of each taxonomic group.

3.2.6 International Finance Corporation habitat assessment

An assessment of marine habitats in accordance with International Finance Corporation (IFC) Performance Standard 6 (IFC 2012) is not included in this nearshore marine baseline, and a separate supplementary nearshore marine habitat assessment is being prepared in this regard for the Papua LNG Project, to meet Lender requirements. This separate assessment will align with the requirements and definitions set forth by IFC PS 6 and the corresponding Guidance Note 6 (GN 6) (IFC, 2012a; IFC, 2019).

A framework for 'Biodiversity Conservation and Sustainable Management of Living Natural Resources' is established within PS 6. This is supported and expanded by GN 6, that provides comprehensive guidance on how to meet the requirements of PS 6, including the need to ensure that ecologically appropriate scales for baseline studies, assessment and determining mitigation are applied. The intention of PS 6 is toward protecting and conserving biodiversity as well as maintaining ecosystem services and sustainably managing living natural resources are fundamental to sustainable development. IFC PS 6 requires that its application is established during the environmental and social risks and impacts identification process.

4. EXISTING PHYSICAL ENVIRONMENT

This chapter describes the physical features of Caution Bay, including climate and oceanographic aspects of the area of the Project and its surrounds.

4.1 PHYSIOGRAPHY

Caution Bay and the LNG Plant are located approximately 20 km north-west of Port Moresby (see Figure 2.1).

The bay is a shallow coastal basin reaching depths of up to 50 m in some areas. Shallower areas close to the coast (< 30 m depth) are generally characterised by coral sands and rubble, with intact patches of reef. Seagrass beds are present near the shore. Deeper waters (30 m to 50 m depth) are characterised by a muddy seabed with sparse distribution of visible biota. Much of the seabed is characterised by silt and clay sediments of terrestrial origin, with epibenthic faunal activity in the form of mounds and burrows ranging in size and abundance. Several offshore coral bommies are present in the bay, rising as high as 5 m below water surface in some areas.

Sandy beaches occur particularly to the north, and small pockets of intertidal mudflats are present, associated with mangroves around the Vaihua River estuary that provide habitat, including feeding grounds, for fish, birds and invertebrates. Saltpan mudflats exist behind the mangroves, beyond the high tide level.

The south-western offshore boundary of Caution Bay is formed by a continuous barrier reef which provides protection from ocean swells. Two sets of islands are located on the outer boundaries of Caution Bay. Vari Vari Island is situated to the north and is a remnant of the mainland. Idihi Island is a coral cay and is located to the south, on the barrier reef. Natural openings occur in the reef to the north of Idihi Island at the north-western extent of the reef, and to the south at Liljeblad Passage. These openings are used by small vessels to move in and out of the reef (Coffey Natural Systems 2008). Beyond the barrier reef, seabed gradients are steep and ocean depths reach over a thousand metres (GEMS 2008).

The current route options for the offshore Papua LNG pipelines initially travel down a relatively deep channel of at least 14 m depth between the nearshore fringing reefs and offshore coral bommies. The routes then cross the fringing reef, subtidal sandy areas and seagrass patches, intertidal and mangrove habitats for approximately 500 m before terminating onshore at the LNG Plant site. The LNG Plant jetty is aligned perpendicular to the shore in the same nearshore habitat zones.

Further south of the Papua LNG pipeline route options, where present, shoals and coral bommies rise to about 5 m below the water surface.

4.2 CLIMATE

The descriptions of climatic and meteorological conditions in this section are based on a synthesis of information sources, including from the PNG LNG Project EIS, with updated data presented where available. Given the generally broad nature of climatic conditions, descriptions are not Project-specific but are representative of the general coastal conditions in the Caution Bay area.

Climate records for Papua New Guinea are generally limited, with the longest ongoing records near Caution Bay collected from meteorological monitoring stations located Port Moresby, approximately 20 km from the LNG Plant (Coffey Natural Systems 2009; WMO 2023). An automatic weather station (AWS)⁶ was deployed on land near the coast of Caution Bay in February 2008 during work undertaken for the PNG LNG Project

⁶ Data from the AWS and the Australian Bureau of Meteorology MesoLAPS atmospheric model was used to describe the climate environment for the PNG LNG Project EIS.

EIS. A weather station has also operated at the LNG Plant since 2014, with weather readings taken at various intervals since the LNG Plant was constructed.

Climatic conditions in Papua New Guinea are governed by several factors, including the trade winds and the movement of the South Pacific Convergence Zone, a zone of high-pressure rainfall that migrates south of the equator across the Pacific.

The Port Moresby-Caution Bay climate regime is classified as Tropical Savanna (Köppen classification: Aw) under the international Köppen-Geiger system (Gillison 1983; Peel et al. 2007). Tropical Savanna is defined by a combination of elevated temperatures and a high annual rainfall with pronounced seasonality. This regime contrasts with the dominant climate regime of Tropical Rainforest (Köppen classification: Af) across the broader region of New Guinea. The seasonality in wind direction, temperature, humidity, and rainfall are broadly controlled by two seasons, between which brief transitional phases occur, namely:

- The north-west monsoonal 'wet season' (known locally as 'lahara') that occurs between the austral summer of December and March, and is associated with warm, humid conditions and frequent rainfall.
- The south-east monsoonal 'dry season' (known locally as 'laurabada') that occurs between June and October, characterised by cooler and drier conditions associated with the south-east trade winds.
- The 'doldrums', typified by more changeable weather that occur during the transitional months of May and November.

El Niño events result in cooler dry and wet seasons than normal in the Port Moresby-Caution Bay area, and lower seasonal sea level and tidal reach. During La Niña events, only the dry season is warmer and both seasonal sea level and tidal reach are higher (Richards et al. 2016).

Topographic factors also play a role in determining local weather patterns at various scales along southern Papua New Guinea, and the Owen Stanley Range that forms the backdrop to Caution Bay results in a climate that, while still seasonal, is not subject to the dry season moisture deficit that characterises the adjacent coast (Richards et al. 2016).

4.2.1 Winds and cyclones

The wind regime of the Gulf of Papua is tied to the seasonal cycles associated with the north-west monsoon 'wet season', and the south-east trade winds 'dry season' (Hasegawa et al. 2010). Martin et al (2008) describe the wet season wind regime as entailing offshore winds with typical speeds below 5 m/s⁻¹, and the dry season wind regime being characterised by increased wind energy that more frequently blows onshore at speeds greater than 5 m/s⁻¹. Data from NSR (1990), Woolfe et al (1997), and Richards et al. (2016) similarly indicate that:

- During the wet season, winds predominantly blow from the north-west or west at speeds of generally less than 31 km/h (17 knots), with wind speeds exceeding this only 15% of the time.
- During the dry season, windier conditions prevail, with winds travelling distances in the order of 1,000 km across the Coral Sea and Gulf of Papua and exceeding 31 km per hour for 30% of the time.

Wind speeds of 55 km to 65 km/hr also accompany the occurrence of short-lived squalls of about one hour's duration. These conditions arise in the Port Moresby area during the north-west monsoon approximately five times a year, occasionally in conjunction with electrical storms and heavy precipitation (McAlpine et al. 1983).

GEMS (2008) identified three main features of the ambient wind conditions in Caution Bay:

- Dominance of winds from the south-east due to trade winds offshore.
- Existence of katabatic winds from the north-east off the coastal topography.
- Significant difference in the wind regime between onshore and offshore sites.

Local weather conditions in the Port Moresby-Caution Bay region are influenced by the interplay of land and sea surface temperatures. McAlpine et al. (1983) describe 'sea breeze cells' that form offshore during the morning and expand both landward and seaward during the day. Progression of the landward frontal zone across the coastline is accompanied by rainfall, local wind gusts, and reduced humidity and temperatures. Convective clouds may also develop along the frontal zone, resulting in thunderstorm fronts over the inland ranges. The sea breeze cell diminishes in the afternoon around sunset and is occasionally replaced by a 'land breeze cell' that creates offshore winds (McAlpine et al 1983). The daily cycle of heating and cooling of air masses within steep-sided valleys, creates convection cells producing afternoon and overnight rainfalls throughout the year, at variable intensities depending on the moisture content of regional air masses.

Tropical cyclones affect southern Papua New Guinea between November and April, occurring mainly during February to April. Large cyclonic storms do not directly impact the Gulf of Papua due to the equatorial proximity (Martin et al. 2008) and the Gulf of Papua is an area of low to moderate cyclone risk. Most cyclones occur further to the south but generate storm-force winds and long-period waves in the Gulf of Papua. These conditions can cause substantial seafloor scouring and sediment movement in shallow waters.

In the 41-year period between 1969 and 2010, 23 tropical cyclones passed within 400 km of Port Moresby, an average of less than one cyclone per season. Over this period, cyclones occurred more frequently in neutral phases of the El Niño-Southern Oscillation (Australian Bureau of Meteorology and CSIRO, 2011). Tropical cyclone database records, extending back to the 1950s to a period prior to the availability of satellite observations, did not indicate cyclone genesis occurring in the northern part of the Gulf of Papua (GEMS 2008). Richards et al. (2016) noted that only three cyclones tracked within 100 km of Caution Bay between 1970 and 2010.

Tropical Cyclone Guba occurred in mid-November 2007 and formed in the Coral Sea. This cyclone skirted the south coast of mainland Papua New Guinea (including the Gulf of Papua) causing flooding and evacuations in Oro and Milne Bay provinces, with peak wind speeds reaching 140 km/h.

4.2.2 Temperature

Regular sea breezes in the Port Moresby-Caution Bay region result in daily maximum temperatures that are usually lower close to the coast compared with further inland on the coastal plain (Fitzpatrick 1965; Löffler 1982).

A seasonal temperature range of 28 to 32°C (mean maximum) was reported by McAlpine et al. (1983).

World Meteorological Organisation (WMO 2022) daily mean air temperatures at Port Moresby⁷ based on monthly averages for the 35-year period 1973 to 2007 are:

- In July, minimum 22.4°C and maximum 29.9°C
- In November, minimum 23.6°C and maximum 32.5°C.

Richards et al. (2016) report daily mean minimum and maximum monthly air temperatures at Port Moresby reaching peak monthly averages of 24°C and 32°C respectively in December and January, and low monthly averages of 23°C and 28°C respectively in July and August. The recorded daytime minimum and maximum for 40 years of records were 18°C to 36°C respectively (Richards et al. 2016).

Results from weather records obtained at the LNG Plant during routine monitoring undertaken at the site each month indicate annual mean, annual mean minimum, and annual mean maximum temperatures of:

- 27.4°C, 24.6°C, and 30.3°C in 2020⁸ respectively.

⁷ The meteorological station located at Port Moresby is situated approximately 20 km from Caution Bay, meaning these results are representative of the ambient conditions in the wider region.

⁸ For 2021 and 2022, no data from the LNG Plant temperature gauge were included as several temperature records were erroneous.

- Monthly mean maximum ranged between 28.8°C in July to 31.6°C in February. Monthly mean minimum ranged between 23.7°C in August to 25.2°C in May.
- 26.7°C, 23.9°C, and 29.6°C in 2019 respectively
 - Monthly mean maximum ranged between 27.6°C in July to 31.3°C in December. Monthly mean minimum ranged between 22.8°C in July to 24.4°C in February.
- 27°C, 24.1°C, and 29.9°C in 2018 respectively.
 - Monthly mean maximum ranged between 28.5°C in September to 32°C in December. Monthly mean minimum ranged between 23.6°C in August to 24.8°C in December.

4.2.3 Rainfall

Rainfall in Papua New Guinea is highly spatially variable due to the range of altitudes and exposure to seasonal wind patterns. Annual rainfall across most areas of Papua New Guinea ranges from about 2,000 mm to 3,000 mm annually, reaching 5,000 mm annually at some high-altitude areas. Conversely, Port Moresby is one of the driest areas in Papua New Guinea with annual rainfall averaging 1,000 mm (Coffey Natural Systems 2009).

Rainfall during the monsoon is typically alternating, with episodic wet 'bursts', and dry 'break' conditions, with the latter typically accounting for approximately 20% of the monsoon season, and a possible 40-to-50-day oscillation in the 'burst and break' cycle (McAlpine et al. 1983; Sturman and Tapper 2001).

Mean total rainfall, based on monthly averages for the 35-year period from 1973 to 2007, ranged between 12 mm in August and 192.2 mm in January (WMO 2022).

Richards et al. (2016) note that reduced rainfall occurs in the Port Moresby-Caution Bay region from June to October, with average monthly rainfalls between 18 mm to 36 mm. The low annual rainfall is partly attributed to the generally parallel alignment of the coast and inland ranges with both the north-west monsoon and south-east trade winds. Average monthly rainfalls during December to April are between 112 mm to 193 mm. February was shown to be the wettest month from a review of 40 years of records.

Results from weather records obtained at the LNG Plant during routine monitoring undertaken on site indicate rainfall that ranged between:

- 14 mm in September 2022 and 301.5 mm in December 2022.
 - Total rainfall recorded for 2022 was 1335 mm.
- 4.6 mm in May 2021 and 334.5 mm in February 2021 (no July, August or September 2021 data recorded).
 - Total rainfall recorded for 2021 was 1202.7 mm.
- 2.8 mm in September 2020 and 200.4 mm in January 2020.
 - Total rainfall recorded for 2020 was 845.6 mm.
- 17.3 mm in October 2019 and 523 mm in January 2019.
 - Total rainfall recorded for 2019 was 1299 mm.
- 0.5 mm in June 2018 and 334.3 mm in January 2018.
 - Total rainfall recorded for 2018 was 895.1 mm.

4.3 OCEANOGRAPHY

Bathymetric and hydrodynamic studies were undertaken for the PNG LNG Project EIS Nearshore Marine Impact Assessment (Coffey Natural Systems 2008) and are the most recent available studies of their kind for Caution Bay.

4.3.1 Bathymetry

Channels, shoals and coral reefs create a complex bathymetry within Caution Bay, which has a wide, westerly facing entrance between Redscar Head to the north and Idihi Island to the south-west. Inshore of this area, the bathymetry gradually shelves from around 50 m to less than 5 m at the nearshore fringing reef (Coffey Natural Systems 2008).

Average water depths in Caution Bay are around 25 m, with several shallow coral bommies present, mostly in the southern part of the bay. A natural channel of at least 14 m depth is present adjacent to the LNG Plant jetty and runs north and west to the open sea. The channel is free of bommies (Coffey Natural Systems 2008).

EGS Survey Pty (EGS) conducted geophysical and bathymetric studies on the PNG LNG pipeline route in April 2008. This study provided detailed bathymetry of Caution Bay at the time, which identified offshore coral bommies and rocky outcrops in the nearshore marine environment (EGS 2008). The area most punctuated by shoals and coral outcrops occurs approximately 2 km west of the edge of the fringing reef, in the central and southern region of Caution Bay, and extends to the west. Further bathymetric surveys were undertaken in the shipping lane and at the LNG Plant jetty prior to, and after, pipeline trenching for the PNG LNG Project. The post-construction survey undertaken in 2013 showed similar bathymetry to that mapped in 2008 (EGS 2013). Bathymetry for the area surveyed is shown in Figure 4.1.

The barrier reef at the seaward extent of Caution Bay forms part of the Papuan Barrier Reef. This continuous reef system spans the south coast of Papua New Guinea, from Yule Island to the south-east Papua Peninsula. The outer barrier reef, to the south and east of Idihi Island, forms the southern boundary of Caution Bay. Beyond this feature, depth increases rapidly as the continental slope reaches depths beyond 1,000 m some 3 km from the shore.

4.3.2 Tides

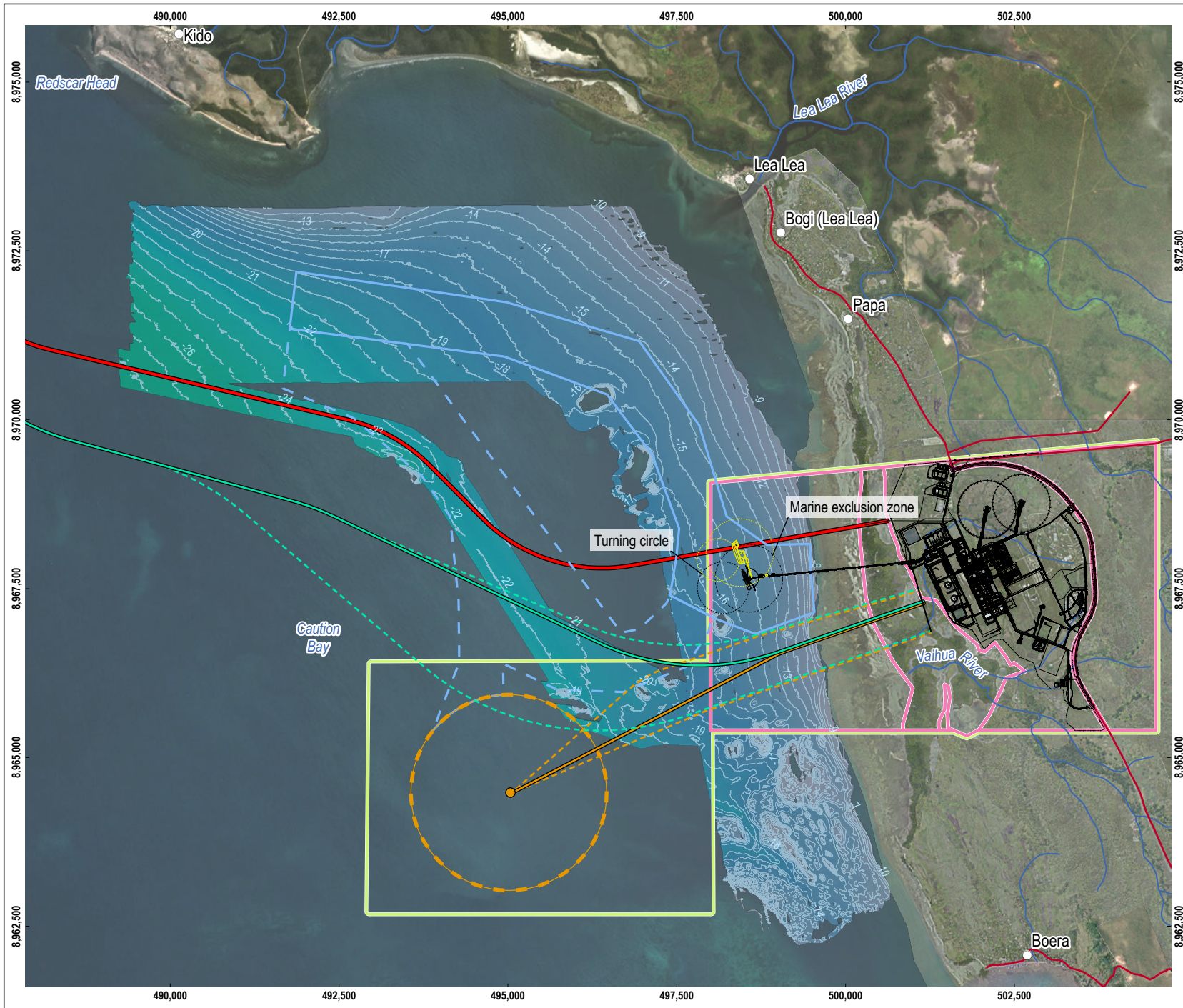
Tides in the Gulf of Papua are semi-diurnal to mixed. A maximum spring tidal range of 4 m and mean spring tidal ranges of 2.5 m to 3 m occur in the western gulf (Wolanski et al. 1991). Tidal ranges in the eastern extent of the gulf and eastwards to Port Moresby tend to be smaller, with a mean spring tidal range of less than 3 m (EMPNG 2009). Caution Bay has semi-diurnal tidal cycles, with two high and low tides per day. Mean spring tide height is less than 3 m (GEMS, 2008).

For the PNG LNG Project EIS, hydrodynamic modelling of sea surface heights was undertaken using tidal data from two loggers placed in Caution Bay and in the western side of the Gulf of Papua. Data were available for the period 20 December 2007 to 8 May 2008. Global tidal data from the Australian region, including the Gulf of Papua was used to compare observed sea surface heights, and showed that longer time predictions could be made with confidence. Overall sea tidal ranges were between -1.50 m and +1.50 m from mean sea level (GEMS 2008).

4.3.3 Currents

Oceanic circulation in the Gulf of Papua is dominated by a clockwise gyre, generated as the northwards-flowing Coral Sea Coastal Current enters the gulf along the eastern edge of Torres Strait and exits to the north-east (Figure 4.2) (Woolfe et al. 1997; Steinberg et al. 2006). Most of the freshwater and sediment delivered to the gulf by Papua New Guinea's rivers tends to travel eastwards (Coffey Natural Systems 2009).

Oceanographic studies and dredging program simulations were undertaken for the PNG LNG Project EIS. These included modelling current movements, sediment transport and coastal processes in Caution Bay (GEMS 2008). Data on currents was obtained from an acoustic doppler current profiler (ADCP) deployed at the LNG Plant jetty prior to construction. The first five months data was used to model a 12-month period.



- LEGEND**
- Village
 - Road
 - Watercourse
 - Bathymetry (1 m interval)
 - PNG LNG pipeline
 - Proposed Papua LNG pipelines route
 - - - Proposed Papua LNG pipelines route alternate
 - Optional jetty extension
 - Existing and proposed plant layout
 - PPFL2 boundary
 - APPF boundary
 - Current navigational channel
 - Proposed navigational channel
 - Proposed CALM buoy components
 - CALM buoy
 - Naphtha and condensate pipelines
 - - - Naphtha and condensate pipelines alternate
 - CALM buoy navigational area

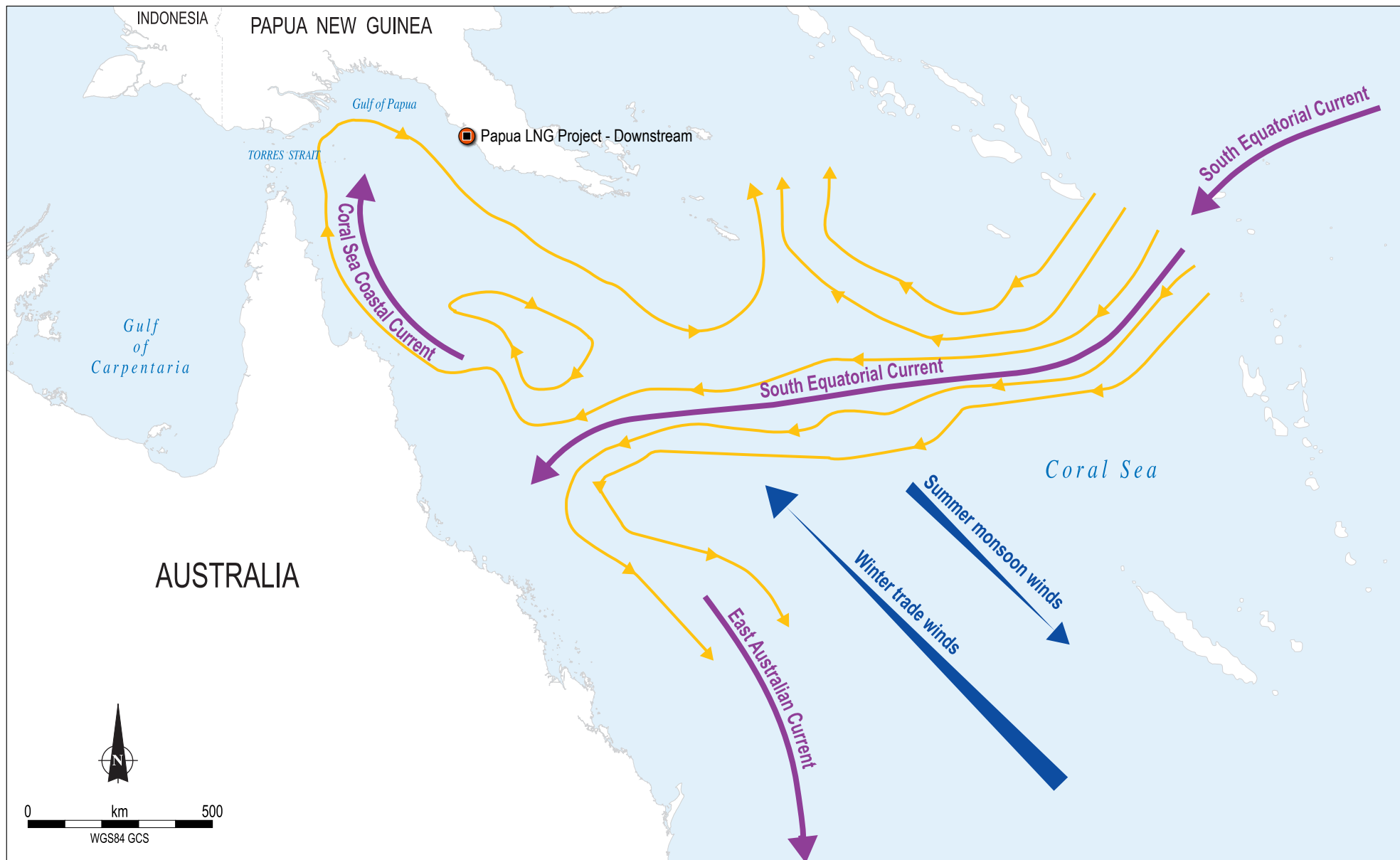
SOURCE
 Infrastructure, bathymetry, roads, watercourses and lease boundary from EMPNGA.
 Imagery from EMPNGA and Planet Labs.

0 1 2 km
SCALE 1:80,000
 PAGE SIZE: A4
 PROJECTION: WGS 1984 UTM Zone 55S

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FIGURE 4.1
Detailed bathymetry of Caution Bay





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FIGURE 4.2

Oceanic circulation in the Gulf of Papua

SOURCE
Burrage et al. (1993) as cited
in Woolfe et al. (1997)



The mean hourly current speed in Caution Bay was 0.07 m/s with a maximum mean speed of 0.32 m/s (GEMS 2008). Figure 4.3 provides an indication of the dominant patterns of tidal and wind driven currents within the bay at that time.

The maximum depth-averaged currents seen in the 2008 data at the CBW ADCP were 0.38 m/s, or 0.74 knots. The maximum near-surface currents seen in the 2008 data at CBW were 0.7 m/s, or 1.1 knots, although these were short-lived and may be related to instrument noise. A de-tided (low-pass filtered) record of depth-averaged currents indicated that sustained residual currents of approximately 0.1 m/s were seen for periods of one to two days in the CBW data.

GEMS (2008) modelled a theoretical tropical storm passing Caution Bay to better understand potential peak currents. The GEMS model indicated that the strongest modelled currents at CBW (CM1 in their report) during a theoretical tropical storm were 0.55 m/s (GEMS 2008) and, inexplicably lower, 0.40 m/s (see GEMS 2008, Table 6). These are presumably reported as depth-averaged currents, so near-surface currents could be higher.

4.3.4 Waves

The Gulf of Papua is exposed to local surface waves generated during the south-east trade winds. Waves generate in the general direction of the winds but refract across shallow water towards shorelines. During the north-west monsoon, offshore winds result in little or no swell (GEMS 2008). The wave climate within Caution Bay differs to the main patterns in the Gulf of Papua, with the highest energy wave conditions occurring during January and February, due to the orientation of the bay and the protection of the fringing reefs to the south-east (RPS 2020).

Seasonally averaged significant wave heights of 1.5 m and 2.1 m occur relatively close to the coast during the south-east trades and further offshore during the north-west monsoon (Hemer et al. 2004). Within Caution Bay, wave action is limited somewhat by the fringing reef. Data modelled over 12 months at the LNG Plant jetty site for the PNG LNG Project EIS (prior to construction) indicated a mean wave height of 0.42 m and a maximum height of 1.9 m. Wave height only exceeded 1 m for 10% of the time over the 12-month period (GEMS 2008).

Tropical cyclones represent the extreme oceanographic conditions likely to be experienced in Caution Bay. The PNG LNG Project is situated north of the main cyclone belt and occurrences of such extremes are rare. Only five named cyclones have entered the Gulf of Papua since 1993. Of these, Cyclone Guba in 2007 was the most significant, entering the gulf from the south-east as a category one cyclone and passing to the south of Port Moresby. Wave recording instruments during this period logged peak significant wave heights at the LNG Plant jetty of just over 1 m. A small storm surge was recorded and peak currents reached 0.2 m/s (GEMS 2008).

A search of the Australian Southern Hemisphere Tropical Cyclone Data Portal (BOM 2022) from 1969 to 2022 does not identify any cyclones having formed in the northern part of the Gulf of Papua.

4.3.5 Sedimentation processes

Sediment transport in the Gulf of Papua is dominated by the action of waves mobilising sediment, which are then transported by either wave-related processes or currents. The composition of bed sediments in the shallow areas of Caution Bay are dominantly calcareous and produced locally in reef and seagrass environments. While no large rivers flow into Caution Bay to deliver substantial sediment loads, the Lea Lea River and Vaihua River catchments delivers intermittent sediment into the bay. Sediment transport rates are therefore expected to be small in magnitude, and any associated changes to morphology would be gradual. There is little evidence that the shoreline in Caution Bay is undergoing active change. Terrigenous sediment

can be locally important near a river or other land-derived sediment source (Margvelashvili and Saint-Cast 2007).

The existing bathymetry of Caution Bay represents a long-term equilibrium between bedrock and reef geometry, sediment production, and sediment transport by waves and currents. A local change to the geometry could enhance or inhibit sediment transport by coastal processes, leading to erosion or deposition. Increased sediment load from the land due to project activities could also result in increased sedimentation or turbid plumes that travel far from the source.

The transport of sediment depends on the balance between the sediment's tendency to sink and the turbulent energy available to mobilise sediment upwards. Considering a nominal Caution Bay depth of 20 metres, sand-sized sediment would settle from the surface to the bottom in a matter of hours. Coarser silt-sized sediment is likely to settle out of the water column within 24 hours. Combining these rates of settling with currents allows a rough estimate of the distance over which a sediment source near the project might travel as a distinct plume. The tidal excursion is a typical distance a particle might travel in one tide cycle due to tidal currents. Estimating the tidal excursion from measurements at one point is not entirely correct, as currents vary across Caution Bay. However, the typical distance potentially travelled by a particle subjected to the currents measured at CBW in 24 hours is between 1 km and 6 km, giving a nominal potential area of effect for any fugitive sediment discharges at the project site. In the absence of a major and constant sediment source such as dredging, such plumes would likely be short-lived, with deposition redistributed by the wave environment.

The interaction of waves with marine structures represents another mechanism for erosion and accretion. The proposed wharf may act as a groyne, potentially increasing erosion at the toe and on the up-drift side subject to wave attack, potentially allowing deposition on the lee or sheltered side. Variability in the number and type of sediment suspension sources, the flux from each source, and the varying dynamics of the transport, settlement and resuspension processes affecting the sediments is expected. This may result in potential spatial patchiness in terms of sediment accretion.

While deployment of sedimentation analysis instrumentation was not included in the scope of field work undertaken in 2019 or 2022, sediment tubes were deployed on reefs in Caution Bay to determine sedimentation rates during sampling undertaken for the PNG LNG Project EIS from December 2007 to February 2008 and February to April 2008 (Coffey Natural Systems 2009). No pattern in sedimentation rates was observed over various sites across the sampling period, with a range in values possibly reflecting localised conditions (Coffey Natural Systems 2009). Sedimentation in the PNG LNG Project study area was determined to be dependent on tidal state, wind direction and strength, which may resuspend sediment, as well as river flows and rainfall events which introduce sediment in various volumes. Ongoing re-suspension may result in elevated levels of TSS, potentially extending over many kilometres, although at relatively low concentrations (<5 mg/L).

Sedimentation rates in 2007 and 2008 ranged from 0.02 mg to 29.17 mg/cm²/day (Coffey Natural Systems 2009). The results of calcium carbonate determination were highly variable but indicated that as much as 60 to 80% of material was likely of marine origin at sites located at Vari Vari Island (located west of Redscar Head) and elsewhere in Caution Bay. In samples taken close to the eastern coastline of Caution Bay, the proportion of calcium carbonate was low indicating sedimentation of terrestrial origin. Sampling was mostly undertaken in the wet season and lower rates would be expected in the dry season. El Niño conditions that occur every few years reduce precipitation, also subsequently reduce sediment discharge to the Gulf of Papua. La Niña conditions result in increased precipitation and sediment discharge (Rodbell et al. 1999; Kawahata and Gupta 2004; Martin et al. 2008).

Detailed results are available in the PNG LNG Project Nearshore Marine Baseline and Impact Assessment (Coffey Natural Systems 2008; Coffey Natural Systems 2009). Video footage obtained during marine ecology transects in 2022 did not show significant evidence of accumulation of sediment on the reef and it is possible that the material collected in the tubes during the sampling for the PNG LNG Project was not indicative of what was permanently settling on the reefs.



- Tidal and wind driven current
- PNG LNG pipeline
- Proposed Papua LNG pipelines route
- Proposed Papua LNG pipelines route alternate
- Existing and proposed plant layout
- Cultural heritage restricted area
- PPFL2 boundary
- APPFL boundary
- Current navigational channel
- Proposed navigational channel
- Proposed CALM buoy components
- Naphtha and condensate pipelines
- Naphtha and condensate pipelines alternate



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 PROJECTION: **WGS 1984 UTM Zone 55S**

FIGURE 4.3
Tidal and wind driven currents



5. EXISTING BIOLOGICAL ENVIRONMENT – INTERTIDAL

This chapter characterises the habitats present in the intertidal zone of the nearshore marine environment within the study area.

Approximately 394 ha of intertidal habitat adjacent to the PNG LNG Plant facility was investigated during the 2019 survey for the Project. Approximately 65% of the mapped area was found to be mangrove habitat, with mudflats and saltpans comprising 33%.

Approximately 167 ha of estuarine habitat (mangroves, salt marshes and salt flats) within the leased area of the PNG LNG Plant was investigated during the 2022 and 2023 surveys for the Project.

The results of the 2019, 2022 and 2023 surveys are summarised below and compared to previous surveys e.g., those associated with the PNG LNG Project, where relevant. Appendix C and Appendix D present the complete mangrove survey reports.

5.1 MANGROVES

Over 30 species of mangrove are found in Papua New Guinea, with an estimated 592,900 ha of mangroves distributed along the coastline. The complex structure of the mangrove root system is important for many ecological processes. Mangrove roots provide natural barriers and facilitate sediment retention, with various studies showing that mangrove removal can increase the likelihood of erosion, allowing greater volumes of tidal waters to persist further up a mangrove stand to areas where mangrove species with low tolerances to frequent tidal inundation occurs. This can change the mangrove community structure over time. Mangroves provide nursery habitat for many juvenile fish species and marine invertebrates, and act as buffers of sedimentation and strong weather, and as a natural nutrient filtration system. Variations in mangrove community features such as biodiversity and distribution occur as a result of several factors; one such factor is the influence of tidal exposure and inundation within the intertidal environment (Faunce and Serafy 2006; Joyce 2005; Pajmians and Rollet 1976; Raga 2006; Robertson et al. 1991; Shearman, 2010).

Surveys of mangrove communities within the lease area of the PNG LNG Plant have been undertaken in 2011, 2014, 2019, 2022 and 2023. Findings of the 2019, 2022 and 2023 surveys are discussed in this section and compared with earlier data where relevant.

5.1.1 Mangrove species and communities

5.1.1.1 Historical information and PNG LNG Project studies

A study of the mangroves of Galley Reach (Pajmians and Rollet, 1976), located approximately 15 km north of Caution Bay, indicated that the area is surrounded by approximately 14,000 ha of mangrove vegetation. Four main types of mangrove habitat were mapped from aerial photographs and their species composition and ecology described and discussed from ground observations. The main mangrove species were observed to grow in zones associated with tidal inundation and water depth, similar to those described from Malaysia and Australia. Regeneration was sparse under a closed forest canopy, but usually prolific in gaps. For the dominant forest type, Rhizophoraceae (mainly comprising *Bruguiera gymnorhiza*), the average basal area from seven 10 x 50 m sample plots was 30 m²/ha.

The PNG LNG Project EIS indicated that the mangrove community structure of Caution Bay was very simple and dominated by the red mangrove (*Rhizophora stylosa*). This species represented more than 90% of all mangrove individuals present in the area, extending from the seaward margin to the start of the mud flats; approximately 300 to 900 m. Trees were typically 4 to 5 m with a maximum height of approximately 10 m. Patches of smaller grey mangrove (*Avicennia marina*) were observed high in the intertidal zone (on the

landward margin). Both the areas of *Rhizophora stylosa* and *Avicennia marina* were visible from aerial imagery. Apart from these two species, only a few individuals of other species were observed, including the club mangrove (*Aegialitis annulata*) and yellow / Indian mangrove (*Ceriops spp*⁹). These species are distributed across other nearby locations such as Indonesia.

Dieback of mangroves in the vicinity of the LNG Plant has been observed over time during the various surveys that have been conducted for the PNG LNG Project. In addition to surveys conducted by Vision Environment, surveys have recently been conducted for the Papua LNG Project - Upstream that also noted the presence of mangrove dieback in aerial imagery records from 2003 to 2006. Initial analysis has indicated that the resolution of this imagery is relatively poor. This makes discerning the locations and extent of dieback with a high degree of confidence difficult, particularly compared with the surveys conducted for the PNG LNG Project and the Project. The causes of the earlier dieback are unknown.

5.1.1.2 2019 Caution Bay mangrove survey

Mangrove communities observed adjacent to the LNG Plant site in 2019 were dominated by *Rhizophora/Bruguiera* forest, with a smaller proportion of grey mangrove (*Avicennia marina*) dominated forest and yellow mangrove (*Ceriops spp.*) shrubland. The most encountered species, particularly at the seaward edge, were the red stilted mangrove (*Rhizophora stylosa*) and the orange mangrove (*Bruguiera gymnorhiza*). The grey mangrove was typically observed towards the mid and back of the stand, and often occurred as emergent. The yellow mangrove was commonly recorded at the landward edge of the mangrove stand with the occasional observation of other mangrove species in the wider area. Saltmarsh species were also encountered including saltbush (*Enchylaena sp.*), bead weed (*Sarcocornia sp.*) and saltcouch (*Sporobolus sp.*).

The composition of mangrove communities was similar to that recorded in surveys undertaken in 2011 and 2014. The mangrove communities were stable with no significant temporal variation in mangrove parameters observed.

5.1.1.3 2022 Caution Bay mangrove survey

The 2022 survey focussed on three previously established transects (T8, T9, and T15) and four new transects (TA, TB, TC, and TD). Mangrove biodiversity parameters were re-assessed and included species richness, adult and seedling densities, live basal areas, canopy cover and crab hole counts.

The four prevalent types of mangrove vegetation consisted of:

- *Rhizophora/Bruguiera* forest communities (seaward extent).
- Grey mangrove dominated communities and growing among other species.
- Yellow mangrove dominated shrub communities (landward extent).
- Mangrove dieback areas, largely in localised areas related to PNG LNG Project construction and operations activities.

A total of 817 mangrove plants were recorded within the seven transects. The three most common mangrove species in order of abundance were the yellow mangrove, the grey mangrove and the red stilted mangrove.

⁹*Ceriops australis* (yellow mangrove) is a member of the Rhizophoraceae family. It is found throughout the Indo-Pacific region and distributed across northern Australia, extending south to the Tweed River on the east coast and to Broome in Western Australia. Due to similarity of appearance and because they are often found growing together, it is often confused or described interchangeably with the more widely distributed *Ceriops tagal* (Indian mangrove). Both species are listed as Least Concern on the IUCN Red List.

Other species were noted during the survey including the myrtle mangrove (*Osbornia octodonta*), milky mangrove (*Excoecaria agallocha*), river mangrove (*Aegiceras corniculatum*) and the cannonball mangrove (*Xylocarpus granatum*). Saltmarsh species encountered during the 2019 survey were also observed in 2022.

The composition of mangrove communities was similar to that recorded in previous surveys. The mangrove communities were stable with no significant temporal variation in mangrove parameters observed, though dieback adjacent to the new water quality sites seemed to be more recent.

5.1.2 Spatial variation

5.1.2.1 2019 survey

Notable spatial variation in mangrove parameters was evident only for seedling density, with Area 2 (see Figure 3.4) consistently exhibiting higher seedling numbers during each of the three surveys.

Mapping of the intertidal zone adjacent to the LNG Plant using Geoeye images from 2018 and ESRI® ArcGIS Pro™ 2019 GIS software showed a loss of approximately 9.3% of mangroves during the construction phase of the PNG LNG Project (2010 to 2013), largely resulting from pipeline right of way and associated ground clearance activities.

Change analysis conducted in 2019 along three transects (T8, T9, and T15) showed areas of mangrove dieback or loss and mangrove forest gain (Vision Environment 2019, Appendix C).

An increase in mangrove area in the landward zones was then recorded between 2013 and 2018, resulting in a lesser overall loss of 4.3% of mangrove vegetation between 2010 and 2018.

5.1.2.2 2022 survey

The variation in mangrove species richness across the transects was not statistically significant ($P > 0.05$). Average species per quadrat ranged from 1.3 species in Transect TC to 2.7 species in Transect TB.

Considerable spatial variation between the transects was not observed for adult plant density due to the amount of variation within each transect and quadrat. The average adult density ranged from 8 adults per quadrat in Transect TB to 24 adults per quadrat in Transect T15. Seedling density was also comparable across the transects, varying from 6 to 18.6 seedlings per quadrat.

In areas where statistical analysis was performed, no significant temporal or spatial variation in mangrove parameters between 2019 and 2022, nor across transects, was found. Notable spatial variation was not apparent for live or dead adults across the transects. This indicated that mangrove dieback had occurred prior to 2019, that recovery was not yet evident, and that the stressor remained.

Canopy cover did not change substantially across the transects and ranged between 42% at Transect TC and 72% at Transect T15 (Appendix C).

5.1.3 Mangrove health and disturbance

5.1.3.1 2019 survey

Vision Environment (Appendix C and Appendix D) noted that potential causes of the mangrove dieback observed from 2013 to 2018 may potentially be due to altered water flow resulting in sediment erosion or deposition, sea level rise, or changes in water or sediment quality potentially increasing the availability of nutrients or contaminants.

Some localised mangrove dieback was observed during the 2019 survey, which was not noted in previous surveys conducted by Vision Environment between 2011 and prior to 2019, particularly in areas 3 and 6

(adjacent to the LNG Plant), and near transects T8, T14 and T15 (see Figure 3.4). Some leaf defoliation and discolouration was observed in areas 2, 3, 4 and 6. Water pooling was typically recorded where the dieback occurred, suggesting that continual saturation of the sediment may have resulted in root rot and eventual plant death, particularly of *Ceriops* spp., in these locations.

The prior clearing of mangroves for the LNG Plant jetty and pipeline landfall was also identified as having potentially resulted in changes in water flow/tidal regime in mangrove habitats located on the landward side, possibly causing erosion and localised pooling and ponding, and subsequent dieback. However, the causal link was unclear, with further investigation required (see Appendix C). A change in water flow regimes may also have been responsible for the recolonisation of *A. marina* and *C. tagal* between 2013 to 2018, although this was not verified.

Evidence of prior and recent harvesting was also observed in some of the 2019 survey transects, with cut stumps present.

5.1.3.2 2022 survey

The targeted surveys conducted in 2022 focussing on areas of mangrove dieback indicated that dieback was present in all seven transects (an expected outcome given the spatial focus of the survey), and most pronounced towards the landward edge of the mangroves in low-lying areas. Dieback was observed to primarily affect *Ceriops* spp. mangroves, followed by *Avicennia marina*. Slight to moderate leaf defoliation and/or discoloration was also documented. Of the mangrove plants recorded, 74% were live and dead adults and 26% were seedlings. For the survey transects toward the back of the stand, within the dieback areas, approximately half of the adult mangroves encountered were found to be dead. Overall, *Ceriops* spp. were the most common mangrove taxa encountered across the transects (live 47%, dead 37%), followed by *Avicennia marina* (live 13%, dead < 1%), and *Rhizophora stylosa* (live 2%, dead < 1%). Mangrove communities within transects T8, T9 and T15 were not considered to have worsened since 2019.

As with 2019, dieback encountered in mangrove areas adjacent to the LNG Plant jetty and pipeline area was noted as potentially being caused by changes in tidal flow (Appendix D).

Elsewhere dieback was observed, including downstream of the retention pond and mixing pit, up to 100 mm of elevation difference was observed between dieback areas and adjacent healthy mangrove areas hosting the same mangrove species. Moderately stagnant pools and ponding of water were observed around the dieback areas with sediment sinking also observed. Water quality results from ponded areas adjacent to the dieback areas suggested the intrusion of freshwater in some areas, indicating possible freshwater intrusion via groundwater or surface water. In some areas, constant downstream water flow was also observed, even during tidal flooding, suggesting the water most likely came from mixing/retention pond discharges. As with 2019, the survey findings indicated that mangrove dieback in these areas was likely a result of pooling water exacerbated by the retention pond mixing pit discharge in low lying sediment areas, leading to root rot and eventual plant death, particularly of *Ceriops* spp. Although indicative, the relationships between elevation, hydrology, and other potential causal mechanisms were not definitive and additional investigations were recommended.

Vision Environment again noted that other possible causes of mangrove dieback observed elsewhere may include altered water flow resulting from sediment erosion or deposition, sea level rise or fall, or changes in water or sediment quality potentially increasing the availability of contaminants. While various natural causes can facilitate or exacerbate dieback, the dieback observed in 2022 was unlikely to be related to the large El Niño dieback events observed in northern Australia between 2015 and 2019 (Appendix D).

5.1.3.3 2023 surveys

Both releases of water tracer in 2023 were tracked directly into two different dieback regions (see Appendix D, Figures 25 and 26), providing further indication that continual water discharge from the mixing pond is

potentially resulting in mangrove dieback and impacting mangrove habitats downstream. Vision Environment noted that the altered hydrological regime has, over time, resulted in a decreased biomass and abundance of *Ceriops* sp., and an increase in the biomass and abundance of *Avicennia marina*.

No leaf disease or fungus, or herbivorous attack of the mangroves adjacent to the dieback areas were observed, and as such it was deemed unlikely by Vision Environment that these factors are the primary cause of mangrove dieback. While not tested during the 2023 survey, Vision Environment also noted that water and sediment chemistry and/or contamination was, based on previous contaminant investigations (raw data provided by the Project), likely not the cause of the mangrove dieback. The presence of mangrove dieback would be more consistent and extensive if contamination was the primary cause, as opposed to the current patchy distribution.

The initial findings of mangrove mapping surveys conducted for the Upstream component of the Papua LNG Project indicated the presence of approximately 1.7 ha of dieback located between and along the Option 15F and Option 15A pipeline alignments. The dieback was observed north of Option 15A towards the PNG LNG jetty and south of Option 15F beyond the Vaihua River. Dieback was observed to be concentrated mainly within shrub *Ceriops* forest, in the fringing saltmarsh and salt flat habitats along the upper high tide zone. Between the first 260 to 300 m along the Option 15F survey line, 25 dead *Ceriops tagal* trees were recorded, with trees measuring 0.8 to 2 m in height noted to be most impacted.

Dieback of *Lumnitzera racemosa* was also observed to a lesser extent on the landward/salt flat margin of the mangrove community, and of *Avicennia marina*, found amongst *Ceriops tagal* forest. Partial dieback was observed in *Rhizophora* tree branches and *Ceriops tagal* in the habitat transition area from the landward mangroves to the seaward mangroves.

Insect infestation was also observed to be affecting six flora species. Nearly all affected trees were observed to have bored holes and defoliation, commencing from the crown of the trees and eventually resulting in tree mortality. The most severe impacts were present on *Ceriops australis*. The insect infestations were deemed to most likely be a secondary impact, given the observations of pre-existing physiological stressors, particularly in the case of *Ceriops tagal* / *Ceriops australis*. Ongoing investigations continue regarding mangrove dieback.

5.1.4 Crab hole analysis

5.1.4.1 2019 survey

Crab hole densities were reported to be higher in 2019 compared to observations in 2011 and 2014. The fluctuation in the densities of crabholes was consistent across all areas, indicating natural influences as opposed to localised or anthropogenic effects.

Crab species observed included the lemon-yellow clawed fiddler crab (*Uca perplexa*), marsh crab (*Sesarma sp.*), mud crab (*Scylla serrata*), orange clawed fiddler crab (*Uca coarctata*), shore crab (*Hemigrapsus sp.*) and tuxedo crab (*Australopax tridentata*). The above-mentioned species are also commonly found in tropical north Australia.

5.1.4.2 2022 survey

Significant ($P > 0.05$) temporal differences in crab hole densities were not observed in 2022. The highest densities were observed in a newly established transect (TB) and a previously established transect (T15). Crab hole densities remained comparable across the transects (13 to 17 holes per 0.25 m²).

The same crab species observed during the 2019 survey were observed during the 2022 survey.

5.1.5 Macroinvertebrates

5.1.5.1 2019 survey

Macroinvertebrates found in the intertidal muds were sampled during mangrove habitat sampling in the intertidal zone in the LNG Plant in 2019.

A total of 22 macroinvertebrates were identified from nine taxa including crustaceans, molluscs, chordates, and annelids. The fiddler crab (*Uca* sp.) was the most common taxa across all transects, followed by the gastropods *Alvania* sp. and *Cerithidae*.

Of the 15 samples, seven samples held no organisms, a common occurrence in mangrove habitats, particularly when compared to adjacent intertidal areas. Macroinvertebrate abundance, species richness and diversity varied across the mangrove habitat. The low number of organisms per sample indicates that a more intensive sampling effort would be required to characterise the relevant macroinvertebrate communities and enable statistical analysis.

5.1.5.2 2022 survey

No further investigation for macroinvertebrates was undertaken in 2022 monitoring.

5.1.6 Water quality

5.1.6.1 2019 survey

During the mangrove survey, sampling of pore water was undertaken at 15 locations within the intertidal zone adjacent to the LNG Plant (see Figure 3.4). Sampling sought to characterise baseline conditions and collect data for context in comparing potential future changes observed in the mangrove community. The results were below the exceedance criteria at all locations with the exception of cobalt. The ANZG (2018) marine trigger value for 95% species protection of 1.0 µg/L for cobalt was exceeded at three sites, as follows:

- 1.8 µg/L at T3B (Area 4, near the southern extent of the study area).
- 1.1 µg/L at T8 (Area 3, near the landfall of the Papua LNG pipelines route options).
- 1.3 µg/L at T12 (Area 5, near the northern extent of the study area).

The results of pore water sampling, including laboratory analytical reports (provided in Appendix E), were provided to the mangrove study specialist to determine whether patterns were apparent between mangrove observations and pore water quality. No trends were apparent across the survey sites.

5.1.6.2 2022 survey

Water quality samples were collected during the 2022 survey from 25 sites where localised pooling and ponding was observed and from the adjacent discharge points. Vision Environment (Appendix C) concluded that the water quality results were generally similar to those typically encountered within tropical mangrove ecosystems (refer to Appendix C Figures 14 to 16, Table A2, and Figures A1 to A3). The water quality results did indicate the intrusion of freshwater in some areas, with fresh to brackish water (salinity 1.3 ppt) recorded in a creek parallel to the LNG Plant, most likely from storm water runoff. Close to mangrove dieback areas, brackish water was also observed (salinity of 12.7 ppt), suggesting freshwater intrusion from the LNG Plant or groundwater sources. Most of the water quality sites in the areas of dieback otherwise displayed comparable salinity ranges (approximately 50 to 60 ppt) to the retention and mixing pond discharge. Vision Environment stated that the recorded levels of salinity were within “typical ranges of mangrove habitat”.

6. EXISTING BIOLOGICAL ENVIRONMENT – MARINE

The results of the 2019 and 2022 marine surveys are presented in this chapter. Where appropriate, results of the 2019 survey are compared with previous monitoring results, including data obtained during surveys undertaken in December 2007 and April 2008 for the PNG LNG Project EIS, February 2010 and January 2011 for the PNG LNG Project (pre-construction), February/March 2012 (at-completion) and in April 2014 (post-construction). The locations of the video transects for the 2019 and 2022 marine ecology surveys, along with those from earlier surveys, are shown in Figure 6.1 to Figure 6.10.

6.1 CAUTION BAY GENERAL MARINE HABITAT CHARACTERISTICS

Caution Bay is situated at the intersection of two oceanic ecoregions¹⁰; with most of the bay primarily located within the Gulf of Papua ecoregion. Green et al. (2014) note that the Gulf of Papua is a large, shallow shelf area heavily influenced by runoff from the Fly River and other major river systems and is characterised by large, complex mangrove systems and silty water. While Caution Bay is located on the eastern edge of the Gulf of Papua, it is characterised by mangrove ecosystems. The Gulf of Papua ecoregion is also located north of the Coral Sea and the Great Barrier Reef far north and Torres Strait ecoregions (Veron et al. 2016). Green et al. (2014) also note that coastal reefs and systems along the southeast PNG coast are primarily affected by oceanic influences from the northern Coral Sea, including the Coral Sea Gyre and Hiri Current. This area also has coastal influences, but it is distinct from the heavily river-influenced Gulf of Papua.

The south-eastern portion of Caution Bay is intersected by the westmost boundary of the Milne Bay oceanic ecoregion (as defined by Veron et al. 2016). This boundary also approximates the boundary of the Solomon Sea Coral Triangle ecoregion (Green and Mous 2008) and the boundary between the Gulf of Papua and Southeast Papua New Guinean ecoregions as delineated by Spalding et al. (2007). While Milne Bay shares similar biophysical characteristics to those found in the Solomon Sea, Solomon Archipelago and Bismarck Sea ecoregions, the Gulf of Papua has different characteristics to those other ecoregions surrounding that are located within the Coral Triangle (Green and Mous, 2008).

While the delineation of seascape boundaries is relatively coarse, the interconnected seascapes and prevailing ocean current regimes also demonstrate that faunal connectivity exists within and between the Gulf of Papua and Milne Bay coral ecoregions, as well as the broader linkages present between the south-east coast Papua New Guinean bioregion, and larger Northern Coral Sea and Solomon Sea marine ecoregions more broadly (Green et al. 2014). Although the prevailing biophysical characteristics suggest that Caution Bay has reduced commonality in terms of biodiversity compared to locations elsewhere in Milne Bay, it is unlikely that isolation and reduced gene flow are dominant factors affecting most species assemblages in Caution Bay.

In the north of Caution Bay, narrow sandy beaches are present along much of the coastline and coral reefs are largely absent, likely due to the higher sediment load and greater turbidity caused by outflowing water and alluvial sediments in these sections of the bay. Beach sediments are medium to fine sands mixed in variable proportion with finely ground coral and shell. A shallow lagoon exists immediately adjacent to shore on the eastern side of Caution Bay, with an intertidal zone comprising mostly mudflat and mangrove habitat. The main occurrences of supra-tidal mudflats are behind the protective barrier complex of dunes and sand spits, and around the Vaihua River estuary. These surfaces are flat to very gently sloping. The Vaihua River estuary is located in the south-west corner of Caution Bay and represents the major landward incursion of mudflat landforms.

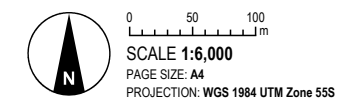
¹⁰ http://www.coralsoftheworld.org/coral_geographic/interactive_map/



LEGEND

- Existing jetty
- Marine survey transect (year)
 - 2010
 - 2011
 - 2012
 - 2014
 - 2019

SOURCE
 Survey transects from Tetra Tech Coffey.
 Infrastructure from EMPNGA.
 Imagery from EMPNGA and Planet Labs.



EXXONMOBIL PNG ANTELOPE LIMITED
 PAPUA LNG PROJECT – DOWNSTREAM

FIGURE 6.1

Marine survey transects – CF-01, CF-02,
 CF-03, CF-04 and CF-07 to CF-10





LEGEND

Marine survey transect (year)

- 2010
- 2011
- 2012
- 2014
- 2019

SOURCE

Survey transects from Tetra Tech Coffey.
Infrastructure from EMPNGA.
Imagery from EMPNGA and Planet Labs.



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EXXONMOBIL PNG ANTELOPE LIMITED

PAPUA LNG PROJECT – DOWNSTREAM

FIGURE 6.2

Marine survey transects – CF-11, CF-12, CF-13, CF-14, CF-15 and CF-16



TETRA TECH
COFFEY



LEGEND

Marine survey transect (year)

- 2010
- 2011
- 2012
- 2014
- 2019

SOURCE

Survey transects from Tetra Tech Coffey.
Infrastructure from EMPNGA.
Imagery from EMPNGA and Planet Labs.



0 50 100 m

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PAGE SIZE: A4

PROJECTION: WGS 1984 UTM Zone 55S

EXXONMOBIL PNG ANTELOPE LIMITED

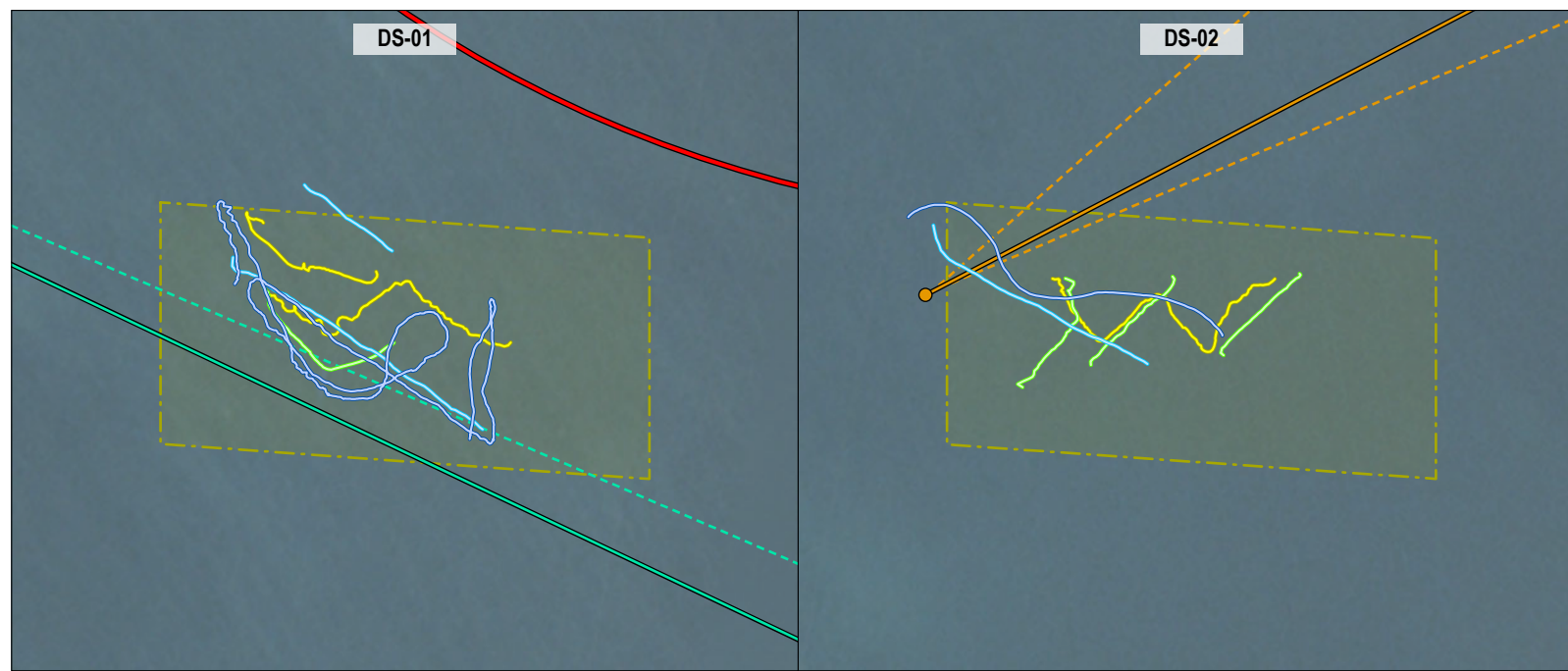
PAPUA LNG PROJECT – DOWNSTREAM

FIGURE 6.3

Marine survey transects – CF-17 and CF-18



TETRA TECH
COFFEY



LEGEND

-  PNG LNG pipeline
 Proposed Papua LNG pipelines route
 Proposed Papua LNG pipelines route alternate
 Previous dredge spoil disposal location
 Proposed CALM buoy components
 Naphtha and condensate pipelines
 Naphtha and condensate pipelines alternate
 Marine survey transect (year)
 2011
 2012
 2014
 2019

SOURCE

Survey transects from Tetra Tech Coffey.
Infrastructure and spoil location from EMPNGA.
Imagery from EMPNGA and Planet Labs.



A horizontal scale bar with markings at 0, 100, 200, and 300 meters. The unit 'm' is at the end of the bar.

SCALE 1:15,000

PAGE SIZE: A4

PROJECTION: WGS 1984 UTM Zone 55S

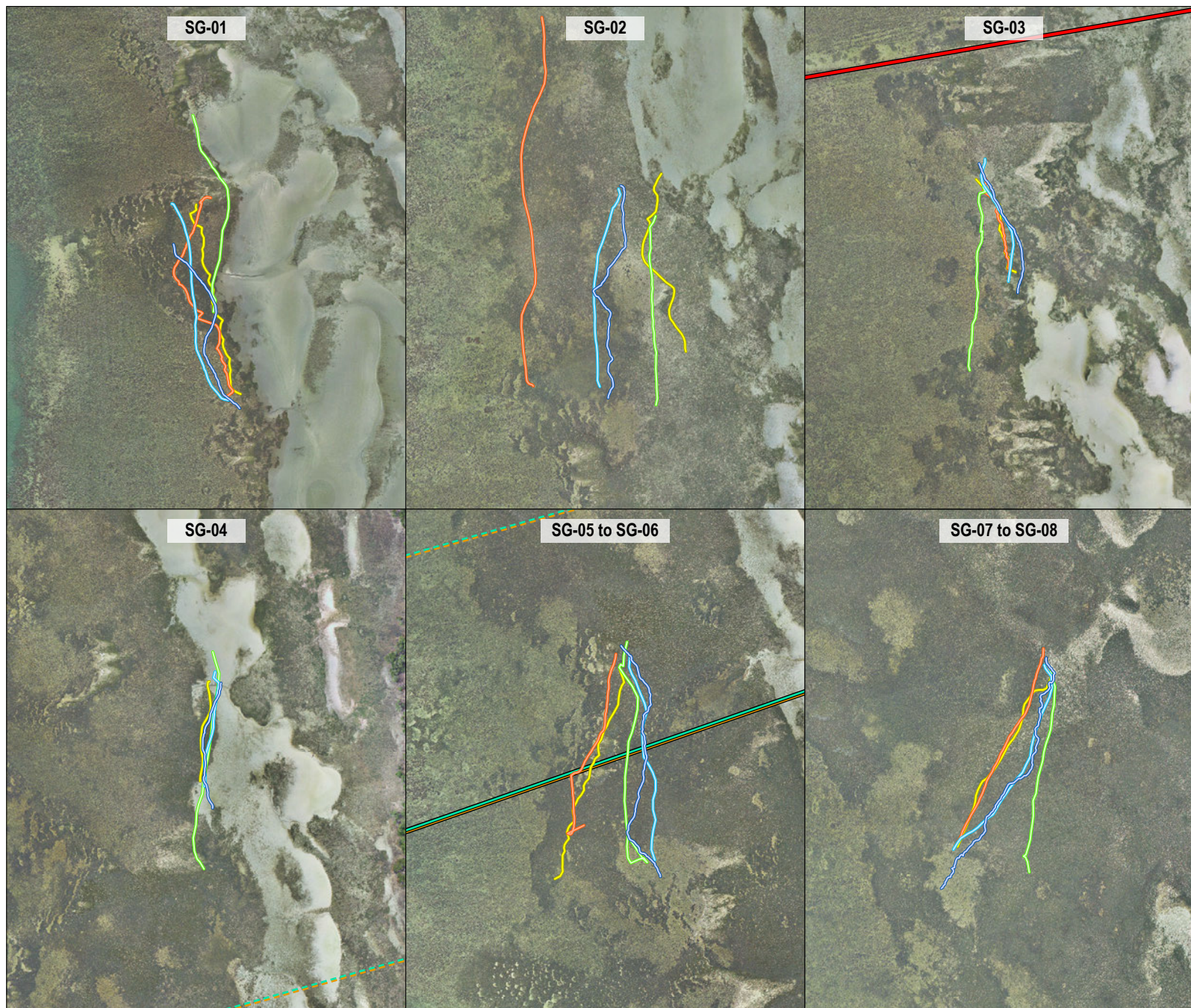
EXXONMOBIL PNG ANTELOPE LIMITED

PAPUA LNG PROJECT – DOWNSTREAM

FIGURE 6.4

Marine survey transects – DS-01 and DS-02



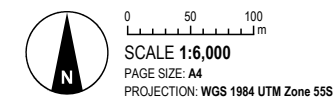


LEGEND

- PNG LNG pipeline
- Proposed Papua LNG pipelines route
- - - Proposed Papua LNG pipelines route alternate
- Proposed CALM buoy components
 - Naphtha and condensate pipelines
 - - - Naphtha and condensate pipelines alternate
- Marine survey transect (year)
 - 2010
 - 2011
 - 2012
 - 2014
 - 2019

SOURCE

Survey transects from Tetra Tech Coffey.
Infrastructure from EMPNGA.
Imagery from EMPNGA and Planet Labs.



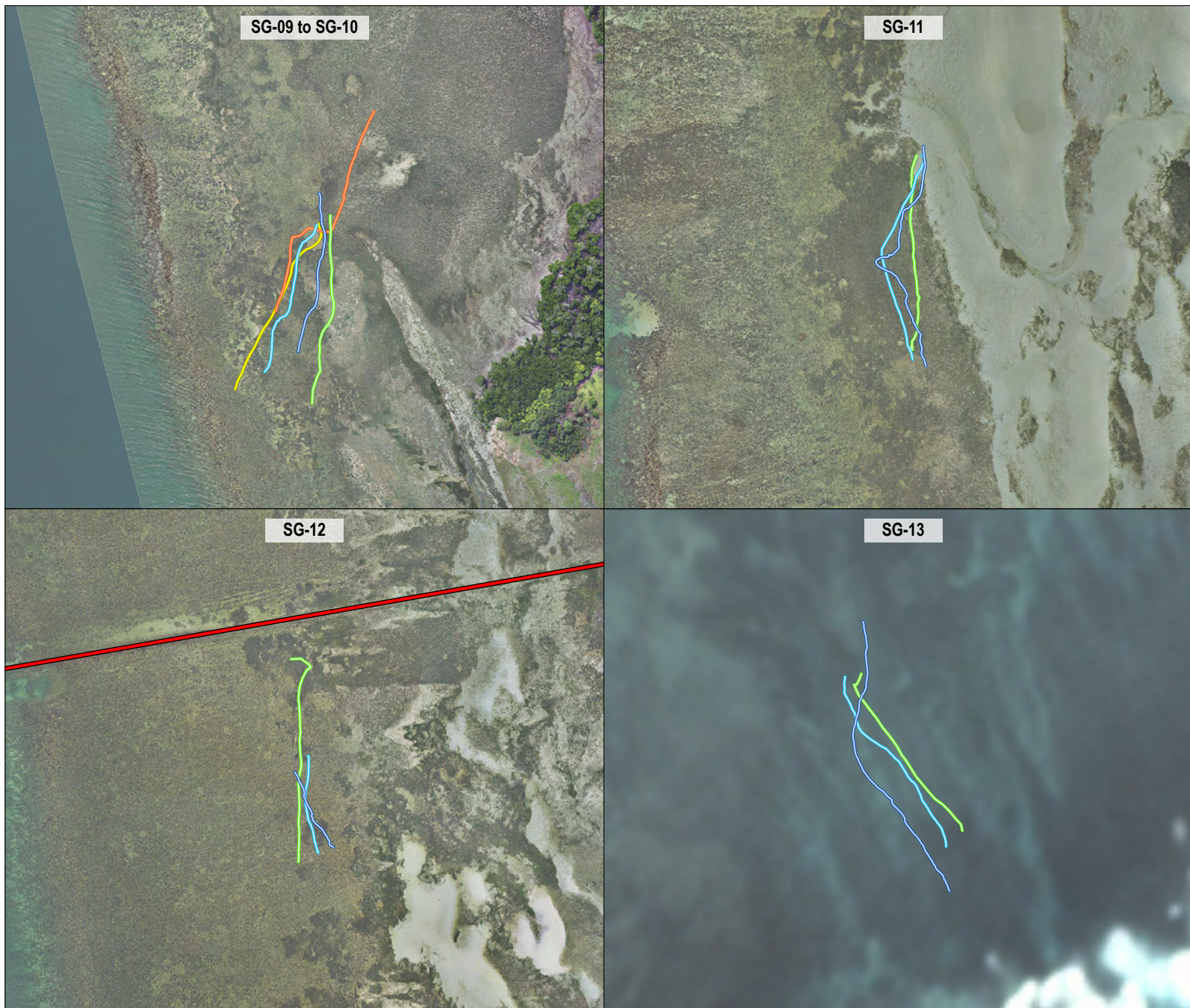
EXXONMOBIL PNG ANTELOPE LIMITED

PAPUA LNG PROJECT – DOWNSTREAM

FIGURE 6.5

Marine survey transects – SG-01, SG-02, SG-03, SG-04, SG-05, SG-06, SG-07 and SG-08





LEGEND

— PNG LNG pipeline

Marine survey transect (year)

— 2010

— 2011

— 2012

— 2014

— 2019

SOURCE

Survey transects from Tetra Tech Coffey.
Infrastructure from EMPNGA.

Imagery from EMPNGA and Planet Labs.



0 50 100
m

SCALE 1:6,000

PAGE SIZE: A4

PROJECTION: WGS 1984 UTM Zone 55S

EXXONMOBIL PNG ANTELOPE LIMITED

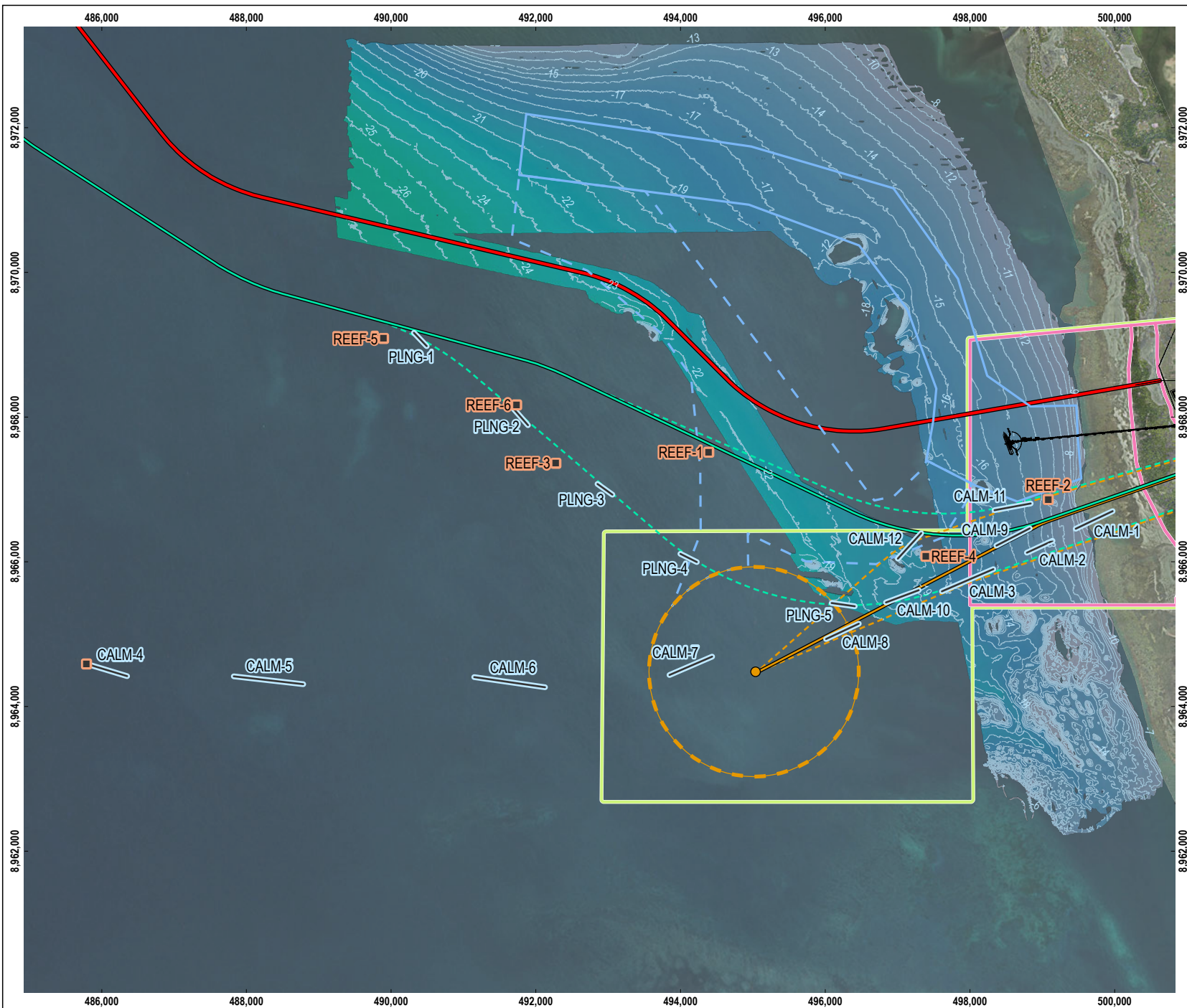
PAPUA LNG PROJECT – DOWNSTREAM

FIGURE 6.6

Marine survey transects – SG-09, SG-10,
SG-11, SG-12 and SG-13



TETRA TECH
COFFEY



LEGEND

- PNG LNG pipeline
- Proposed Papua LNG pipelines route
- - - Proposed Papua LNG pipelines route alternate
- Existing and proposed plant layout
- Bathymetry (1 m interval)
- PPFL2 boundary
- APPFL boundary
- Current navigational channel
- Proposed navigational channel
- Proposed CALM buoy components
 - CALM buoy
 - Naphtha and condensate pipelines
 - - - Naphtha and condensate pipelines alternate
 - CALM buoy navigational area
- Marine survey transect (2022)
 - Patch reef
 - Pipeline

SOURCE
 Survey transects from Tetra Tech Coffey.
 Infrastructure, bathymetry and lease boundary from EMPNGA.
 Imagery from EMPNGA and Planet Labs.



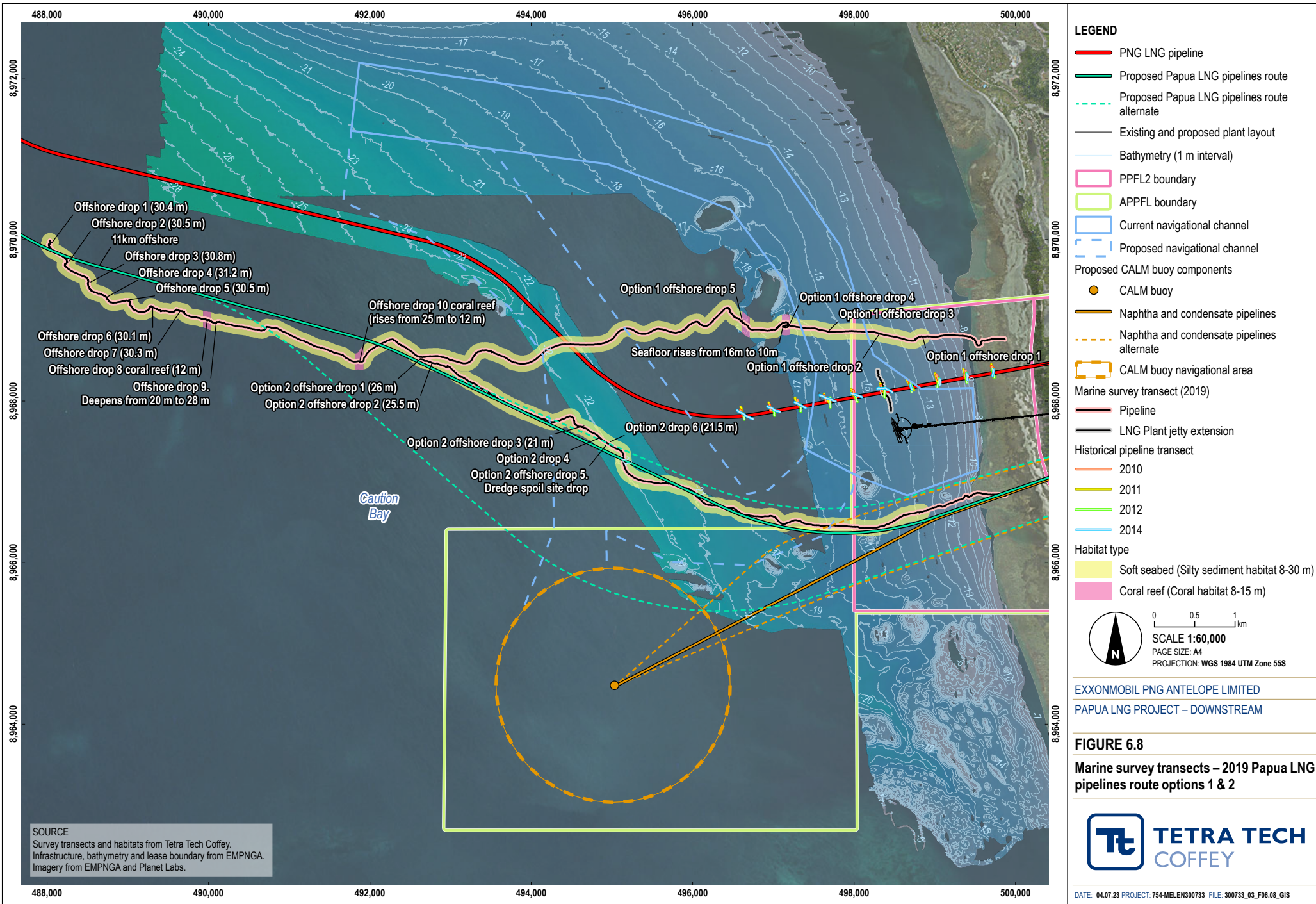
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SCALE 1:75,000
 PAGE SIZE: A4
 PROJECTION: WGS 1984 UTM Zone 55S

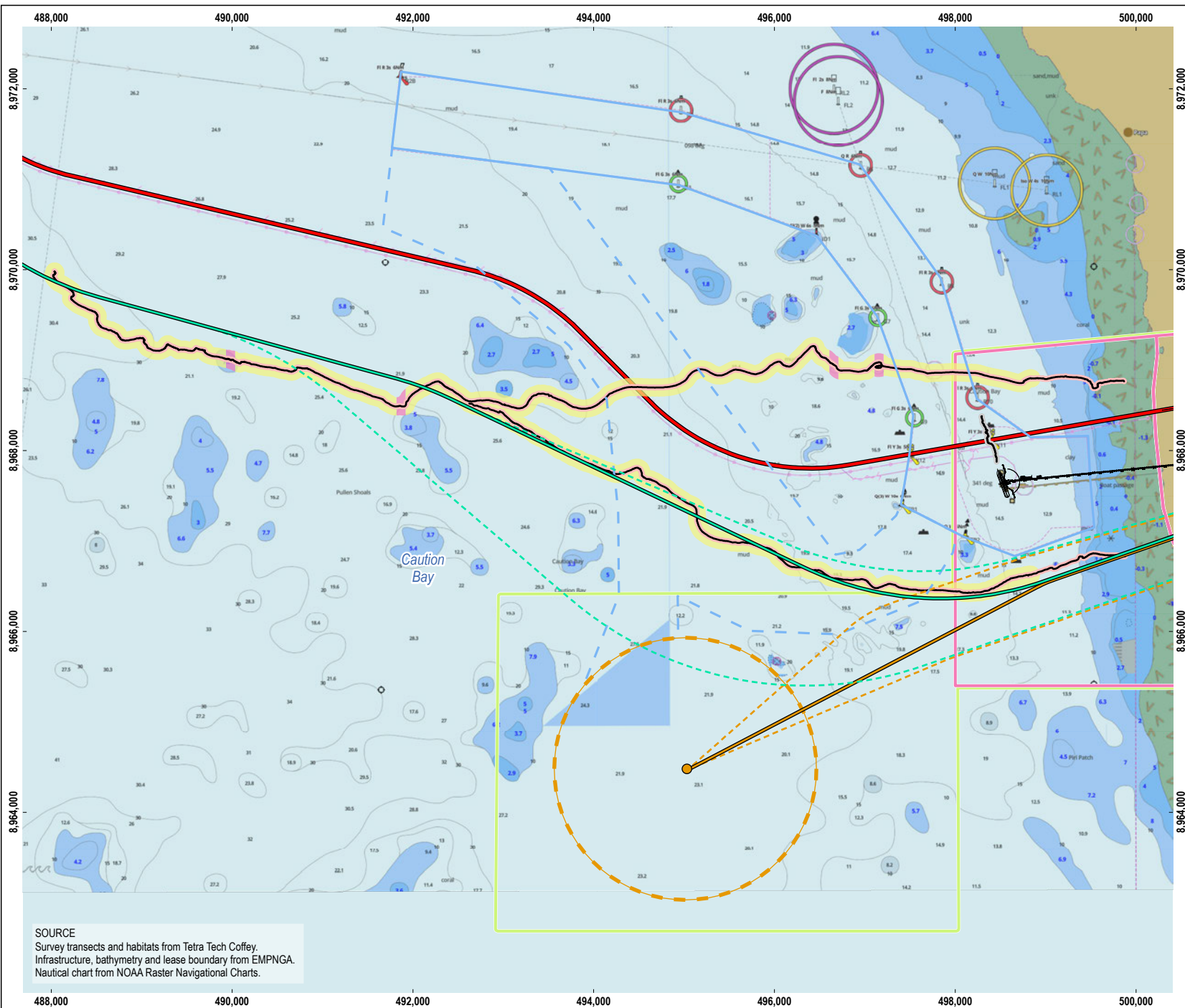
EXXONMOBIL PNG ANTELOPE LIMITED
PAPUA LNG PROJECT – DOWNSTREAM

FIGURE 6.7

Marine survey transects – 2022 Papua LNG pipelines route options







SOURCE
Survey transects and habitats from Tetra Tech Coffey.
Infrastructure, bathymetry and lease boundary from EMPNGA.
Nautical chart from NOAA Raster Navigational Charts.

LEGEND

- PNG LNG pipeline
- Proposed Papua LNG pipelines route
- Proposed Papua LNG pipelines route alternate
- Existing and proposed plant layout
- PPFL2 boundary
- APPFL boundary
- Current navigational channel
- Proposed navigational channel
- Proposed CALM buoy components
 - CALM buoy
- Naphtha and condensate pipelines
- Naphtha and condensate pipelines alternate
- CALM buoy navigational area
- Marine survey transect (2019)
 - Pipeline
 - LNG Plant jetty extension
- Habitat type
 - Soft seabed (Silty sediment habitat 8-30 m)
 - Coral reef (Coral habitat 8-15 m)



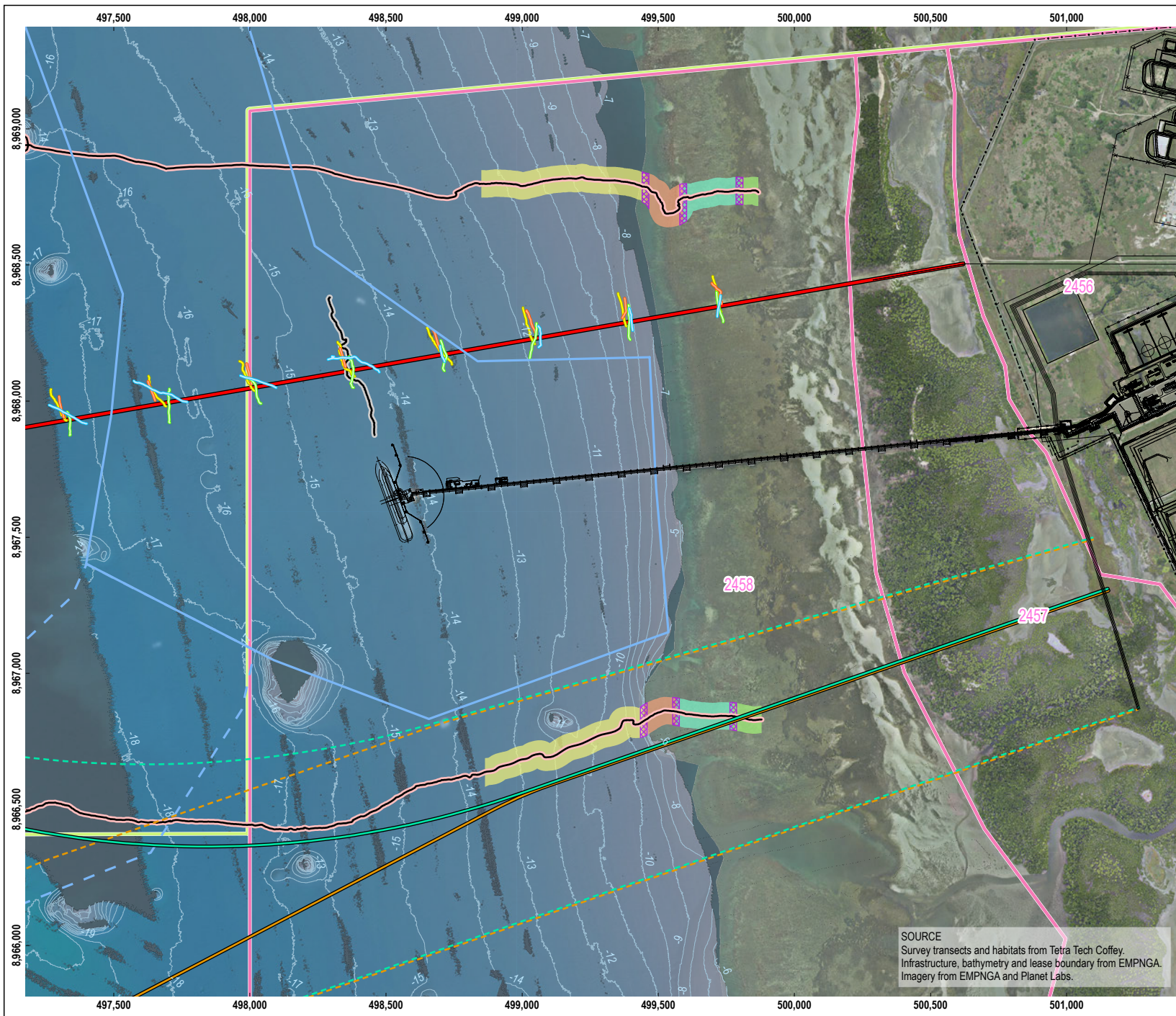
0 0.5 1 km
SCALE 1:60,000
PAGE SIZE: A4
PROJECTION: WGS 1984 UTM Zone 55S

EXXONMOBIL PNG ANTELOPE LIMITED
PAPUA LNG PROJECT – DOWNSTREAM

FIGURE 6.9

2019 marine survey transect and habitat types





LEGEND

- PNG LNG pipeline
- Proposed Papua LNG pipelines route
- Proposed Papua LNG pipelines route alternate
- Existing and proposed plant layout
- Bathymetry (1 m interval)
- PPFL2 boundary
- APPFL boundary
- Current navigational channel
- Proposed navigational channel
- Proposed CALM buoy components
- Naphtha and condensate pipelines
- Naphtha and condensate pipelines alternate
- Marine survey transect (2019)
 - Pipeline
 - LNG Plant jetty extension
- Historical pipeline transect
 - 2010
 - 2011
 - 2012
 - 2014
- Habitat type
 - Habitat transition zone
 - Mixed substrate macroalgae zone (Sand/coral/rubble/seagrass 1 m)
 - Mixed substrate macroalgae zone (Sand/coral/rubble/macroalgae 1-3 m)
 - Fringing reef (Coral habitat 4-8 m)
 - Soft seabed (Silty sediment habitat 8-13 m)



0 500 m
 SCALE 1:20,000
 PAGE SIZE: A4
 PROJECTION: WGS 1984 UTM Zone 55S

EXXONMOBIL PNG ANTELOPE LIMITED
 PAPUA LNG PROJECT – DOWNSTREAM

FIGURE 6.10

Marine survey transects – 2019 Papua LNG pipelines route options 1 & 2 (inset)



The main subtidal habitat zones in Caution Bay are distributed across distinct substrates and habitat types (as also described in Richards et al. 2016) that run approximately parallel to the shoreline as a series of discontinuous bands. From the shore outwards, these are:

- Submerged sand patches.
- Seagrass meadows.
- A *Sargassum* (brown macroalgae) community.
- A fringing reef, situated less than 1 km offshore.
- Silty soft sediments and muds.
- Patch reefs

Seabed in shallower water below 2 m depth (mean sea level) typically comprises soft and sandy sediments. The subtidal reaches of the lagoon mainly comprise patchy sand, coral rubble, and reef habitat.

Sand- and rubble-dominated seabed is colonised by seagrass beds in shallow waters, while in slightly deeper waters, areas of larger coral rubble and reef are colonised by macroalgae and live corals. The seabed in areas less than approximately 4 m in depth is characterised by the same general depth-related habitat zonation present elsewhere in Caution Bay. In shallow waters up to 1 m depth, sand and seagrass (mainly *Enhalus*, *Syringodium* and *Cymodocea* sp.) is predominantly present (Plate 6.1) before depth gradually increases and transitions to a zone of mixed substrate mainly comprising coral rubble, rock and sand habitat with macroalgae and scattered individual corals (Plate 6.2 and Plate 6.3).

Generally dense (with coverage between 80 and 100% in places) stands of *Sargassum* and *Padina* sp. (brown macroalgae) are the dominant macrophytes present between 1 m to 3 m water depth on coral rubble and reef, in the region of more pronounced evidence of wave action; with *Halimeda* and *Caulerpa* (green macroalgae) and encrusting coralline algae (red macroalgae) also present. Seagrass is also present in some places. Microphytobenthos (benthic microalgae) is evident on the sediment surface, generally being more conspicuous in shallower waters along the alignment (associated with greater light exposure), while the seabed habitat shows some limited evidence of bioturbation. This is likely due to the spread of rock and rubble on the seabed because of wave action across previously disturbed surfaces, restricting burrowing and sediment filtering activity compared to that which occurs in soft sediments.

The marine habitat then transitions toward a coastal fringing reef of variable continuity, comprising a band of living corals, rocky outcrops, and rubble in depths of 4 m to 8 m. Immediately before and beyond the intact fringing reef, larger sized coral rubble and occasional solitary corals are present but become less frequent with depth on the seaward side of the fringing reef. A layer of filamentous algae is observable on rock structures (Plate 6.4) that visibly decreases with depth. Shoals and outcrops of reef habitat of various sizes and complexity, are present further from shore at depths ranging from 10 m to 30 m. These reef features are present in areas surrounded by otherwise flat, low complexity seabed and appear to be disconnected from the fringing reef structure, with no clear trend as to their spatial distribution. Islands such as Vari Vari, to the north of Caution Bay and Idihi to the south-west, are also fringed by more extensive coral reefs and seagrass beds.

Beyond the coastal fringing reef, at depths greater than 8 m to 10 m, coarse sand substrate transitions into softer sediments with some organic detritus and shell fragments (Plate 6.5 and Plate 6.6). In still deeper waters the seabed largely comprises soft, sandy or silt substrates and infaunal activity is evident from surface disturbance (bioturbation). Mounds and burrows are typically abundant, indicative of a variety of burrowing benthic fauna and a thicker layer of unconsolidated sediments is present in the deeper extents. Very rarely, epibiota (sea whips) were observed and no attached vegetation was identified on the soft seabed. Few mobile benthic epibiota were observed in 2019, as reported previously. These subsea habitats, which follow a spatial pattern generally related to water depth and wave exposure, have been observed during previous surveys for the PNG LNG Project by Coffey Natural Systems (2008; 2009), and Coffey Environments (2010; 2011; 2012; and 2014a). The spatial distribution of most of the surveyed sites within Caution Bay represent habitats in

Plate 6.1
PNG LNG pipeline transect imagery 1.
Seagrass.



Photo credit: Tetra Tech Coffey

Plate 6.2
PNG LNG pipeline transect imagery 2.
Macroalgae, sand, rubble and vagabond
butterflyfish (*Chaetodon vagabundus*).



Photo credit: Tetra Tech Coffey

Plate 6.3
PNG LNG pipeline transect imagery 3.
Mixed substrate of rubble, sand and
rock with macroalgae.



Photo credit: Tetra Tech Coffey

Plate 6.4
PNG LNG pipeline transect imagery 4.
Mixed substrate, dead reef, rubble, layer of
sediment on macroalgae and coarse sands.



Photo credit: Tetra Tech Coffey

Plate 6.5
PNG LNG pipeline transect imagery 5.
Coarse sand, organic matter, bioturbation
mounds and sediment.



Photo credit: Tetra Tech Coffey

Plate 6.6
PNG LNG pipeline transect imagery 6.
Soft seabed and sediment.



Photo credit: Tetra Tech Coffey

areas either within or outside potential Project impacts, with several sites located in shallow waters (typically less than 10 m water depth and occasionally less than 2 m).

The above pattern was confirmed during the 2019 and 2022 surveys, with the data gathered from towed video transects in 2019 and 2022 also indicating that most sites were representative of the major subtidal habitat types present more broadly in Caution Bay, being distributed across:

- Soft sediment and sand seabed close to shore, with small amounts of terrestrial organic debris, solitary corals, coral rubble and shell fragments (usually closer to river mouths, where the establishment of larger reefs does not typically occur).
- Assemblages of varying proportionality of seagrass, macroalgae and patchy coral growth or coral rubble, typically in depths shallower than five metres, including locations adjacent to the LNG Plant jetty and the discharge point of treated wastewater from the LNG Plant retention pond.
- Coral reef habitat (including coastal fringing reefs and microscale reef features such as patch reefs and bommbora).
- Soft silty sediment seabed in deeper waters (typically flat and without three-dimensional features rising from the seabed, though with occasional isolated large coral bommbies, patch reefs and shoals interspersed). These habitats have similar features to those investigated and subsequently used for trenched spoil material disposal for the PNG LNG Project.

Of the main habitat zones listed above, there are transitional areas that blend the features of each habitat zone, forming a mixed mosaic where convoluted or perforated boundaries exist, prior to the discontinuities between the habitat types becoming more distinctive.

6.2 TRENCHING SPOIL PLACEMENT AREAS

While not required for the Downstream component of the Papua LNG Project (that is, the Project), two trench material placement sites (DS-01 and DS-02) were previously proposed for potential use in 2019, in the same locations selected for dredged material for the PNG LNG Project (Figure 6.4). These sites were formerly identified as offshore areas of flat seabed with uniform sediment and an absence of reef habitat or other unique habitat features, representative of most of the offshore area of Caution Bay. These sites were previously monitored from January 2011 to 2014 prior to and post-construction for the PNG LNG Project (Figure 6.4). The sites may be utilised for works associated with the Papua LNG Project – Upstream.

Video transects recorded between 2011 to 2014 within each trench material placement area were reviewed, alongside footage from a series of drop camera deployments and data from side scan and down scan sonar swathes, captured during the 2019 survey. Table 6.1 summaries the key seabed and ecological features observed at sites DS-01 and DS-02 during the 2011, 2012, 2014 and 2019 surveys. As previously identified, both these sites are located entirely on soft sediment.

A layer of turbid water just above the seabed has been observed during each survey and decreases the quality of video obtained, although the seabed was generally sufficiently distinguishable for comparative assessment. The 2019 video footage was able to identify bioturbation of the sediments by infauna, much the same as in 2011 and 2012, while visibility in 2014 only allowed confirmation that the seabed comprised fine sand, silt and mud. Sonar data recorded along the transects during the 2019 survey indicated that the seabed was low relief at DS-01, and low relief with some undulation at DS-02, and without any complex three-dimensional structure. Representative imagery of the seabed is shown in Plate 6.7 and Plate 6.8).

No substantial changes in the character of the seabed were observed during the 2019 survey compared with the findings of previous monitoring. No environmental sensitivities were identified.

Table 6.1 Trenching spoil monitoring and LNG Plant jetty extension site descriptions

Site	Depth (m)	Observations							
		2011		2012		2014		2019	
		Seabed	Biota	Seabed	Biota	Seabed	Biota	Seabed	Biota
DS-01	21 – 22	Soft seabed comprising grey mud. Occasional shell/rubble and organic matter.	Bioturbation visible in the form of burrows and mounds. No epifauna visible.	Soft seabed comprising grey mud. Occasional shell and organic matter.	Bioturbation visible in the form of burrows and mounds. No epifauna visible.	Soft seabed of sand/silt/mud.	No observations were possible due to poor visibility.	Soft seabed comprising grey mud.	Bioturbation visible in the form of burrows and mounds. No epifauna visible.
DS-02	22 – 23	Soft seabed comprising grey mud. Occasional shell/rubble and organic matter.	Bioturbation visible in the form of burrows and mounds. No epifauna visible.	Soft seabed comprising grey mud. Occasional shell and organic matter.	Bioturbation visible in the form of burrows and mounds. No epifauna visible.	Soft seabed of sand/silt/mud.	No observations were possible due to poor visibility.	Soft seabed comprising grey mud.	Bioturbation visible in the form of burrows and mounds. No epifauna visible.
Jetty extension		N/A	N/A	N/A	N/A	N/A	N/A	Soft seabed comprising grey mud and some unconsolidated rock, rubble, and coral fragments.	Bioturbation visible in the form of burrows and mounds. Epifauna comprising gorgonians and sea whips, isolated soft corals.



Plate 6.7
Trenching spoil site DS-01 soft seabed and
bioturbation



Plate 6.8
Trenching spoil site DS-02 soft seabed and
bioturbation

Overall, the characteristics of the seabed and associated ecosystem components at the two trench material placement areas remain similar to each other and to much of the seabed present in Caution Bay in waters deeper than about 10 m. This includes the depth-comparable locations of the currently and previously proposed (2019) Papua LNG pipelines route options and the existing PNG LNG pipeline.

6.3 LNG PLANT JETTY EXTENSION

The review of footage from the towed video transect conducted in 2019 for the previously proposed potential LNG Plant jetty extension footprint, showed that the seafloor substrate was of low relief, low structural complexity, and primarily comprised of soft sediments. Occasional areas of unconsolidated rock and rubble with moderate siltation/sedimentation were observed.

Epifauna was sparse though occasional patches of generally small to moderate sized, scattered gorgonian coral colonies (mainly *Junceela* and other unidentified species of sea whip) and isolated soft corals (likely *Cladiella* or *Sinularia* spp.) were present. While water clarity and visibility were low, bioturbation (small mounds and burrows) of the sediments by infauna was generally apparent. The seafloor habitat was broadly comparable to that observed at the trench spoil placement areas, and in the deeper sections of the existing PNG LNG pipeline route. Table 6.1 provides a summary of the key seabed and ecological features observed.

6.4 PNG LNG PIPELINE

The existing PNG LNG pipeline route through Caution Bay was surveyed in 2019 via one continuous video transect (approximately 1 km in length) recorded along the alignment and perpendicular to shore. Poor visibility encountered in deeper waters along the pipeline route meant that not all the prior monitoring sites were resurveyed. Review of the prior monitoring data indicates that these sites are absent of biotic diversity apart from some bioturbation (mounds and burrows), were without noteworthy or complex benthic habitats, and primarily comprise a soft silty and muddy seabed.

As with the 2014 survey, no visible rock ballast that could be readily distinguished from the surrounding coral rock and rubble, or sections of the pipeline above the surface of the seabed, were observed during the 2019 survey. The most recent evidence of pipeline installation (which occurred in 2011) was observed in 2012, where rock ballast and the pipeline were visible at site P-01 where the pipe traverses coastal fringing reef habitat about 500 m from shore. In this location in 2011, the seabed showed evidence of trenching and flattening, over a width of some 50 m in waters up to 3 m deep. Those general signs of disturbance (that were most visible in 2011) were difficult to distinguish in 2019.

The 2019 video remote imagery along the shallow extent of the pipeline showed bioturbation (mounds and burrows) and various macroalgae growth. Gradual natural sedimentation processes, the mixing of coral rubble (due to wave action) with the rock ballast, progressive biotic settlement of the pipeline and surrounding substrate recolonisation (via filamentous algal and larger macrophyte growth) appears to have occurred. No evidence of obvious widespread sediment accumulation (such as that resulting in smothering) was observed on coral, rubble, rock, or biotic surfaces.

As with previous surveys, visibility was very poor (usually less than 1 m) above the seabed in deeper waters beyond 8 m to 10 m along the pipeline route. This consistent finding across all surveys does not appear to be directly associated to construction activities. As also observed in earlier surveys, low visibility is a factor that limits the interpretation of some ecological characteristics.

Overall, the seabed and ecological characteristics for the areas that were re-examined surrounding the existing PNG LNG pipeline in 2019, remained consistent with the data collected during the pre-pipeline installation 2010 and 2011 surveys and the post-pipeline installation surveys in 2012 and 2014 in terms of the visible epifauna/flora and bioturbation. Some biotic recolonisation appears to have occurred in previously disturbed areas in the shallower waters where conditions suitable for macrophyte growth have persisted.

6.5 PAPUA LNG PIPELINES AND CALM BUOY

This section summarises the findings of the marine habitat surveys conducted in 2019 (along the 2019 Papua LNG pipelines route options; route options 1 and 2) and 2022 (along the 2022 Papua LNG route options 15C, 15A, 15F, and of existing and proposed marine facilities locations) and describes the main environmental features observed. The currently proposed Papua LNG pipelines and CALM buoy export pipelines are located south of the LNG Plant Jetty (see Figure 2.3).

The sonar data from both surveys indicated that most of the seabed in the deeper portions of the surveyed areas (beyond 10 m water depth) displayed high benthic homogeneity and low structural complexity or three-dimensionality above the seafloor (Plate 6.9), which was confirmed by drop camera deployments. Occasional exceptions to these observations were made in the form of discrete patch reefs and other generally limited (in terms of spatial extent) areas of hardstand rocky substrate where relatively well-established ecological communities (in terms of fauna) were recorded, and other discrete locations where various gorgonians colonising otherwise low-complexity, generally bare silty sediments tended to be the main corals.

6.5.1 Offshore alignment to junction point

The survey of the most seaward section of the proposed Papua LNG pipeline route options 1 and 2 commenced 11 km offshore at approximately 30 m depth and 4 km further to the west of where the divergence between the route options begins (junction point) at approximately 26 m water depth (Figure 6.7, Figure 6.8 and Figure 6.9). Water depth gradually increases from shore, reaching approximately 30 m at the 11 km mark. Two main types of benthic habitat were identified from video records along the survey areas investigated for the proposed pipelines route:

- Largely homogeneous, unvegetated soft and silty sediments without noteworthy three-dimensional structure aside from gentle undulations, and surface disturbances due to bioturbation
- Coral reef habitat.

Visibly, the unvegetated soft and silty seabed conditions present were the same as those observed beyond the coastal fringing reef along the deeper water sections of the existing PNG LNG pipeline route. This includes the same types of evidence of benthic infauna (mounds, burrows, and occasional tracks) seen elsewhere in Caution Bay where similar substrate characteristics and depths are present. Epibiota (such sea whips) were very rarely observed in association with this habitat type and no attached macrophytes were identified on the soft seabed. Few mobile benthic epibiota were observed in these habitats.

Overall, aside from areas of reef, a general absence of hardstand substrate or other three-dimensional structure was observed along this section of the survey area and very sparse epifauna was identified. Coral reef habitat was observed along the route in two locations before the junction point, as follows:

- First reef, located approximately 2.2 km south-east of the 11 km distance marker, toward the junction point of route options 1 and 2:
 - Substantial size and rugosity (spanning tens of metres across the seabed and comprising high three-dimensional complexity).
 - Coincides with seabed steepening, with the associated coral and rock structures rising steeply to within 10 m of the sea surface, before transitioning back toward the flat, gently sloping, and broadly homogeneous silty seabed in depths around 27 m.
 - Various live corals including the conspicuous presence of large gorgonians, some around 1 m high and larger than observed elsewhere in Caution Bay (including a variety of growth/morphological forms from flattened and branching, fan-like, whip-like, feathery, and pinnate), and associated reef fauna communities.

- Smaller scattered patches of live coral and coral rubble are also present along the fringes of the contiguous reef structure. No obvious connection (i.e., underlying calcareous bedrock) to other areas of reef was observed.
- Second reef, located a further 2 km closer to shore, approximately 800 m west of the branching point of routes 1 and 2. Encountered where the seabed steepens, rising from approximately 26 m to 12 m depth, before deepening again and reaching the branching point of the two options where flat soft sediments are again present at around 26 m water depth.

Water clarity and visibility (as interpreted via video records) was generally higher near areas of reef habitat, particularly further from shore, and observed to worsen along the edges of, and with distance from, these features. The enduring concentrations of suspended solids elsewhere may be a key environmental aspect affecting the ecological characteristics of the fine silt habitats of Caution Bay.

Representative seabed photography and downscan sonar imagery along the offshore section of the route is shown in Plate 6.10 to Plate 6.26. The locations of this imagery, along with the predominant habitat types, including demarcations where high-relief reef features were encountered, are illustrated in Figure 6.7 and Figure 6.8.

6.5.2 2019 Papua LNG pipelines route option 1

In the shallow water portions of the previously proposed Papua LNG pipelines route option 1, the seabed reaches depths of approximately 10 m, at 1 km from shore. The shallow waters traverse the same depth-related habitat types previously identified in Caution Bay near the existing LNG Plant jetty, with these broadly comprising:

- Sand and seagrass (0 to 1 m water depth)
- Macroalgae, scattered coral and rubble (1 to 3 m water depth)
- Fringing reef habitat (4 to 8 m water depth)
- Coral rubble and sand transitioning to low complexity soft seabed (8 m and beyond).

Further offshore from the fringing reef, the route reaches 26 m water depth approximately 7 km from shore (the junction point of options 1 and 2). While hardstand structures are largely absent beyond approximately 8 m depth, the largely homogeneous conditions are interspersed by some coral habitat, with two main habitat types observed, similar to those discussed above for the offshore portion of the route:

- Relatively homogeneous, flat, and low complexity habitats comprising soft fine silt, mud and clay. These features represented most of the seabed observed during the survey and the seabed in these areas is generally covered by thin films of algae, microphytobenthos, occasional shell fragments and evidence of benthic fauna in the form of burrows, mounds, tracks, and casts.
- Intact reef that disrupts the otherwise flat and low complexity habitats. This was observed 3 km from shore in a location where the seabed rises sharply from approximately 17 m to 10 m, before sloping back down and transitioning from reef, into scattered coral rubble and toward the predominant low complexity seabed conditions. These features appear to be discrete coral bommies and do not appear to be associated with the more contiguous fringing reef present in shallower waters.

The spatial distributions of the predominant habitats and locations of environmental sensitivities such as reef formations situated along the proposed route are illustrated in Figure 6.8, Figure 6.9, and Figure 6.10. Selected representative imagery of benthic features and habitat types is shown in Plate 6.27 to Plate 6.45.

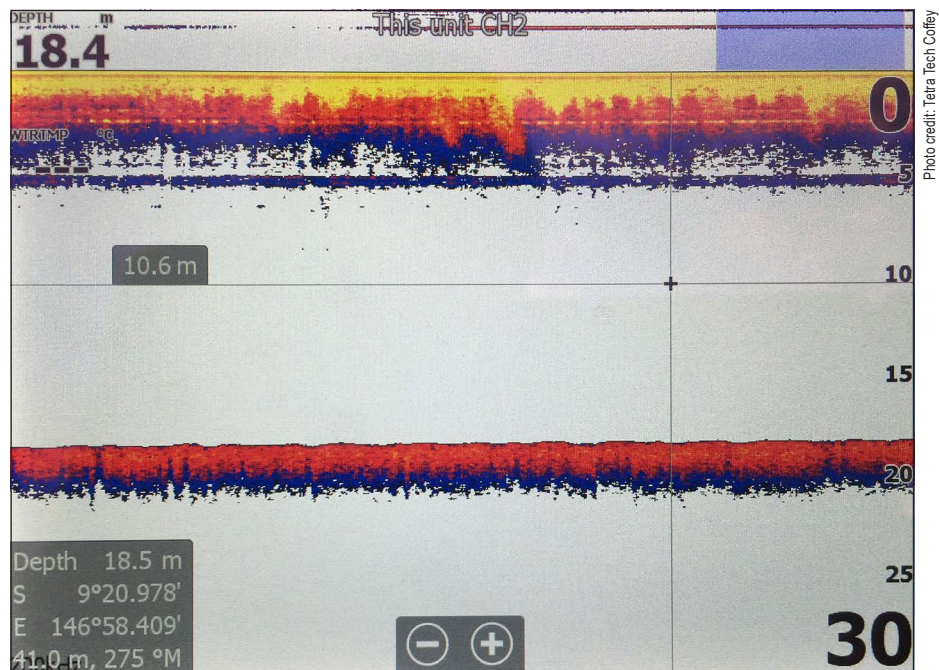


Plate 6.9
Representative sonar imagery illustrating flat, low relief seabed encountered along much of the deeper water sections of the proposed Papua LNG pipeline route options survey transects

Plate 6.10
Papua LNG pipeline (2019). Soft seabed and
bioturbation 11 km offshore.



Photo credit: Tetra Tech Coffey

Plate 6.11
Papua LNG pipeline (2019). Offshore camera
drop 1. Soft seabed and bioturbation.



Photo credit: Tetra Tech Coffey

Plate 6.12
Papua LNG pipeline (2019). Offshore camera
drop 2. Soft seabed and bioturbation.



Photo credit: Tetra Tech Coffey

Plate 6.13
Papua LNG pipeline (2019). Offshore camera
drop 3. Soft seabed and bioturbation.



Photo credit: Tetra Tech Coffey

Plate 6.14
Papua LNG pipeline (2019). Offshore camera
drop 4. Soft seabed and bioturbation.



Photo credit: Tetra Tech Coffey

Plate 6.15
Papua LNG pipeline (2019). Offshore camera
drop 5. Soft seabed and bioturbation.

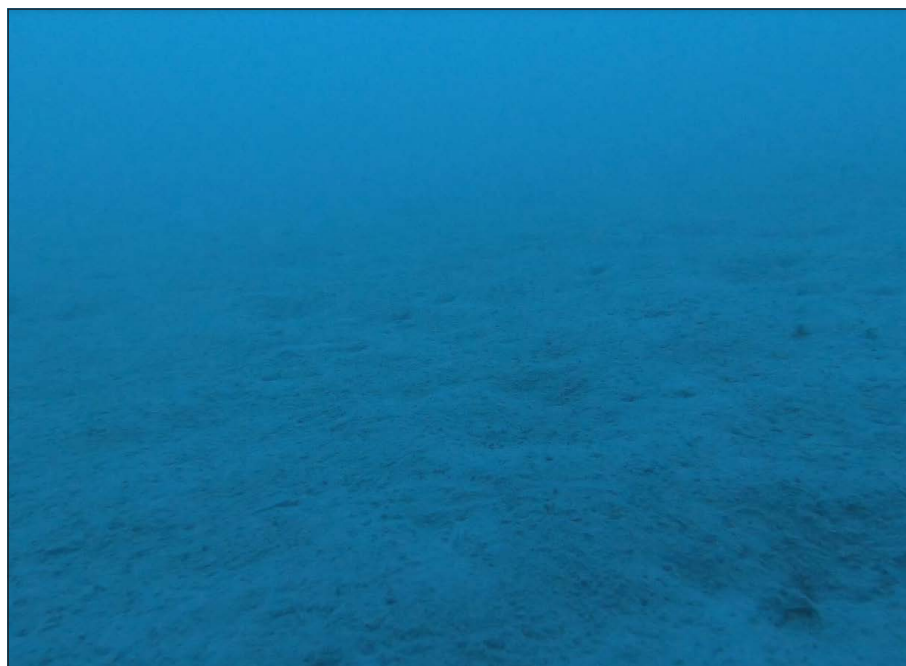


Photo credit: Tetra Tech Coffey

Plate 6.16
Papua LNG pipeline (2019). Offshore camera
drop 6. Soft seabed and bioturbation.

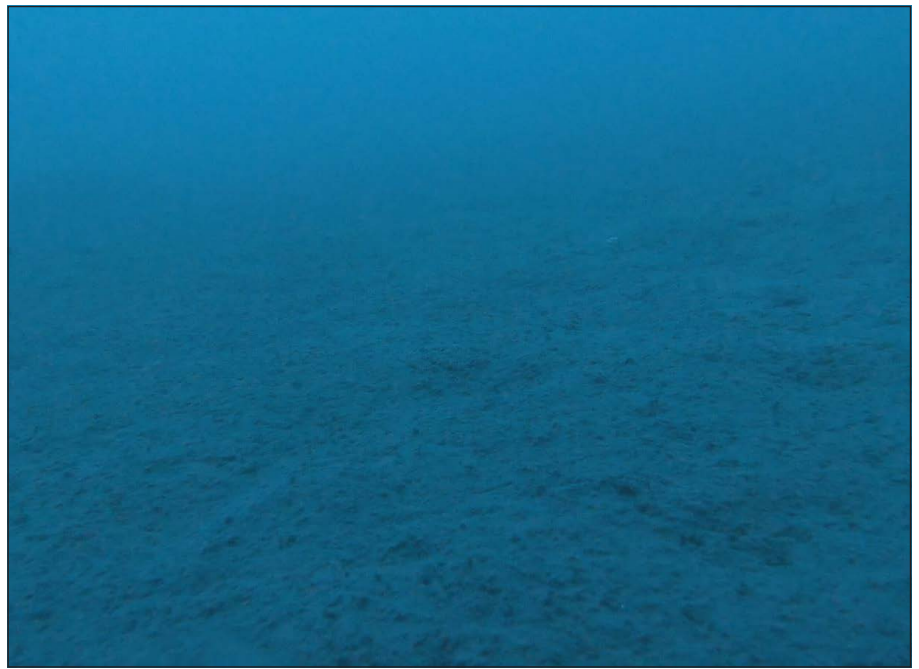


Photo credit: Tetra Tech Coffey

Plate 6.17
Papua LNG pipeline (2019). Offshore camera
drop 8. Soft sediment and bioturbation.



Photo credit: Tetra Tech Coffey

Plate 6.18
Papua LNG pipeline (2019). Offshore camera
drop 8. Reef and rubble.



Photo credit: Tetra Tech Coffey

Plate 6.19
Papua LNG pipeline (2019). Offshore camera
drop 8. Complex reef habitat.



Photo credit: Tetra Tech Coffey

Plate 6.20
Papua LNG pipeline (2019). Offshore camera
drop 8. Seawhips and reef.



Photo credit: Tetra Tech Coffey

Plate 6.21
Papua LNG pipeline (2019). Offshore camera
drop 8. Extensive high relief reef.

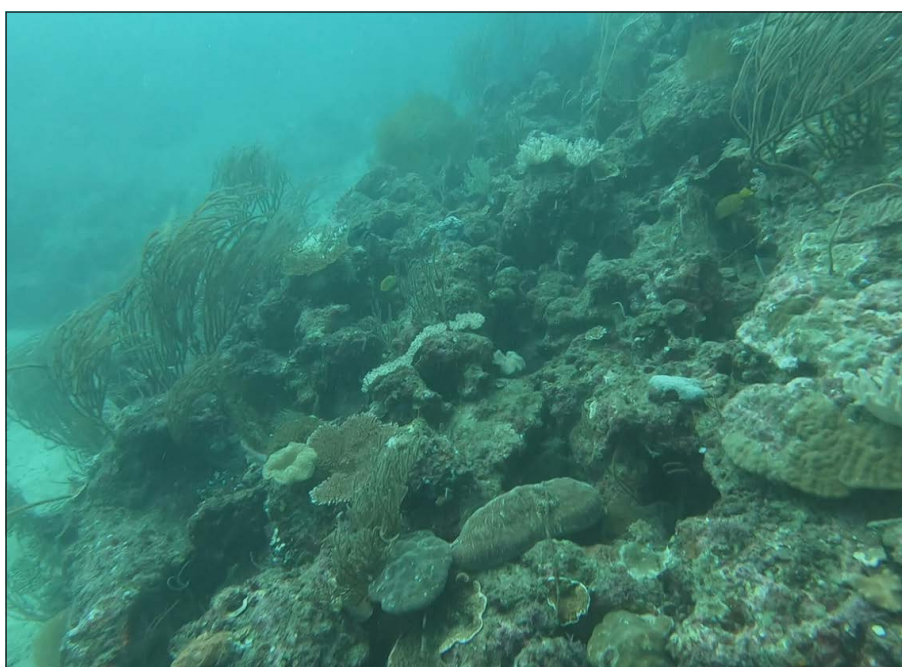


Photo credit: Tetra Tech Coffey

Plate 6.22
Papua LNG pipeline (2019). Offshore camera
drop 8. Large seafan and other corals on reef
and mixed substrate.



Photo credit: Tetra Tech Coffey

Plate 6.23
Papua LNG pipeline (2019). Offshore camera
drop 9. Soft seabed and bioturbation.



Photo credit: Tetra Tech Coffey

Plate 6.24
Papua LNG pipeline (2019). Offshore camera
drop 10. Soft seabed and bioturbation.



Photo credit: Tetra Tech Coffey

Plate 6.25
Papua LNG pipeline (2019). Reef habitat
observed at offshore camera drop 10.



Photo credit: Tetra Tech Coffey

Plate 6.26
Lowrance sonar imagery showing steep
seafloor rise due to presence of reef along
Papua LNG pipeline (encountered at offshore
camera drop 8, 2019)

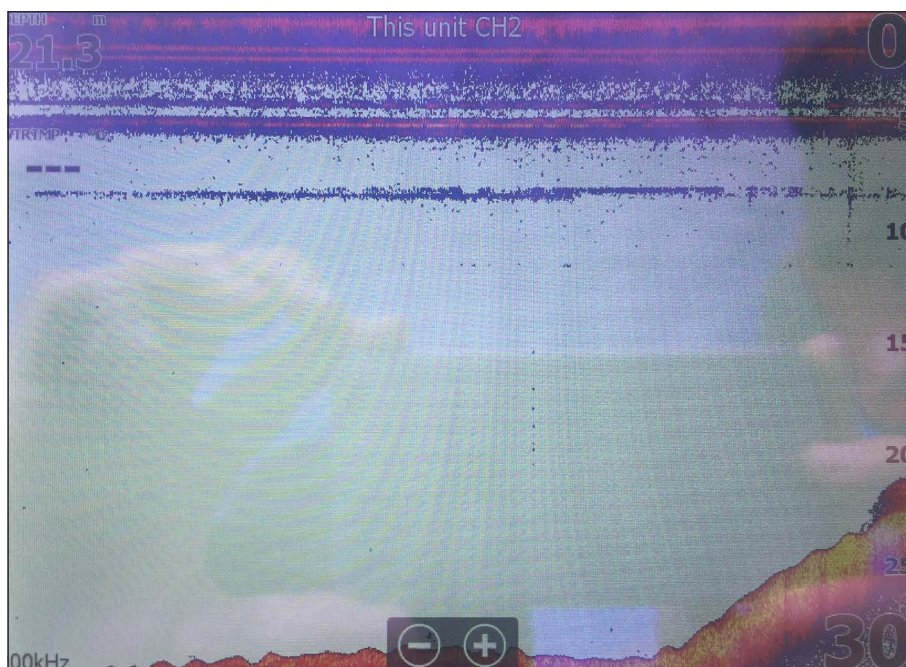


Photo credit: Tetra Tech Coffey

Plate 6.27
Lowrance sonar imagery showing irregular
seafloor due to presence of reef along
Papua LNG pipeline (encountered at offshore
camera drop 8, 2019)

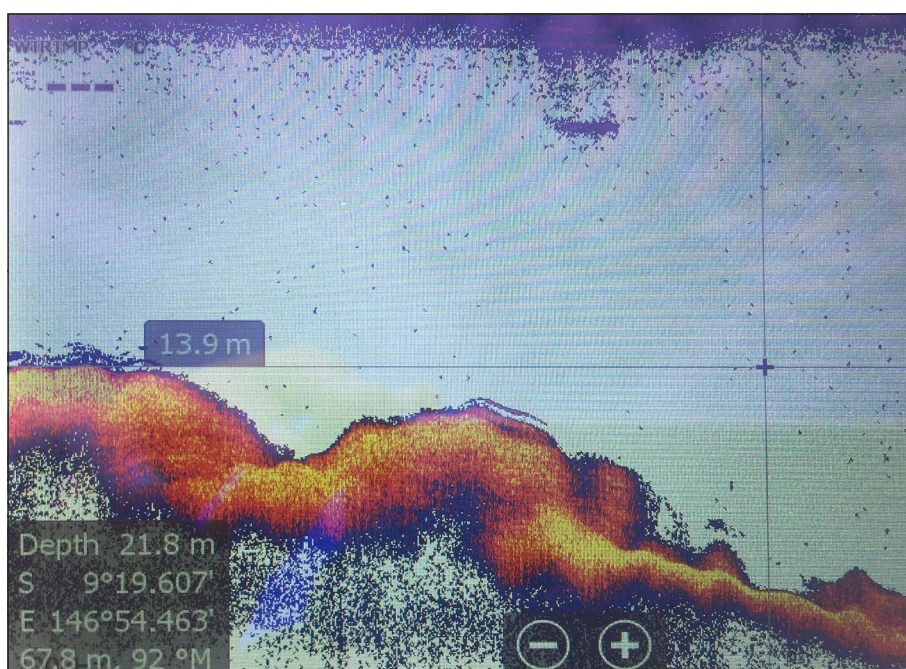


Photo credit: Tetra Tech Coffey

6.5.3 2019 Papua LNG pipelines route option 2

The general features of the seabed and habitat types observed along the survey area for the previously proposed Papua LNG pipelines route option 2 are very similar to those observed for the route option 1. The shallow water habitats observed along this route also broadly comprise:

- Sand and seagrass (typically 0 to 1 m water depth)
- Macroalgae, scattered coral and rubble (typically 1 to 3 m water depth)
- Fringing reef habitat (typically 4 to 8 m water depth)
- Coral rubble and sand transitioning to low complexity soft seabed (typically 8 m water depth and beyond).

Beyond the shallower waters, only relatively homogeneous, flat and low complexity habitats comprising soft fine silt, mud and clay were observed on video records. Outcrops of reef were not observed from video footage or sonar data, in waters beyond the fringing reef (from approximately 8 m to 25 m depth). While slightly more seabed undulation was observed from the sonar records in some areas than for route option 1, such as near the proposed trenching spoil disposal location, no environmental sensitivities such as reefs and shoals associated with seabed steepening were encountered. However, given the observably patchy nature of reef and shoal formations in Caution Bay, these may be present nearby the proposed route.

The spatial distributions of the predominant habitats and locations of environmental sensitivities such as reef formations situated along the survey area for the proposed route are illustrated in Figure 6.8, Figure 6.9 and Figure 6.10. Selected representative imagery of benthic features and habitat types is shown in Plate 6.47 to Plate 6.62.

Plate 6.28
2019 Papua LNG pipelines route option 1.
Offshore drop 1. Soft seabed and bioturbation
burrows.



Photo credit: Tetra Tech Coffey

Plate 6.29
2019 Papua LNG pipelines route option 1.
Offshore drop 2. Flat seabed, some low profile
reef and solitary soft coral present.

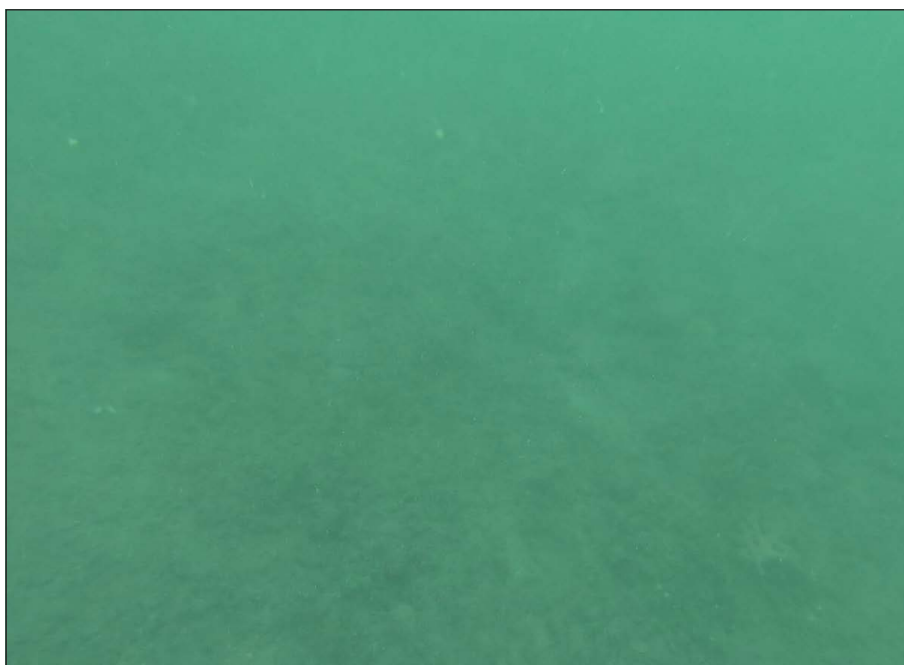


Photo credit: Tetra Tech Coffey

Plate 6.30
2019 Papua LNG pipelines route option 1.
Offshore drop 3. Flat seabed and soft sediment.



Photo credit: Tetra Tech Coffey

Plate 6.31
2019 Papua LNG pipelines route option 1.
Offshore drop 3. Soft sediment and bioturbation
(large burrow).



Photo credit: Tetra Tech Coffey

Plate 6.32
2019 Papua LNG pipelines route option 1.
Offshore drop 4. Backslope of reef- rubble, rock,
sand and gorgonian.

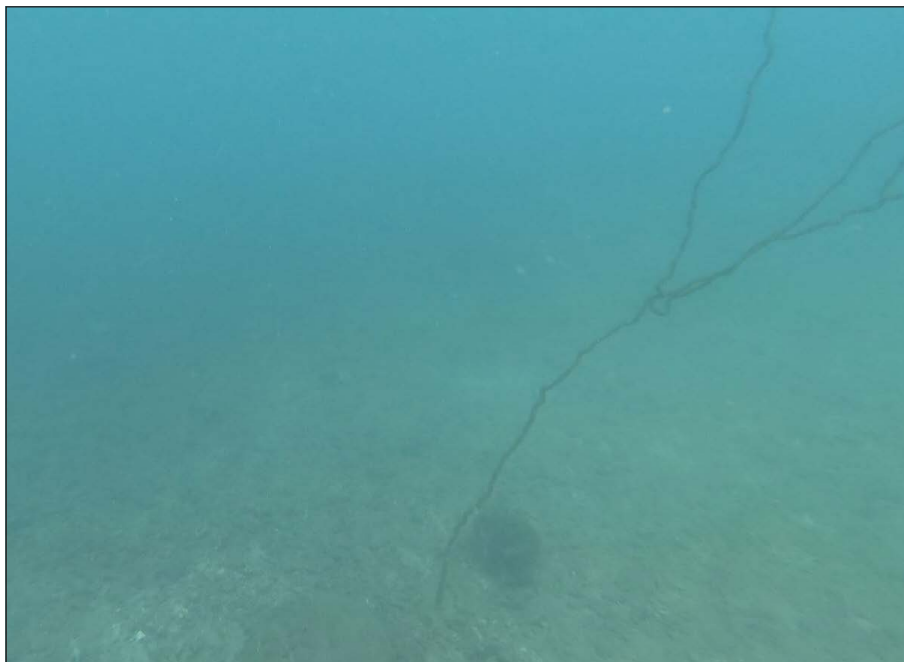


Photo credit: Tetra Tech Coffey

Plate 6.33
2019 Papua LNG pipelines route option 1.
Offshore drop 4. Large coral,
rubble and patchy reef.



Photo credit: Tetra Tech Coffey

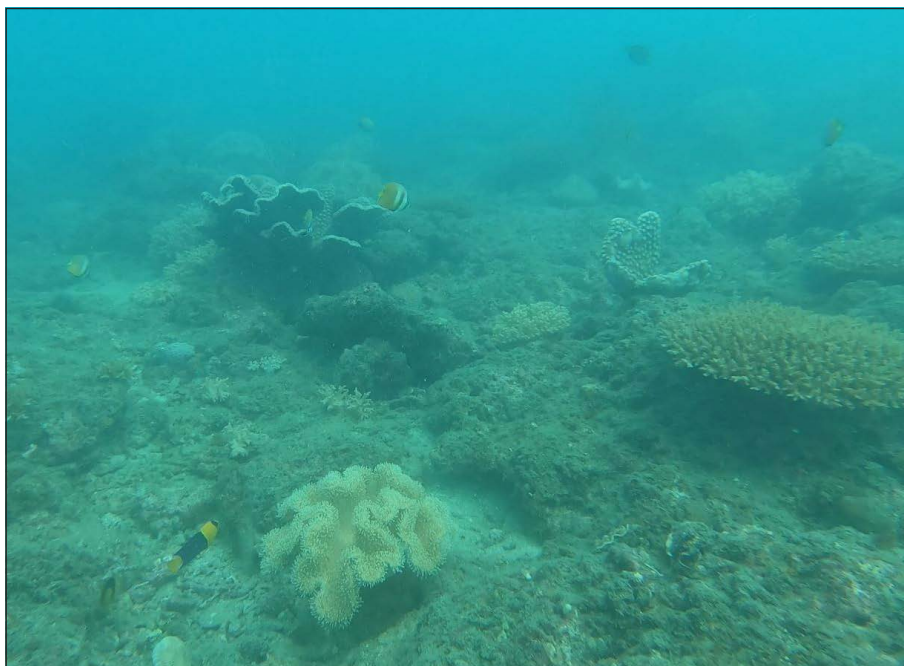


Plate 6.34

2019 Papua LNG pipelines route option 1.
Offshore drop 4. Reef in area of high-rise relief.



Plate 6.35

2019 Papua LNG pipelines route option 1.
Offshore drop 5. Soft sediment,
microphytobenthos and organics.



Plate 6.36

2019 Papua LNG pipelines route option 1.
Nearshore drop 1. Seagrass in 1 m water depth.

Plate 6.37
2019 Papua LNG pipelines route option 1.
Nearshore drop 2. Low profile reef and sand at
1.5 m water depth.



Photo credit: Tetra Tech Coffey

Plate 6.38
2019 Papua LNG pipelines route option 1.
Nearshore drop 3. Mixed macroalgae, rubble
and sand.



Photo credit: Tetra Tech Coffey

Plate 6.39
2019 Papua LNG pipelines route option 1.
Nearshore drop 4. Macroalgae and rubble.



Photo credit: Tetra Tech Coffey

Plate 6.40
2019 Papua LNG pipelines route option 1.
Nearshore drop 5. High relief reef outcrop.



Photo credit: Tetra Tech Coffey

Plate 6.41
2019 Papua LNG pipelines route option 1.
Nearshore drop 5. Reef and *Acropora* sp. hard corals.

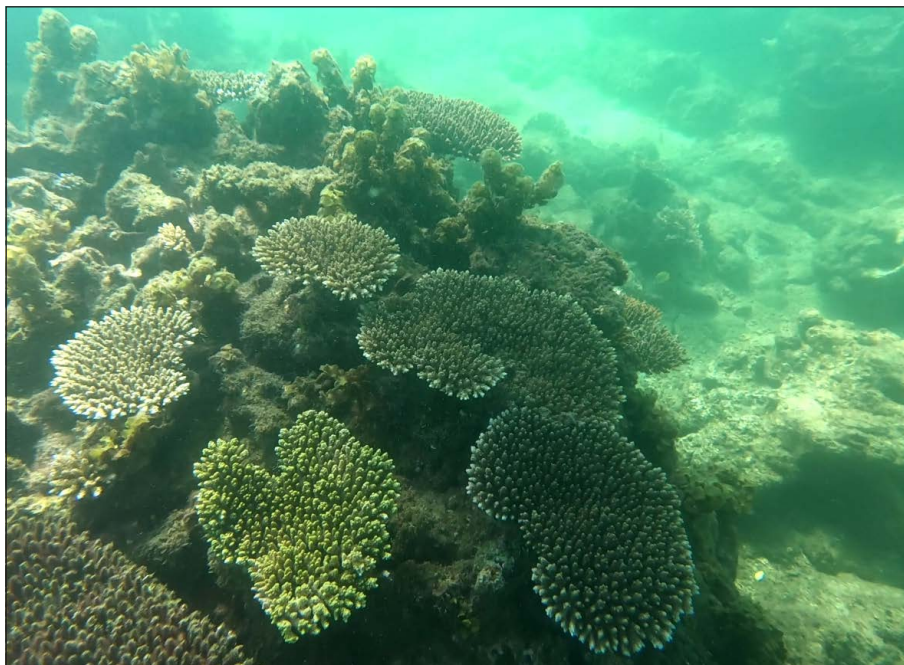


Photo credit: Tetra Tech Coffey

Plate 6.42
2019 Papua LNG pipelines route option 1.
Nearshore drop 6. Reef and *Acropora* sp. hard corals.

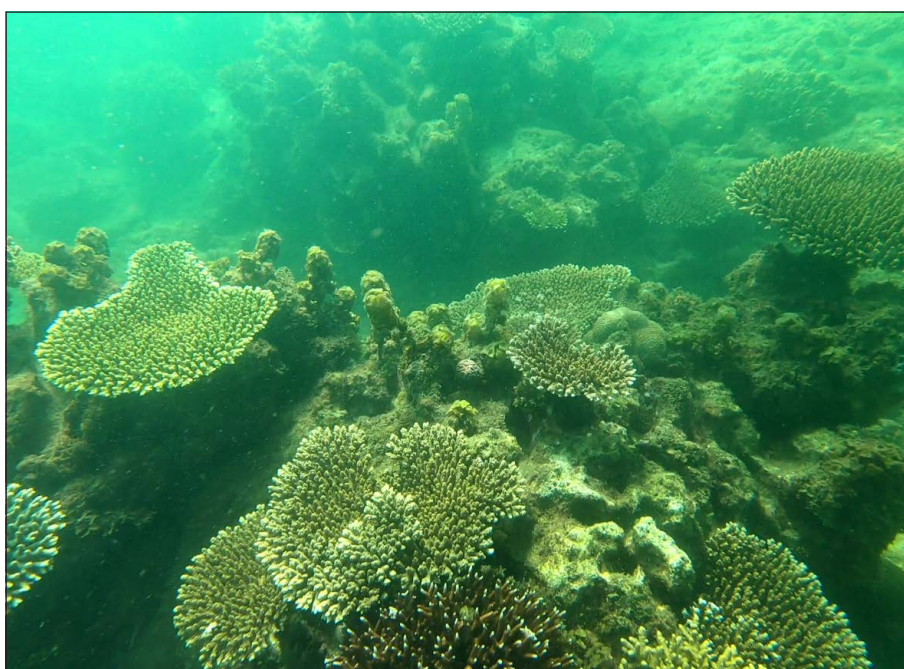


Photo credit: Tetra Tech Coffey

Plate 6.43
2019 Papua LNG pipelines route option 1.
Nearshore drop 7. Reef and corals.



Photo credit: Tetra Tech Coffey

Plate 6.44
2019 Papua LNG pipelines route option 1.
Nearshore drop 8. Rubble and sand.



Photo credit: Tetra Tech Coffey

Plate 6.45
2019 Papua LNG pipelines route option 1.
Nearshore drop 9. Coarse sand and shell fragments.



Photo credit: Tetra Tech Coffey

Plate 6.46
 2019 Papua LNG pipelines route option 1.
 Nearshore drop 10. Soft seabed, bioturbation
 and microphytobenthos.



Photo credit: Tetra Tech Coffey

Plate 6.47
 2019 Papua LNG pipelines route option 2.
 Offshore drop 1. Soft seabed and bioturbation
 burrows.



Photo credit: Tetra Tech Coffey

Plate 6.48
 2019 Papua LNG pipelines route option 2.
 Offshore drop 2. Soft seabed.



Photo credit: Tetra Tech Coffey



Plate 6.49

2019 Papua LNG pipelines route option 2.
Offshore drop 3. Soft seabed. Very low visibility.



Plate 6.50

2019 Papua LNG pipelines route option 2.
Offshore drop 4. Soft seabed and bioturbation
burrows.



Plate 6.51

2019 Papua LNG pipelines route option 2.
Offshore drop 5. Soft seabed mobilised
sediment.

Plate 6.52
2019 Papua LNG pipelines route option 2.
Offshore drop 6. Soft seabed.



Photo credit: Tetra Tech Coffey

Plate 6.53
2019 Papua LNG pipelines route option 2.
Nearshore drop 1. Rock and macroalgae.



Photo credit: Tetra Tech Coffey

Plate 6.54
2019 Papua LNG pipelines route option 2.
Nearshore drop 2. Rock, rubble and
macroalgae.



Photo credit: Tetra Tech Coffey

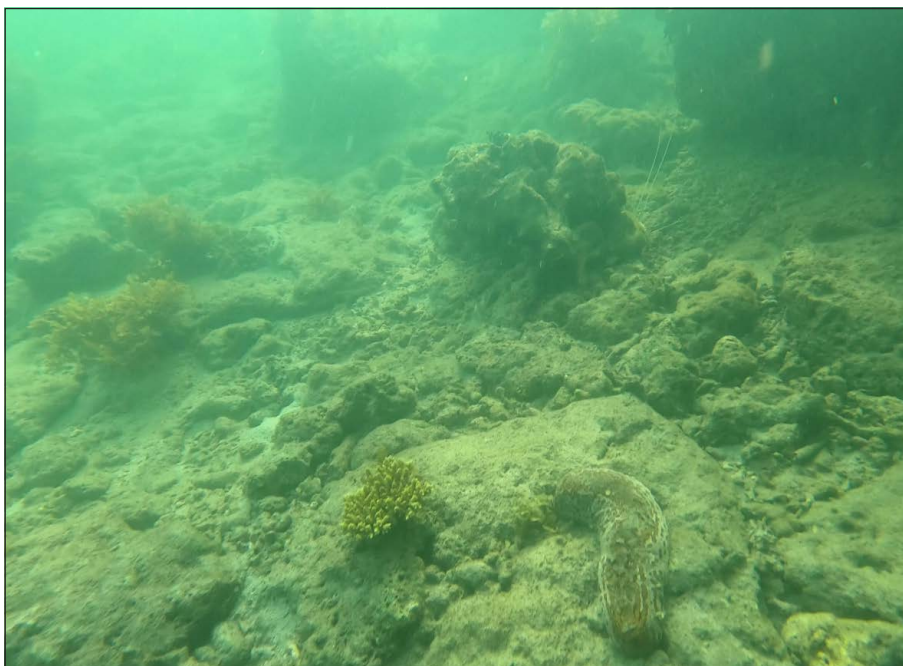


Plate 6.55

2019 Papua LNG pipelines route option 2.
Nearshore drop 3. Rock, rubble, macroalgae
and patchy biota.



Plate 6.56

2019 Papua LNG pipelines route option 2.
Nearshore drop 4. Low relief reef, rubble and
Porites sp. coral.



Plate 6.57

2019 Papua LNG pipelines route option 2.
Nearshore drop 5. Low relief reef, rubble and
mixed biota including coral, macroalgae and
Junceella sp. Gorgonian.



Plate 6.58

2019 Papua LNG pipelines route option 2.
Nearshore drop 6. Mixed soft sediments and
bioturbation.



Plate 6.59

2019 Papua LNG pipelines route option 2.
Nearshore drop 7. Soft sediments and
horned sea star (*Protoreaster nodosus*).



Plate 6.60

2019 Papua LNG pipelines route option 2.
Nearshore drop 8. Mixed soft sediments.



Plate 6.61

2019 Papua LNG pipelines route option 2.
Nearshore drop 9. Mixed soft silty sediments
and bioturbation.



Plate 6.62

2019 Papua LNG pipelines route option 2.
Nearshore drop 10. Soft seabed and
bioturbation burrows.

6.5.4 2022 Papua LNG pipelines survey

Results from the 2022 Papua LNG pipelines video transect survey are presented in this section. Table 6.2 presents a summary of the main observations made during the video transect survey. Figure 6.7 shows the video transect locations for the 2022 marine ecology surveys.

Contiguous tracts of hardstand seabed and rocky outcrops or reefs were generally absent beyond approximately 8 m water depth, however isolated areas were observed where rocky outcrops and patch reefs supported relatively diverse coral assemblages, such as those identified along the PLNG-2 transect. Two main habitat types were observed, which are similar to those discussed in Section 6.5.2, and are further described as follows:

- Relatively homogeneous, flat and low complexity habitats comprising soft fine silt, mud and clay. These features are present across most of the seabed observed during the survey, with most benthic areas covered by silts, thin films of algae, microphytobenthos, occasional shell fragments and ample evidence of benthic fauna present in the form of burrows, mounds, tracks and casts. While limited, the main corals are gorgonians (sea whips and sea fans), as well as some sponges and other soft corals. Reef building hard corals were largely absent.
- Sporadic occurrences of occasionally dense stands of corals, that punctuate the otherwise generally homogeneous and flat seabed and silty, muddy, and low complexity benthic habitat (e.g., sites designated as 'REEF' along and near option 15F and option 15a shown on Figure 6.7). Corals mainly included tabulate, branching, and encrusting growth forms, as well as occasionally large gorgonians (sea whips and sea fans), sponges and soft corals. The relatively high proportion of gorgonians in these areas suggests that these communities are potentially more adapted to higher suspended sediment and turbidity levels and potentially lower levels of light than reefs close to shore or observed in other tropical coastal locations. This may be due to the proximity of riverine sources of particulates, such as those discharged from the Vaihua River. These coral assemblages are discrete 'coral bommies' or patch reefs and are not readily connected with the more contiguous fringing reef present closer to shore and in shallower waters in Caution Bay.

Selected representative imagery of benthic features and habitat types is shown in Plate 6.63 to Plate 6.67.

Table 6.2 2022 Papua LNG pipelines route option 15A and 15F transect survey observations

Site ID	Location	Approximate distance from shore (km)	Depth (m)	Observations
REEF-5	Option 15F. Approximately 100 m west of transect PLNG-1, furthest offshore survey location.	10	28	An area of soft seabed sediments supports a benthic community including various large gorgonians (mainly sea fans), soft corals, sponges, and occasional hard corals. Macro invertebrates such as basket and feather stars, fish, and large groups of urchin present. Scattered coral rubble observed.
PLNG-1	Papua LNG pipelines route Option 15F. Route branching point.	9.65 to 9.85	28	Substrate mainly comprises muddy seabed with sparse distribution of benthos aside from infaunal burrows. No complex habitat features, or outcropping rock observed directly along this transect.
REEF-6	Adjacent northern extent of PLNG-2. Papua LNG pipelines route Option 15F.	8.6	23.5	REEF-6 supports an established coral reef community comprising a mixture of hard corals, whip corals (gorgonians), soft corals, sponges, ascidians, and feather stars.
PLNG-2	Papua LNG pipelines route Option 15F.	8.4 to 8.6	30	Substrate mainly comprises muddy seabed with sparse distribution of benthos aside from infaunal burrows.
REEF-3	REEF-3 is located midway between PLNG-2 and PLNG-3.	8	28	REEF-3 is a locally extensive area of coral reef, base rock, and rubble that supports an established coral reef community comprising a mixture of hard corals (mainly tabulate growth forms), whip corals (gorgonians), soft corals, sponges, ascidians, and feather stars. Numerous small reef fish observed.
PLNG-3	Papua LNG pipelines route Option 15F.	7.3 to 7.5	28	Substrate comprises muddy seabed with sparse distribution of benthos aside from infaunal burrows. No complex habitat features, or outcropping rock observed along transect. REEF-3 supports a similar ecological assemblage to REEF-6.
PLNG-4	Papua LNG Pipeline. Transect is near the CALM buoy navigational area boundary (north-western edge) and Sed 31 sampling site.	6.3 to 6.5	29	Soft silts and muddy sediments characterised by bioturbation, mainly in the form of burrows. Low visibility/water clarity due to high particulate levels. Bottom sediments easily disturbed and mobilised by camera sled.
REEF-1	Option 15A. Within navigational corridor.	6.7	8.8 to 12.2	An extensive area of reef that supports various reef-building hard corals, large gorgonians (mainly sea fans and whip corals), soft corals, ascidians, and sponges. Macro invertebrates such as basket and feather stars, and various reef fish present. Scattered coral rubble observed.
PLNG-5	Papua LNG Pipeline. On boundary of CALM buoy navigational area / naphtha alternate alignment.	4.3 to 4.7	22	Transect begins at intersection of eastern edge of the CALM buoy navigational area and proposed pipeline and heads inshore along route. Similar habitat to PLNG-3 and PLNG-4. Low underwater visibility with evident suspended particulates. Soft, muddy bottom sediments readily disturbed / resuspended.

Plate 6.63
 Reef observed at REEF-1 (near 2022 Papua
 LNG pipelines route option 15A) - sea fans,
 encrusting hard corals and Pacific sailfin tang
 (*Zebrasoma veliferum*)



Photo credit: Tetra Tech Coffey

Plate 6.64
 Intact reef observed at REEF-1 (near 2022
 Papua LNG pipelines route option 15A)

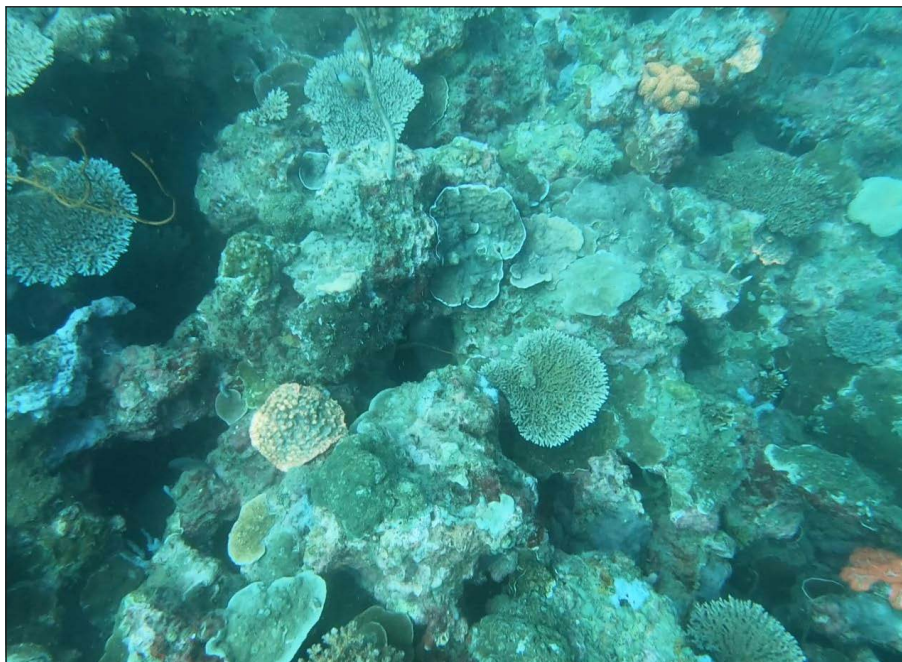


Photo credit: Tetra Tech Coffey

Plate 6.65
 Soft sediments and bioturbation observed at
 PLNG-4 (near 2022 Papua LNG pipelines route
 option 15F)



Photo credit: Tetra Tech Coffey



Plate 6.66
Sea fans observed at PLNG-2 (near Papua LNG
pipelines route option 15F)



Plate 6.67
Urchins (species undetermined) observed
at PLNG-2 (near Papua LNG pipelines
route option 15F)

6.5.5 2022 CALM Buoy and naphtha and condensate pipeline surveys

Results from the 2022 CALM buoy and naphtha and condensate pipeline video transect surveys are presented in this section. Figure 6.7 shows the video transect locations for the 2022 marine ecology surveys.

Table 6.3 presents a summary of the main observations made during the video transect survey.

6.6 SEAGRASS SITES

The PNG LNG Project and proposed Papua LNG pipelines pass through seagrass habitat. Seagrass communities are of ecological significance as nursery habitats for prawns, lobsters, crabs, turtles, dugongs and fish, and aid in stabilising the substrate.

6.6.1 Species and distribution

Locally dense seagrass meadows are established in the Caution Bay lagoonal environment, along a narrow band of shallow soft seabed (0 to 2 m depth) situated between the intertidal flats and the coastal fringing reef. Although called seagrass sites, the habitat generally includes areas of coarser sediment and rubble that support algae and emergent corals, with seagrass most prolific in a narrow zone parallel to the coast. Larger macroalgae species such as *Sargassum* are typically present over a wider depth range. The reef attenuates wave energy and protects the seagrass from high wave energy impacts. No dugong feeding trails have been observed in the seagrass beds during any surveys that have taken place for the PNG LNG Project i.e., during the EIS studies, or in 2011, 2012, 2014 or 2019.

Ten seagrass sites were surveyed in 2019. GPS records, including those of previous surveys, are presented in Figure 6.5 and Figure 6.6. and show that most transects over the years had similar alignments. Seagrasses observed at seagrass (and also coral and fish) sites range from dense, multi-specific stands mainly comprising *Enhalus acoroides*, *Syringodium isoetifolium* and *Cymodocea* sp., to patchy and sparsely distributed *Enhalus acoroides* or *Cymodocea* sp. *Enhalus acoroides* is the largest of the species present, with noticeably taller ribbon-like leaves 30 cm to 150 cm in length. The relatively broad strap-like blades of *Enhalus acoroides* form a patchy canopy over the more densely distributed smaller species of tube-like *Syringodium* and strap-like *Cymodocea*. *Halophila* sp. seagrass is also present, though typically sporadically and in lower abundance, interspersed amongst the dominant assemblage.

Where present, seagrass meadows along the transects were typically dense, except where patchy substrate resulted in the meadows being interspersed with areas of bare sand, rubble, macroalgae and occasional corals. Dense macroalgae beds (*Sargassum* and to a lesser extent *Turbinaria* and *Padina* spp.) were also observed. The calcareous green algae *Halimeda* was occasionally observed throughout areas of coral reef and rubble. As with prior surveys, seagrass and macroalgae were observed to be the two most visibly abundant biota (occupying most of the seabed). Bare unconsolidated substrates including sand and coral-rock and rubble, were the predominant substrates underlying the seagrass and macroalgae assemblages, respectively.

Seagrass was typically associated with sand substrates and macroalgae with the larger rubble and rock substrates. The presence of macroalgae (*Sargassum*) was also higher in areas where the alignment of transects transitioned into deeper waters (beyond 1.0 m to 1.5 m), while seagrass was present in shallower waters. This pattern illustrated the distinct depth-related zonation of the main aquatic macrophytes in Caution Bay.

Table 6.3 2022 CALM buoy and naphtha and condensate pipeline route transect survey observations

Site ID	Location	Distance from shore (km)	Depth (m)	Observations
CALM-1	Transect runs southwest toward Sed37, between and parallel to Option 15A and Option 15F.	1.25	3.6	Habitat types include bare silty sand and organic debris and dead leaves from mangrove and seagrass communities. Very low visibility due to suspended sediments caused by rough seas.
REEF-2	East of transect CALM-11, approximately 40 metres off Option 15A pipeline route	1	15	An established coral reef community supporting gorgonians, soft corals, hard corals, macro invertebrates and reef fish.
CALM-2	Transect starts at SED37, runs southwest toward SED36 along naphtha / condensate route / Option 15F.	2	20	Low visibility at surface due to suspended particles though clear at seabed. Habitats include soft sediment, mud, and bare sand. Benthic fauna evidenced by burrowing holes.
CALM-11	Alternate naphtha / condensate route / Option 15C.	2	14	Substrate comprises muddy seabed with sparse distribution of benthos aside from infaunal burrows and scattered isolated sea pens (Pennatulacea). Low visibility with notable / observable suspended materials.
CALM-9	Alternate naphtha / condensate route / Option 15A.	2	14	Muddy, soft sediment seabed with scattered sponges (Porifera), limited seagrass (likely <i>Enhalus</i> sp.) and evidence of bioturbation mainly in the form of benthic burrows. Low visibility with notable / observable suspended materials.
CALM-3	Transect begins where CALM-2 finishes and runs southwest towards SED36, along naphtha / condensate route / Option 15F	3.2 to 4.3	21	Similar benthic habitat as CALM-2.
CALM-10	Southern alternate naphtha / condensate route.	3.5 to 4	20	Substrate comprises muddy seabed with sparse distribution of benthos aside from infaunal burrows. No complex habitat features or outcropping rock observed.
CALM-12	Located along northern alternate naphtha / condensate route	3.25	19	Substrate along CALM-12 transect comprises muddy seabed with sparse distribution of benthos aside from infaunal burrows. No complex habitat features or outcropping rock observed along transect.
REEF-4	Located adjacent to and south of CALM-12. Located near northern alternate naphtha / condensate route	3.25	15	A relatively large area of low-lying reef and rubble, in a generally degraded state and with an overall low coverage of live coral, though supporting various fish and hard and soft corals.
CALM-8	Within CALM buoy navigational area along naphtha / condensate route / Option 15F.	5.35 to 5.85	30	Low visibility due to suspended particles in water column. Habitat is mostly muddy bottom with benthic burrows.

Site ID	Location	Distance from shore (km)	Depth (m)	Observations
CALM-7	Transect runs between SED35 and SED 31. Within western portion of CALM buoy navigational area.	7.5 to 8.15	31	Low visibility due to suspended particles in water column. Habitat is mostly muddy bottom with benthic burrows.
CALM-6	Transect starts near SED34 and runs inshore towards SED35. Alternate CALM buoy alignment.	9.4 to 10.5	33	Similar habitat to CALM-4, increasingly silty around SED35.
CALM-5	Transect runs from SED33 inshore toward SED34. Alternate CALM buoy alignment.	8.6 to 10	40	Bottom habitat comprises soft sediments and sand; low complexity.
CALM-4	Furthest offshore transect, west of CALM buoy. Runs inshore from SED30 towards SED33. Alternate CALM buoy alignment.	14.9 to 15.7	43	Patch reef habitat observed near SED30, including sea fans, sea whips, soft corals, and small reef fish including from family Chaetodontidae. Near SED33, seafloor is mostly soft sediments with extensive bioturbation (burrows). Low visibility, and signs of sedimentation apparent.

Sessile biota, such as sponges and corals, were scattered sparsely throughout the seagrass transects and more commonly in the macroalgae-dominated zones. Similarly, fish were generally less commonly sighted in the seagrass-dominated areas (partially due to visibility being obscured by the dense vegetation) and were most commonly associated with emergent corals, reef/rubble outcrops or *Sargassum* beds. An observation was made of what is likely to be a giant guitarfish (*Glaucostegus typus*) at site SG-13 near Idihi Island, on sand amidst seagrass (Plate 6.68)

While small differences in transect alignment and camera field of view influence the video data record between monitoring events, a review of current and prior data indicates that most sites in 2019 had a generally consistent distribution of macrophytes (seagrass or macroalgae) compared with the prior periods of monitoring. Where seagrasses and macroalgae are present, the consistency of substrate coverage and density appears to be stable, or have increased, over time at most locations. No visible decrease in seagrass coverage was observed at any sites, even when taking account of differences in the various transect tow paths between surveys. No seagrass was observed in deeper water seaward of the fringing reef.

6.6.2 Areas of disturbance

During construction and pipeline installation activities for the PNG LNG Project, mangrove habitat was cleared near the LNG Plant, along with trenching of an area of seafloor habitat where seagrass and macroalgae were present. Approximations of the general size and characteristics of the disturbed areas of seagrass were made following the 2019 survey using historical and the most recently available Google Earth satellite imagery, cross referenced with survey and video records. While the overall extent of seafloor disturbance was larger (extending further offshore), the disturbance to potential macrophyte habitat encompassed a narrow strip of shallow seafloor habitat perpendicular to shore of approximately 18,600 m² (1.9 ha). This area extended from just seaward of the mangrove fringe to water depths of approximately 3 m.

The flora/fauna types impacted by previous subsea trenching/pipeline installation activities comprised the same prevailing features of the surrounding area and included a benthic substrate of sand, gravel, shell and coral rubble fragments, soft sediments, and occasional small individual corals. The associated macrophyte community was a mixed assemblage where several aquatic vegetation types co-occur, mainly including *Padina*, *Turbinaria* and *Sargassum* macroalgae, filamentous algal turfs and seagrasses (*Enhalus*, *Cymodocea* and *Syringodium* spp.).

The zone of seafloor disturbance specifically affecting seagrass was conservatively estimated to comprise a maximum area of approximately 0.35 ha. The area of historical seagrass disturbance represents approximately 0.4% of the potential seagrass habitat in the immediate area; based on an estimation of the broader coastal area directly seaward of the LNG Plant suitable for seagrass growth of approximately 80 ha (comprising the southern entrance of Caution Bay to just south of Lea Lea, where water depths of between 0.5 m and 2 m occur). Seagrass is also present across the broader surrounding area, including dense meadows around Idihi Island.

6.6.3 Quantitative analysis

The abundance (% points) for species and substrate categories observed at the seagrass sites during the 2019 survey at sites north and south of the LNG Plant jetty (shown in Figure 6.6) are shown in Appendix F. Sites are ordered according to location along the coast – from the northernmost site (SG-01) to the southernmost site (SG-09-10) and offshore site (SG-13, Idihi Island). Appendix F also provides figures illustrating the proportion of transects occupied by the three major categories (seagrass, macroalgae and bare unconsolidated substrate) at seagrass sites for all five surveys conducted between 2010 to 2019. All sites except site SG07-08 exhibited an increase in seagrass abundance from 2014 to 2019. The largest increase occurred at SG11 (from approximately 55% to 75%). The decrease at site SG07-08 was slight (80% to 75%).

The highest abundance (approximately 88%) was recorded at SG05-06 and the lowest abundance was recorded at SG12 (20%).

The nMDS plot for seagrass sites between 2010 and 2019 is shown in Appendix F. Points in the lower left of the nMDS plot were characterised by low macroalgae cover. The cluster of points in the middle left were characterised by higher seagrass cover than other sites/surveys. The Kruskal stress for the plot was low at 0.08. A low Kruskal stress value indicates the plot provides a reliable representation of differences between sites (Clarke and Warwick, 1994).

The factors explaining the form of the multivariate MDS plot can be found by examining univariate plots for seagrass in Appendix F. Seagrass sites SG12 and SG13 plotted in the upper right in each year and these sites were characterised by the highest macroalgae cover over the five surveys. The nMDS plots also show if sites have migrated out of their cluster over time (e.g., if sites of formerly high percentage cover of seagrass (or some other substrate category) have become low percentage cover, or vice versa). Where the relative locations of the sites have been similar over all the sampling periods, then change over time is not apparent.

Examination of remote imagery between 2010 and 2019 shows that the distribution of features such as sand patches and seagrass beds has changed over time at some sites, most likely due to natural coastal processes occurring in Caution Bay. To varying degrees, differences in the towed camera transect alignment between the surveys have also occurred. Consequently, these factors contribute to differences in the recorded habitat/substrate types that have been subject to point count analysis, which correspondingly influences the recorded proportions of the various substrate categories. For instance, substantial changes are evident in the percent cover analysis of unconsolidated seabed (increase), macroalgae (decrease) and seagrass (increase) at most sites between 2011 and 2012 (Appendix F). Rather than an appreciable reduction in seagrass density, this change is better explained by the natural changes in the dynamic boundaries of the observed habitat/substrate types, in conjunction with smaller variability in transect alignment.

The proportion of unconsolidated substrate along video transects is typically the inverse of the proportion of transects with seagrass and/or macroalgae. Accordingly, where large changes in the proportion of vegetation recorded along video transects have been seen between surveys, inverse changes of similar magnitude in the proportion of unconsolidated substrate are observed.

At some locations, little appreciable change in the boundaries of macrophyte or other substrate cover were visible in remote images, and most survey tracks were close to each other. In these cases, a change in biomass is more likely to have occurred. Further detailed explanation of the above factors and the observed changes in recorded percent cover that have occurred across the surveys undertaken between 2010 and 2014, which is relevant to the results of and 2019 is provided in Coffey (2014a).

Appendix G provides a detailed comparative summary of each seagrass transect including key abiotic and biotic features in 2010, 2011, 2012, 2014 and 2019. Plate 6.68 to Plate 6.73 provide representative imagery of selected seagrass monitoring locations.

6.7 CORAL AND FISH SITES

Coral rock consists of remnant coral skeletons overgrown with living filamentous and encrusting invertebrates and algae and provides the physical structure of the live coral and fish habitat in Caution Bay. These hardstand, rocky substrates are derived from biochemical processes and directly from reef-forming corals. They are largely associated with the coastal reefs that fringe the intertidal flats, isolated bombooras that rise from the deeper silty seabed, and the outer reef that separates the bay from the open ocean further offshore.



Plate 6.68
Giant shovelnose ray and seagrass at SG-13



Plate 6.69
Seagrass and coral rubble at SG-02



Plate 6.7
Sargassum and seagrass at SG-03

Plate 6.71
Mixed substrates and coral at site SG-12



Photo credit: Tetra Tech Coffey

Plate 6.72
Dense multi-specific seagrass bed at SG-11



Photo credit: Tetra Tech Coffey

Plate 6.73
Patchy seagrass and macroalgae growth at
SG-07-SG-08



Photo credit: Tetra Tech Coffey

6.7.1 Habitat types and species

Observations within Caution Bay made since the PNG LNG Project EIS studies have generally shown that reef habitat is variable and exists as a patchy, fragmented mosaic with some sections of complex, contiguous limestone. The coral and fish monitoring sites within the survey area generally comprise the following habitat variants:

- Soft sediment (silt and sand) with coral rubble
- Coral rubble and scattered rock with macroalgal growth
- Coral rubble, sand and silt with sparse, occasionally large coral bombora, seagrasses and/or macroalgae
- Contiguous coral reef of varying three-dimensional complexity with scattered to numerous living corals attached.

The same 15 coral and fish sites surveyed in 2014 were again surveyed in 2019. Site CF-18 was introduced in 2019 to obtain broader coverage of the survey area. As with earlier surveys, the 2019 survey included the amalgamation of sites CF-07 to CF-10 into a single continuous transect to enable a direct assessment of potential seabed impacts from construction of the proposed jetty extension, and changes that may have occurred since the most recent survey in 2014. Appendix G provides a qualitative description of each transect analysed at each site including key substrate, and abiotic and biotic features. Plate 6.74 to 6.87 show various seabed substrates and benthic features at representative coral and fish sites.

A similar set of features were observed along 2019 as in 2014, and no ongoing changes to species or ecosystem-scale changes related to construction and operation of the existing jetty were apparent.

Observations from this transect included:

- Mostly patchy reef and boulders, with the most complex continuous reef present at the end of the transect near CF-10.
- Scattered hard corals seen all along the transect, including beneath the jetty.
- Soft corals, sea-whips (*Junceella* sp.) and other gorgonians common along the transect.
- Sargassum sp. seaweeds present along much of the transect with encrusting and turfing macroalgae colonising rocky substrates all along the transect.
- A reduction in sedimentation on some low-relief substrates compared with the 2012 survey and to a lesser extent the 2014 survey.

In general, most of the hardstand substrate and limestone 'base rock' to which coral and sponge biota attach, was observed to be without substantial inter-connected colonisation by large living colonies of hermatypic reef-building stony corals, soft corals, or sponges. Where present, apart from the typically ubiquitous reef-building crustose coralline algae species, coral growth tended to be scattered or clustered around reasonably discrete areas. Some sites, or locations within sites, were observed in a naturally degraded condition, as evidenced by the coverage of coral rubble on the seabed and presence of filamentous turfs of algal growth, particularly close to shore. This pattern has been observed during all prior monitoring studies undertaken for the PNG LNG Project.

Plate 6.74
Reef habitat at CF-01



Photo credit: Tetra Tech Coffey

Plate 6.75
Hard corals and reef at CF-02

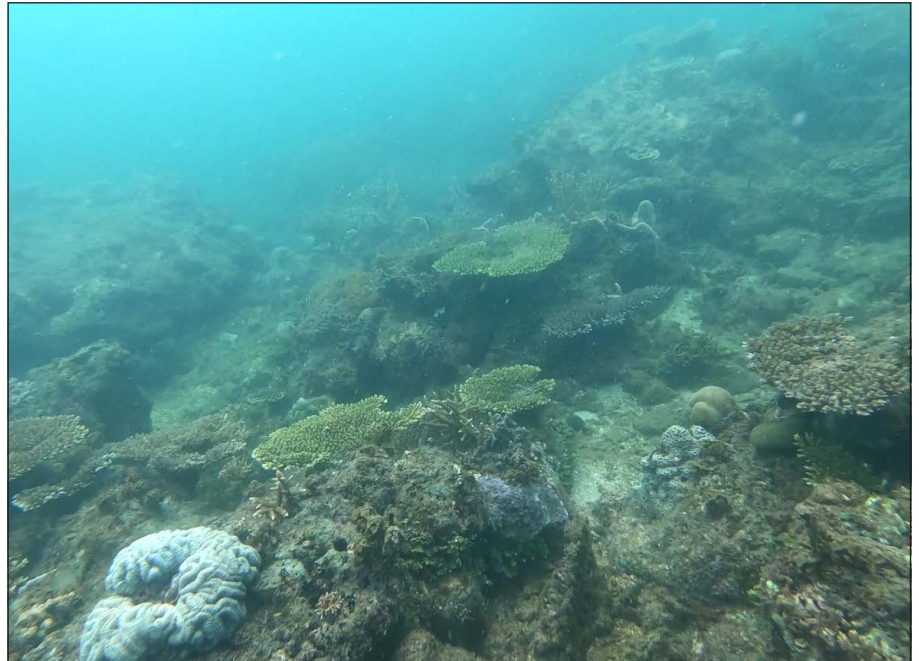


Photo credit: Tetra Tech Coffey

Plate 6.76
Dense gorgonian growth and *Neptheidae* on rubble and low-relief reef at CF-02



Photo credit: Tetra Tech Coffey

Plate 6.77
Benthic habitat at CF-03



Photo credit: Tetra Tech Coffey

Plate 6.78
Large intact *Acropora* sp. coral and reef at CF-04



Photo credit: Tetra Tech Coffey

Plate 6.79
Patchy low relief reef with macroalgae and coral at CF-07-CF-10



Photo credit: Tetra Tech Coffey

Plate 6.8
Saddled butterfly fish (*Chaetodon ephippium*),
redfin butterflyfish (*Chaetodon lunulatus*) and
macroalgae at CF-07-CF-10



Photo credit: Tetra Tech Coffey

Plate 6.81
Macroalgae, patchy coral growth and low
complexity reef at CF-07-CF10



Photo credit: Tetra Tech Coffey

Plate 6.82
Benthic habitat at CF-11 showing degraded reef,
moorish idol (*Zanclus cornutus*), patchy coral
and small damselfish (*Dascyllus* sp.)



Photo credit: Tetra Tech Coffey

Plate 6.83
Reef habitat and corals at CF-12



Photo credit: Tetra Tech Coffey

Plate 6.84
Coral rubble at CF-12



Photo credit: Tetra Tech Coffey

Plate 6.85
Expansive *Pavona clavus* colony at CF-14



Photo credit: Tetra Tech Coffey

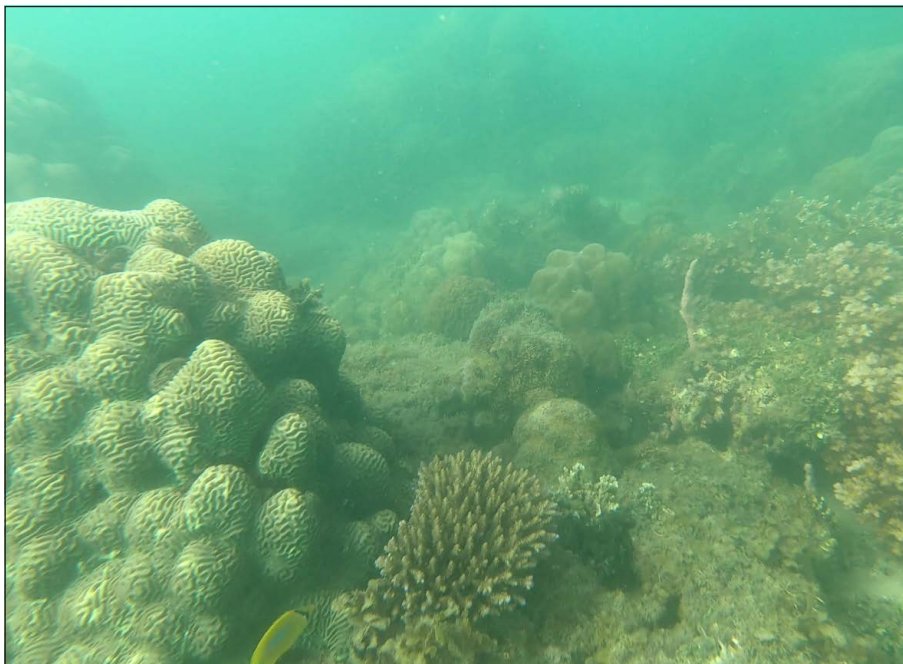


Plate 6.86

Reef habitat, various hard corals and blue-blotch butterflyfish (*Chaetodon plebius*) at CF-16



Plate 6.87

Intact reef and various corals at CF-17

While most sites typically comprised the scattered, low densities of live hard coral growth described above, alongside gorgonians, sponges, tunicates and cnidarians (such as anemones), large corals do persist either as isolated solitary colonies or among areas of moderately complex reef habitat. The qualitative assessment of video imagery showed that the highest coral coverage was generally present at sites further from shore including CF-03, CF-04, CF-07, CF-10, CF-11, CF-13, CF-16 and CF-17; the latter site being the location of vibrant, healthy tracts of complex reef with near continuous cover of live coral.

The most readily recognisable hard corals identifiable from video records were various *Acropora*, *Faviid*, *Porites*, *Pocillopora* and *Seriatopora* species. Some smaller colonies belonging to other genera could not be easily identified from video records, and others were also more conspicuous at deeper sites and at locations where the reef was of greater complexity. This includes the high coral cover and diversity present at Idihi Island (CF-17), and at site CF-14 where an extremely large *Pavona clavus* colony exists that has been documented since the PNG LNG Project EIS studies first observed this colony (Coffey Natural Systems 2008) and during subsequent monitoring studies. The *Pavona clavus* colony was previously deemed globally significant due to its uncommonly large size (over 15 m across, 3 m high), age (potentially in the range of 150 to 300 years (Coffey Natural Systems 2008) and the extent of live coral cover and associated fish abundance. The repeat observations in 2019 (see Plate 6.85) indicate that it retains these characteristics. While this species is common across a very large area and is not endangered or under threat, it is significant and provides a degree of local ecological connectivity and habitat for various other species including snapper (Lutjanidae), damselfish (Pomacentridae) and anthias (specifically Pseudanthias, not observed elsewhere in Caution Bay).

Soft corals mainly comprised *Sinularia* and *Sarcophyton* species. The notable presence of occasional large barrel (*Petrosiidae*) and other sponges and gorgonians (including dense aggregations of *Junceella* sp.) was also observed.

The IUCN Red List (IUCN, 2023) has identified one coral species classified as EN (*Cantharellus noumeae*), and 86 species classified as VU, with distributions that overlap Caution Bay. The IUCN Red List designations for corals were based on a paper which evaluated species based on the best scientific information available at the time against the IUCN Red List criteria (Carpenter et al. 2008). In the case of corals, threatened species known from the Gulf of Papua and Milne Bay ecoregion with a good probability of being present at Caution Bay are of most relevance to the assessment of conservation significance. There are no known endemic coral species in all of Papua New Guinea (including the Gulf of Papua or Milne Bay ecoregions), let alone at Caution Bay Island (Veron et al. 2016). While population data are not available for most corals, all known corals likely to be present at Caution Bay have large ranges with populations elsewhere across the tropical Indo-Pacific.

Cantharellus noumeae is found in water depths of 10 to 20 m, close to sediment in sheltered bays. It is stated that *Cantharellus noumeae* is endemic to New Caledonia, has a restricted range size and is naturally rare (Hoeksema et al. 2008). The IUCN Red List information is inconclusive for this species, as the species distribution map indicates its presence in the Gulf of Papua (including Caution Bay) and the IUCN geographic range notes that while it is reported from Milne Bay Province (Allen et al. 2003), it is also stated that this is unconfirmed and not included in the current distribution (Hoeksema et al. 2008). In published Corals of the World distribution maps its presence is confirmed in the western and central marine regions of PNG, but not the Gulf of Papua where Caution Bay is located (COTW 2022). There are Miocene fossil records for the species from Indonesia (Hoeksema, 1989).

6.7.2 Quantitative analysis

Nearshore characterisation surveys were conducted in 2007 and 2008 by Coffey Natural Systems to inform the PNG LNG Project EIS (Coffey Natural Systems, 2008; 2009) and assessed coral cover, species abundance and coral reef community composition in Caution Bay. The studies indicated that hard coral cover in the nearshore marine areas adjacent the PNG LNG Project marine facilities (i.e., the jetty area, shipping

access channel and offshore pipeline routes) was typically low and very patchy, ranging between 21% to 61% across seven survey sites. The selection of sampling sites was not random (i.e., sites were selected for areas of higher coral cover) and did not provide a broader representation regarding coral cover over the entirety of the fringing reefs.

The lowest abundance of coral cover (21 %) occurred at site CF-7. Large areas of coral rubble and bare substrate were observed at this site which may have been due to impacts associated with local villages employing dynamite fishing techniques and the exposure of the reef top during low tide to sedimentation from wave and current action. However, this site had the second highest diversity (diversity index of 1.91) with nine different types of hard corals identified along the 6 m transect. CF-7 also had the highest cover of *Halimeda* (calcareous green algae), which are amongst the most abundant macrophytes in tropical habitats. Massive *Porites* sp. corals dominated the reefs that were surveyed, accounting for between 8% and 88% of the hard coral cover at all sampling locations. While a greater diversity of *Acropora* spp. coral was also observed, rates of coverage were lower. Branching *Acropora* coral, although usually dominant on tropical coral reefs, was observed infrequently during the study.

Live soft corals represented a small proportion of reef substrate at all coral transect sites and ranged from 0.4% (CF-3) to 4% (CF-6). The most observed soft coral species within Caution Bay were gorgonian sea fans, *Dendronephthya* sp. and sea whips (*Junceella frailis*).

The major substrate type across all sampling sites combined was abiotic lifeforms such as dead coral, rubble, and sand (Coffey Natural Systems, 2008). Abiota contributed over 55% of total percentage substrate composition at five of the seven sampling sites. The high abundance of abiotic features on the reef was not considered unusual but indicated their poor overall condition. It was also noted that despite protection from ocean swells, the fringing reefs in Caution Bay are exposed to sediment mobilisation from wind-induced waves during storms and extended periods of south-east trades. Additional coral reef damage may have been due to extensive local dynamite fishing and/or overfishing pressures (often indicated by higher abundance of *Diadema* sp. sea urchins) (Coffey Natural Systems, 2008).

From a qualitative/observational perspective, the 2019 survey showed no clear increases in the abundance of dead or diseased coral compared to surveys conducted between 2010 and 2014, or signs of the recent occurrence of these aspects. No changes to species abundance or diversity or large-scale or ecologically significant changes were evident from video footage or remote imagery in 2019.

Similar to the findings regarding percent cover analysis at seagrass sites, the general pattern in abundance and distribution of living coral colonies in 2019 appeared to be relatively consistent and comparable with observations made during surveys conducted in 2011, 2012 and 2014 (and notwithstanding the slight differences in transect alignments, and consideration of natural coral growth and attrition rates).

Appendix F includes figures showing the abundance of each category at the 'coral and fish' sites assessed in 2019. These include comparisons of the abundances of key categories at each coral and fish site in the five surveys conducted in 2010, 2011, 2012, 2014 and 2019. The largest change in coral percentage cover was at site CF-11, where an increase from approximately 22% to nearly 70% (the highest proportion of coral at any site, followed by 60% at CF-03) was recorded. The largest decrease occurred at site CF-17 (65% to 40%). The lowest per cent cover was recorded at CF-14 (approximately 12%) and CF-15 (18%).

The nMDS plot for coral and fish sites between 2010 and 2019 is shown in Appendix F. The Kruskal stress for the plot was 0.15 and indicates the plot provides a reliable representation of differences between sites (Clarke and Warwick 1994). The factors explaining the form of the plot can be found by examining the univariate data for coral fish sites. Points (site time) to the extreme left of the MDS plot were characterised by a high proportion of unconsolidated seabed. Points in the upper right of the plot were characterised by high macroalgae cover. Points to the lower right of the plot were characterised by low macroalgae cover. Points in the mid-right of the plot were characterised by higher coral reef cover. The relative locations of most sites have been similar over all the sampling periods, indicating that substantial change in coral cover over time is

not apparent (such as with sites CF-03, CF-07, CF-11, CF-12, CF-14, CF-15). Sites CF-09, CF-10 and CF-16 show an increase in macroalgae cover in 2019 compared to prior years.

As with seagrass, the proportion of unconsolidated substrate along video transects is typically the inverse of the proportion of transects with live coral. This is clearly apparent in the case of CF-11 between 2014 and 2019.

6.7.3 Summary of coral and fish site habitat survey results

The survey results from the coral and fish sites are summarised as follows:

- Coral and fish sites were characterised by a mosaic of habitat types and ecological complexity (species abundance and diversity) that was typically proportional to the extent of the intact three-dimensional structure of the observed habitats. The following general habitat features were often present at various locations within the same site, ranging from:
 - Relatively flat seabed with extensive coral rubble
 - Patchy, low-relief hardstand calcareous rock, with some larger isolated coral bommbora
 - Large contiguous outcrops of hardstand reef/rock substrate, usually interspersed with or fringed by boulders, rubble and sand.
- Characteristics of the coral and fish monitoring sites were similar in 2019 to those observed in earlier surveys, particularly the 2014 survey. No noteworthy visual changes to species abundance or diversity or to the ecological values at these monitoring sites were detected.
- A visual assessment of video footage did not indicate any substantial changes (such as coral-algal phase shifts, evidence of recent damage, disease or coral bleaching, no crown-of thorns-starfish infestations or other invasive species infestations). No alterations to species abundance or to the ecological structure or functionality of the ecosystem were apparent, particularly compared to the observations made during the most recent survey conducted in 2014.
- The ecological composition of the coral and fish sites varied between sites due to the heterogenous nature of the marine habitats within Caution Bay, particularly as it relates to depth and distance from shore, and the use of spatially random sampling.
- Live corals were usually sparsely distributed and observed to be healthy i.e., no sign or minimal sign of bleaching or disease in most colonies. Hard substrates not supporting hermatypic reef-building coral colonies were usually colonised by encrusting, filamentous turf and macroalgae (e.g., red coralline algae, *Halimeda*, *Turbinaria*, *Sargassum*). Minor sedimentation was only observed on low lying, fragmented coral reef/rubble.
- The most extensive areas of complex reef structure were again observed further from shore (e.g., CF-02, CF-03, CF-12, CF-13, CF-17). This pattern remains consistent with observations from 2014 and appears to indicate that these sites are less affected by natural wave induced resuspension of sediment and freshwater runoff than the sites closer to shore. These sites are also less likely to have been affected by human pressures such as fishing, boat anchoring or prior construction activities in shallower waters. The sites also retain greater three-dimensional reef habitat (higher rugosity) and other biogenic habitat for reef fish and have a greater diversity and abundance of invertebrate species than the sites closer to shore.
- The increased proportion of sediment observed in 2012 at monitoring sites close to the jetty and pipeline construction activities, also seen to have reduced in 2014, was not observed in 2019.
- Most MDS plots show no major separation of the coral and fish habitat types over the sampling periods, with the exception of a higher proportion of macroalgal cover at sites CF-09, CF-10 and CF-16.
- The most notable changes in live coral per cent cover between 2014 and 2019 (the large increase at site CF-11 and decrease at CF-17) are likely the result of differences in transect alignment.

- The increase in per cent cover of macroalgae at sites CF-09, CF-10 and CF-16 are likely the result of differences in transect alignment as well as an increase in macrophyte biomass.
- Over the >10-year duration of the studies, the main indicators of the condition of the marine environment have remained generally very consistent over time, notwithstanding the period of construction and operation of the PNG LNG Plant facility, the proximity to expanding marine activities of Port Moresby, and extensive utilisation of fishery resources.
- While the clarity of nearshore waters has been variable, though typically low since the initial studies, the clarity and condition of marine ecosystems progressively improves with increasing distance and depth from the shore into Caution Bay.

6.8 MARINE FAUNA

This section summarises the marine fauna observed within the study area at:

- Coral and fish and seagrass sites
- Along the PNG LNG pipeline route and proposed Papua LNG pipelines route options
- In the CALM buoy locations and along the associated naphtha and condensate pipeline routes

This section also summarises the findings of a desktop review focused on species of conservation significance.

6.8.1 Fish

The fish fauna of Caution Bay relevant to the Project, and assessed during various studies between 2007 and 2022, is described in this section.

6.8.1.1 PNG LNG Project

The fish assemblage observed during PNG LNG Project surveys in December 2007 and April 2008 respectively were of small-sized reef fish (i.e., less than 10 cm), with smaller numbers of medium (i.e., 10 to 20 cm) and large (i.e., greater than 20 cm) sized reef fish. These observations comprised mostly reef-associated, generalist species including damselfish (Pomacentridae), wrasse (Labridae), surgeonfish (Acanthuridae), bream (Nemipteridae), butterflyfish (Chaetodontidae) and dwarf angelfish (Pomacanthidae). These fish are typically active during the day and often conspicuous, generally aggregating around static habitat features, with most observations seen near intact live coral formations. Other common fish families such as threadfin bream, surgeonfish and larger types of wrasse such as tuskfish were mostly seen at the more complex reef sites, and occasionally appeared in schools, across the study area. Only butterflyfish and damselfish were observed at all sampling sites during both field studies.

A total of 1,280 (2007) and 1,825 (2008) fish were recorded across seven sites in Caution Bay. The difference in fish abundance was mainly due the clearer water conditions encountered during April 2008, particularly inshore, enabling divers to observe fish more effectively. Such notable temporal variation was less likely to represent seasonal movements, as most of the species were resident on the reef.

The lowest density and biomass of reef fish of all the sampling sites was observed at site CF-7. This site also had the lowest abundance of hard coral, suggesting a direct correlation between fish abundance and coral cover. Sites CF-6 and CF-7, situated closest to the proposed marine facilities, had the lowest combined biomass across all sampling sites, although from the limited survey data to date, differences between the inshore reef sites would not be significant. In contrast, Site CF-4 at Idihi Island had the highest combined biomass (10.7 g/m² and 29.9 g/m² during December 2007 and April 2008 respectively) across all sampling locations. This was not unexpected as the higher structural complexity of coral forms at Idihi Island provides shelter, food, and refuge for reef fish.

Larger predator fish groups, such as snappers, emperors, groupers, and sharks, were absent or very rarely seen. This is consistent with the heavy reef usage determined in the survey of resource utilisation within Caution Bay (Coffey Natural Systems 2009). Larger reef fish were present at Idihi Island.

6.8.1.2 Coral and fish and seagrass monitoring sites

The fish communities associated with the marine habitats surveyed Caution Bay in 2019 primarily comprised a range of small, mostly reef-associated generalist species, present as small schools or individuals.

Fish abundance was highly variable between sites, though fish were present at all transects. Damselfish (Pomacentridae), wrasse (Labridae), surgeonfish (Acanthuridae), bream (Nempiteridae), butterflyfish (Chaetodontidae) and the dwarf angelfish (Pomacanthidae) were the most consistently conspicuous fish families/species observed across the sites, and this pattern was very similar to observations made during 2010, 2011, 2012 and 2014 (Coffey Environments 2010; 2011; 2012; 2014a). The Caution Bay fish fauna appeared to be stable and consistent with observations from previous surveys in terms of the types of species present and their association with healthy, intact sections of reef and live coral. As with previous surveys, most reef-associated and reef-attached fish such as damselfish, anthias, small wrasse and butterflyfish were seen near intact coral formations. These fish are typically active during the day and often conspicuous, generally aggregating around static habitat features. Other common fish families, such as threadfin bream, surgeonfish, and wrasse (common residents on coastal fringe reefs throughout tropical areas) were mostly seen at the more complex reef sites, and occasionally appeared in schools. Goatfish (Mullidae), pufferfish (Tetraodontidae) and triggerfish (Balistidae) were observed less commonly.

Areas of greater three-dimensional reef habitat and intact reef structure provide habitat for a wider variety of fish as well as greater diversity of associated invertebrate species, and fish populations were larger and more diverse at reefs further from the coast (at sites CF-01, CF-03, CF-11 to CF-14, and CF-17). Juvenile grouper (Serranidae) and snapper (Lutjanidae and Lethrinidae) were present at locations such as CF-17, where the reefs provide higher habitat value for reef-associated species, particularly schooling species. Site CF-02 in 2019 was also observed to have a slightly higher abundance of fish around the sections of intact reef observed along the transect, compared with 2014.

Fish populations were generally observed to be smaller and less diverse at the lower-quality reefs along the shoreline (CF-07, CF-09, CF-10 and CF-16). These sites generally lack a high degree of complex three-dimensional structure associated with reef-forming coral growth and therefore attract fewer numbers of fish. Being closer to shore, these sites may be subject to environmental perturbations such as suspended sediment. An increase in fish abundance was observed at sites CF-04 and CF-15 compared to the 2014 survey. This is likely due to the towed video passing closer to intact coral reef, and consequently a wider variety of fish, particularly small reef-attached damselfish (Pomacentridae) were seen.

As with the 2014 survey (Coffey Environments 2014a), the relative abundance of each taxa at each coral and fish site was also estimated (Appendix H).

6.8.1.3 PNG LNG pipeline

Fish fauna observations from the tow camera footage along the PNG LNG pipeline route were sparse, i.e., few fish were observed in the review of video footage. The main observations included the moorish idol (*Zanclus cornutus*), some damselfish (Pomacentridae), butterflyfish (Chaetodontidae) and bream (*Scolopsis* sp.). Other smaller fish were seen but could not be identified, possibly due to evasive behavioural responses in the presence of the towed video camera.

Fish fauna had been observed during prior surveys along the PNG LNG pipeline route, with members of the dartfish (Ptereleotridae), dragonet (Callionymidae), goby (Gobiidae), jawfish (Opistognathidae), lizardfish (Synodontidae), sand diver (Trichonotidae), sandperch (Pinguipedidae) and tilefish (Malacanthidae) families known to closely associate with and inhabit soft/sandy seabeds and associated burrows.

6.8.1.4 2019 Papua LNG pipelines route options survey

Fish were not observed in video imagery from 2019 for most of the previously proposed Papua LNG pipelines route (i.e., where soft sediment habitats were present at depths beyond 10 m). Where reef habitat was identified in deeper waters, the associated fish fauna was amongst the most abundant and diverse observed during the study. Large schools of fusiliers, and smaller schools of surgeonfish and other reef-associated species were conspicuous near healthy corals. This fauna mainly included various members of the goatfish, grouper, snapper, angelfish, parrotfish, and butterflyfish families. No rare or conservation significant (i.e., listed on the IUCN Red List as CR, EN or VU) species were identified from a review of video records. Individual coral species were not able to be identified to species level using towed video. Closer to shore, the proposed pipeline routes intersect the coastal fringing reef at depths of 4 m to 8 m. In these locations, similar assemblages of small reef-associated fish, similar to those present at other survey locations in Caution Bay (such as Coral and Fish monitoring sites), were observed.

6.8.1.5 2022 survey

Fish were largely not observed in video imagery collected in 2022 along the naphtha and condensate pipeline routes and in the CALM buoy location. This was likely due to the general absence of well-developed subsea habitat features, given that the transects traversed mostly muddy, silty, soft sediment seabed characterised mainly by benthic burrows and shell grit, particularly in water beyond 10 m depth.

In some locations along the Papua LNG pipeline route 15F (such as REEF-3), where coral reefs and more complex habitat were observed, typically small reef-associated and reef-attached fish were also present. Fish fauna included various schooling chromis and damselfish (Pomacentridae), dwarf angelfish (Centropyge), cleaner wrasse (*Labroides dimidiatus*), anthias (Pseudanthias), schooling fusiliers (Caesionidae), rabbitfish (Siganidae), butterflyfish (Chaetodontidae) and juvenile grouper (Serranidae). Based on data from drop camera transects and sonar, locations of established reef habitat where fish were observed are likely to represent less than 5% of the overall pipeline route area.

At the LNG Plant jetty pylons, small schools of five-lined surgeonfish (*Acanthurus grammoptilus*) and trevally (*Caranx* sp.), western king wrasse (*Coris auricularis*) and longfin bannerfish (*Heniochus acuminatus*) were observed in close association with the pylons. The absence of sightings of large trevally (in particular) elsewhere in the vicinity of the jetty in Caution Bay suggests that these structures provide additional habitat to support fish and other fauna. Schooling trevally and macrophyte colonisation encountered at a jetty pylon are shown in Plate 6.88.

Although not observed during the 2019 and 2022 surveys, fish fauna listed as either CR, EN or VU on the IUCN Red List (accessed 10 November 2022) that have distributions overlapping Caution Bay that were identified in a geographic search centred on the LNG Plant jetty include:

- Camouflage grouper (*Epinephelus polyphekadion*): listed as VU on the IUCN Red List.
- Squaretail coral grouper (*Plectropomus areolatus*): listed as VU on the IUCN Red List.
- Brown-marbled grouper (*Epinephelus fuscoguttatus*): listed as VU on the IUCN Red List.
- Harlequin filefish (*Oxymonacanthus longirostris*): listed as VU on the IUCN Red List.
- Green humphead parrotfish (*Bolbometopon muricatum*): listed as VU on the IUCN Red List.
- Shortjaw bonefish (*Albula glossodonta*): listed as VU on the IUCN Red List.
- Four-spined glass perchlet (*Tetracentrum apogonoides*): listed as VU on the IUCN Red List.
- Indo-Pacific sailfish (*Istiophorus platypterus*): listed as VU on the IUCN Red List.
- Papuan rainbowfish (*Melanotaenia papuae*): listed as VU on the IUCN Red List.

- Threespot grunter (*Hephaestus trimaculatus*): listed as VU on the IUCN Red List.
- Spiny seahorse (*Hippocampus histrix*): listed as VU on the IUCN Red List.

6.8.1.6 Summary of fish fauna

Most observations of fish fauna within Caution Bay from 2008 to 2022 have typically comprised small-sized reef-attached and reef-associated fish, been recorded in the vicinity of reef habitat, and included species from common groups such as damselfish (Pomacentridae), dwarf angelfish (Centropyge), surgeonfish (Acanthuridae), wrasse (Labridae), threadfin and monocle bream (Sclopsis / Nemipteridae) and butterflyfish (Chaetodontidae).

While a detailed fish fauna study was not conducted during the 2019 and 2022 field surveys, given the proximity to previous study areas, it is likely that the potentially extant fish fauna present in the Project area of influence is similar to that encountered during PNG LNG Project studies and other marine and resource use investigations (Coffey Natural Systems 2008, 2009, Coffey 2019). Prior records have therefore largely been used to infer the current context.

The reefs within Caution Bay have previously been referred to as the ‘nursery reefs’ by people from local communities inhabiting the coastal regions of Caution Bay (Coffey Natural Systems 2009). In general, observations of larger reef predators, such as snapper (Lutjanidae), jack (Carangidae), grouper (Serranidae), and sharks (Carcharhinidae) have been rare across all survey locations. This general absence of large marine fauna may be due to the general absence of large tracts of complex, undisturbed and intact reef habitat in survey areas, as well as fishing pressure (Coffey Natural Systems 2008). Fish catch more broadly however, from villages in and around Caution Bay, as documented in Coffey (2020a) has included some larger species and been dominated by species from the family Carangidae (jack mackerel and scads) and Lethrinidae (bream, emperor bream and emperor). Spawning grounds for coral trout, hammerhead sharks and finger mark bream are thought (by local people) to occur along the Caution Bay coast. None of these species were observed during dive surveys for the PNG LNG Project (Coffey Natural Systems 2009) or during the 2019 or 2022 surveys.

As part of the literature review, data from the Papua LNG Project Marine Biodiversity Baseline Report (BMT WBM 2017) was also reviewed. Findings from baited remote underwater video station (BRUVS) deployments in January 2017 indicated that a total of 42 fish species were identified across three BRUVS located on reefs throughout Caution Bay. Reef fish assemblages were dominated by damselfish (Pomacentridae), wrasses (Labridae), Butterflyfish (Chaetodontidae). Representatives from several other families were also identified including squirrelfish (Holocentridae), goatfish (Mullidae), monocle bream (Nemipteridae), triggerfish (Balistidae) and pufferfish (Tetraodontidae).

Information on the fishes of pelagic waters beyond a barrier reef off the village of Barakau, 20 km east of Port Moresby (Raga 2006), also provides useful comparative data for Caution Bay. Pelagic fishes observed in this area included chevron barracuda (*Sphyraena genie*), rainbow runner (*Elagatis bipinnulata*), Spanish mackerel (*Scomberomorus commersoni*) and a trevally (*Caranx* sp.). Local fishermen (and more rarely fisherwomen) using trolling methods in this area reported mainly catching the following species: bonito (*Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacares*), giant barracuda (*Sphyraena barracuda*), giant trevally (*Caranx ignobilis*) and rainbow runner. Deep-sea catches include long-nosed emperor (*Lethrinus elongatus*), red emperor (*Lutjanus sebae*), red snapper (*Lutjanus* sp.) and coronation trout (*Variola louti*). The deeper water fish communities of the study area (i.e., around Lagava Island in the north of Caution Bay and Redscar Bay) have not been surveyed specifically, either between the barrier reef and fringing reef, or in the pelagic zone.

Plate 6.88
Schooling fish (trevally) and macrophyte
colonisation at LNG Plant jetty pylon



Photo credit: Tetra Tech Coffey

The commonality of fish observations, fish abundance and fish diversity have been highly spatially variable between survey sites, with these factors positively associated with areas of greater three-dimensional complexity and intact reef structure. This is due an increased availability of habitat for a wider variety of fish, as well as greater diversity of associated invertebrate species, compared with areas of bare seabed. Fish fauna observations were generally infrequent during the 2019 and 2022 field survey video transects along pipeline alignment options in waters beyond approximately 10 m depth, where silty seabed substrates were predominant, and habitat is limited. In locations with low visibility, fish fauna observations were very rare.

There is a broad body of literature that describes a tight linkage between habitat complexity and reef fish abundance (Komyakova et al. 2013, Khan et al. 2017; Wimser et al. 2019). At the local scale, various factors appear to be explanatory in the context of the relatively low diversity and abundance of fish and other biota observed during the field survey, as well as the known prior effects of human impacts such as fishing pressures and dynamite usage. Oakley-Cogan et al (2020) note that experimental manipulations have indicated that holes/crevices are directly related to increases in local prey populations, as they provide suitable areas of refuge. In contrast, while in the presence of a predator decoy, herbivores opted to forage in lower complexity areas, suggesting a preference for enhanced field-of-view to detect potential predators. The density of suitable refuges, and the amount of field-of-view, can therefore shape the likelihood of a successful predatory attack and the probability that prey will escape. A trade-off exists between having access to suitable refuges to shelter from predation versus being able to detect a predator sooner, allowing for greater flight initiation distances. The specific strategy fishes adopt to avoid predation is likely to relate to their biology, as well as the nature of the predators they are trying to avoid. While predation risk may be mediated by the characteristics of a given habitat, field of view and access to refugia are two facets of predation risk. Predation risk can also include predator abundance, species-specific behaviours, and diurnal predation rates.

No reef-attached fish species are known to be migratory, although larger predator species such as reef sharks and trevallies may have larger home ranges than most reef fish. The formation of spawning aggregations at specific locations and times is a common mode of reproduction for species in some tropical reef fish families, such as groupers (Domeier and Colin, 1997), though there is no information available on whether Caution Bay supports any such spawning aggregation sites, or for which species and in what numbers, if so. These areas are often well recognised due to their predictable patterns of aggregation, meaning they are targeted by fishing activities. The species of fish typically inhabiting the coral reefs of Caution Bay, and Papua New Guinea more broadly, are widely distributed throughout the tropical Indo-Pacific, and there are no species known to be endemic or restricted to Caution Bay (IUCN, 2023).

6.8.2 Cetaceans and marine mammals

Twenty species of cetacean are recorded from Papua New Guinea, and all are widely distributed in tropical seas. Some of these species may utilise the waters in the study area although published data specific to cetaceans in Caution Bay is limited, as is knowledge on marine mammals in Papua New Guinea more generally (Haywood et al. 2012). While these species may be present from time to time, Caution Bay does not appear to hold feeding or calving areas of whale congregation.

During the 2019 survey, and earlier surveys (Coffey Natural Systems 2008), opportunistic observations of dolphins (species undetermined) were made. No endemic species of marine mammal were identified during the 2019 or 2022 field surveys. The bottlenose dolphin (*Tursiops truncatus*) and common dolphin (*Delphinus delphis*) have also been observed at the LNG Plant, including around the LNG Plant jetty¹¹.

¹¹ Various findings are provided in the PNG LNG Project annual environment and social reports, e.g.: https://pnglng.com/media/PNG-LNG-Media/Files/Environment/Environment%20and%20Social%20reports/Q3_2013_ES_Full_Report.pdf and <https://pnglng.com/media/PNG-LNG-Media/Files/Environment/Environment%20and%20Social%20reports/Q3-2012-ESR-Full.pdf>

The Australian snubfin dolphin (*Orcaella heinsohni*) and the Australian humpback dolphin (*Sousa sahulensis*), (listed as VU on the IUCN Red List) have distributions that overlap Caution Bay. These species occur mainly within shallow, protected coastal and estuarine habitats. In Papua New Guinea, snubfin dolphins are known to inhabit the Kikori Delta from Morigio Island east to Baimurru. It is likely that they also occur further east to Karema, which is situated at the headwaters of the Purari River. There is no evidence available to suggest that these species are present in Caution Bay.

Other species may be present that have not been confirmed through direct observation include the pantropical spotted dolphin (*Stenella attenuata*), spinner dolphin (*Stenella longirostris*), and Indo-Pacific bottlenose dolphin (*Tursiops aduncus*). If present, all are likely to inhabit Caution Bay on a transient or sporadic basis, rather than be resident.

Dugong (*Dugong dugong*) have a distribution that overlaps the study area and are protected under the PNG *Fauna (Protection and Control) Act 1976* and listed as Vulnerable (VU) on the IUCN Red List (Marsh et al 2019). While possible dugong feeding areas are present due to the seagrass that exists in Caution Bay, there is no available evidence to suggest resident populations are present in the study area and no indication of site-dependence or other established resident populations have been observed. During PNG LNG Project EIS (Coffey Natural Systems 2009) surveys it was noted from discussions with local people that dugong do not occur in Caution Bay and are 'rarely caught'. No dugong feeding trails were observed in the seagrass beds during these surveys.

The Pacific Year of the Dugong was launched in Daru, PNG, on 24 March 2011. Daru was selected as the launch location because of the high cultural significance of dugongs to the coastal villages in the Western Province of Papua New Guinea; no similar measures or initiatives exist for Caution Bay. Underestimated populations of the coastal waters of northern Australia number at least 70,000 individuals (Marsh et al. 2019); the population at Caution Bay would need to be at least 400 to constitute 0.5% of this total.

The absence of, for example, documented concentrations of dugong or other marine mammal feeding or breeding activity, or other clear evidence that Caution Bay is a location of importance for migratory or congregatory species indicates that the location is not a known agglomeration location for megafaunal species. While absence of evidence may not constitute evidence of absence, substantial aggregations of various species of conservation significance are documented elsewhere, including in Indonesia and elsewhere in Papua New Guinea (such as leatherback turtles in the Huon Gulf; which are discussed in the Wafi-Golpu Project EIS¹²). These locations have received corresponding levels of attention and associated conservation and management actions. Conversely, given that Caution Bay is a relatively well studied location, i.e., several field studies have occurred in the area and a human presence is well established, this does suggest that such significant aggregations are not present in this location.

6.8.3 Chondrichthyes

Scientific knowledge of the biodiversity of sharks in PNG is limited. The first field guide (White et al. 2017b) for identifying and describing sharks of PNG was published in 2017 and indicated that the populations and distributions of sharks in Papua New Guinea is largely unknown.

The first detailed examination of shark species biomass caught from an artisanal fishery in Milne Bay Province was published in 2018 (Appleyard et al. 2018). These studies provide current insight to shark community compositions; however, minimal historical information is available to characterise the sharks found or fished in the Caution Bay region.

Appleyard et al. (2018) found that the artisanal fishery in Milne Bay Province mostly caught the grey reef shark (*Carcharhinus amblyrhynchos*, listed as EN) and the blacktip reef shark (*Carcharhinus melanopterus*). Like most Chondrichthyes, these species are important for marine ecosystems and are under substantial

¹² <https://www.wafigolpujv.com/eis987654321>

harvesting pressure, resulting in fisheries-driven population declines. Appleyard et al. (2018) indicated that 21% of the species caught and identified were IUCN listed as VU or EN, 8% of which was attributed to the scalloped hammerhead (*Sphyrna lewini*, listed as EN).

No sharks were identified during the PNG LNG Project EIS nearshore marine surveys in 2008, even though reef sharks, being the apex predators of coral reef ecosystems, were expected to be present during the survey.

Apart from the Papuan epaulette shark (*Hemiscyllium hallstromi*) and the giant guitarfish (*Glaucostegus typus*) no conservation significant species of cartilaginous fish (Chondrichthyes) were observed during the 2019, 2022 or earlier field surveys in Caution Bay.

Although not observed during surveys, an IUCN Red List search with a radius of 30 km centred on the seaward extent of the LNG Plant jetty, indicates that various other Chondrichthyes of conservation significance have ranges including Caution Bay, the most relevant of which are summarised below.

6.8.3.1 Sharks

- Scalloped hammerhead (*Sphyrna lewini*): Listed as CR on the IUCN Red List. This is a coastal and semi-oceanic pelagic species with a wide distribution (Rigby et al. 2019a). It occurs in most tropical and warm temperate waters from the surface and intertidal zone to depths of 1,043 m. The species is caught globally as target and bycatch in pelagic commercial and small-scale longline, purse seine, and gillnet fisheries, and is retained for the meat and fins. The weighted global population trend estimated median reductions of 76.9 to 97.3%, with the highest probability of >80% reduction over three generation lengths (72.3 years).
- Great hammerhead (*Sphyrna mokarran*): Listed as CR on the IUCN Red List. Similar to *Sphyrna lewini*, this coastal and semi-oceanic pelagic shark is wide-ranging in tropical in warm temperate seas to depths of 300 m. It is caught globally as target and bycatch in coastal and pelagic large- and small-scale longline, purse seine, and gillnet fisheries, and is often retained for the fins. It has a long lifespan of up to 44 years and only breeds once every two years, which combined with high bycatch mortality, makes it susceptible to depletion where it is taken in unmanaged fisheries. There is a lack of data from the Pacific, limited regional representation of some time series, intensive fisheries in data-poor regions that are suspected to have driven significant declines, and uncertainty about levels of exploitation that are potentially similar to those of *Sphyrna lewini* (Rigby et al. 2019b).
- Northern river shark (*Glyphis garricki*): Listed as CR on the IUCN Red List. Known to inhabit turbid freshwater rivers, brackish estuaries, and adjacent coastal marine waters. In PNG waters, both species are known from very few records. Data on population and distribution is limited and no records are available for the study area, although the species may be present (White et al. 2015). The northern river shark was first recorded from PNG in the 1960s, but not recorded again until 2014 during field surveys to Daru and Katatai in Western Province.
- Speartooth shark (*Glyphis glyphis*): Listed as EN on the IUCN Red List. Known to inhabit turbid freshwater rivers, brackish estuaries, and adjacent coastal marine waters. In PNG waters, both species are known from very few records. Data on population and distribution is limited and no records are available for the study area, although the species may be present (White et al. 2015).
- Grey reef shark (*Carcharhinus amblyrhynchos*): Listed as EN on the IUCN Red List (Simpendorfer et al. 2020). The species is found in clear tropical waters from the surface to depths of around 280 m and is common around coral reefs, particularly near drop-offs and fringing coral reefs. Its distribution is patchy in continental shelf waters.
- Shortfin mako shark (*Isurus oxyrinchus*): Listed as EN on the IUCN Red List (Rigby et al. 2019). Wide-ranging coastal, neritic, oceanic, epipelagic, and mesopelagic species found globally in tropical and warm-

temperate seas to depths of approximately 890 m. Likely to be present along the coastal zone of the study area at various times.

- Pelagic thresher (*Alopias pelagicus*): Listed as EN on the IUCN Red List. The species is a wide-ranging Indo-Pacific pelagic shark that occurs from the surface to depths of 300 m. Across its distribution, the species is estimated to have reduced by 50 to 79% over the last three generations (55.5 years) (IUCN 2021).
- Whale shark (*Rhincodon typus*): Listed as EN on the IUCN Red List. Reports by local fishermen (Coffey Natural Systems 2008) noted that the species is observed occasionally beyond the fringing reef in Caution Bay. Whale sharks have a pan-tropical distribution (Pierce and Norman 2016).
- Winghead shark (*Eusphyra blochii*): Listed as EN on the IUCN Red List. Found in mostly shallow waters of the coastal and continental shelves in the Indo-west Pacific from the Persian Gulf to Papua New Guinea and northwards to Taiwan. Not evenly distributed throughout its range, with most sharks focused around major river outflows (White et al. 2017b).
- Sharptooth lemon shark (*Negaprion acutidens*): Listed as EN on the IUCN Red List. Resides in the tropical Indo-west and central Pacific Oceans. Generally, inshore, on or near the bottom between the surface and 30 m, with a preference for turbid, still bays, outer reef shelves and reef lagoons (SRI, 2020).
- Sandbar shark (*Carcharhinus plumbeus*): Listed as EN on the IUCN Red List. The sandbar shark is demersal and pelagic in tropical and temperate seas on the continental shelf from close inshore to a depth of 280 m. It occurs in shallow waters associated with bays, estuaries and harbours and offshore on oceanic banks (Rigby et al. 2021a).
- Zebra shark (*Stegostoma tigrinum*): Listed as EN on the IUCN Red List. This is a broadly distributed continental and insular shelf species of the Indo-West Pacific. It is usually found within a narrow band of shallow coral and rocky reef and soft bottom sandy plateau habitat, in tropical and subtropical, shallow inshore and offshore waters, at depths down to at least 62 m (Dudgeon et al. 2019).
- Papuan epaulette shark (*Hemiscyllium hallstromi*): Listed as VU on the IUCN Red List. The species is endemic (range-restricted) due to having a small distribution off the southern coast of Papua New Guinea, including Milne Bay, the Gulf of Papua and Torres Strait, (Dudgeon et al. 2016; Bray 2020). The species is typically reef-associated, living in shallow, coastal, tropical waters on seagrass beds and occasional rock and coral outcrops to depths of up to 30 mm, and found in association with coral reefs. The species limited distribution includes records mostly from the Port Moresby region, although records extend to the eastern tip of Papua New Guinea and the Torres Strait (primarily from Mer (Murray) Island, about 125 km southeast of the Papua New Guinean mainland). The species has also been recorded from Jervis Reef near Badu Island, approximately 90 km north of the tip of Cape York Peninsula (Bray 2020). Little is known about the population size in this range and no scientific data are currently available (Dudgeon et al. 2016). This species was observed among catch during the Caution Bay fisheries resource use study (Coffey 2020a).
- Graceful shark (*Carcharhinus amblyrhynchoide*s): Listed as VU on the IUCN Red List. This shark is distributed throughout coastal waters of the Indo-west Pacific. It is generally found in nearshore waters of the continental shelf to a depth of 50 m (Simpendorfer et al. 2021).
- Snaggletooth shark (*Hemipristis elongata*): Listed as VU on the IUCN Red List. A coastal species, found inshore and offshore on the continental and insular shelves (up to 130 m deep) in the Indo-west Pacific (from South Africa to the Persian Gulf, as far north as China, and south as Australia (EDGE, 2017).
- Silky shark (*Carcharhinus falciformis*): Listed as VU on the IUCN Red List. Pelagic shark found in tropical and warm temperate seas (Blackwell, 2008). It sometimes approaches coastlines but is generally found in depths of at least 500 metres.

- Milk shark (*Rhizoprionodon acutus*): Listed as VU on the IUCN Red List. Occurs in tropical, east Atlantic Indo-west Pacific waters (from West Africa to southern Japan) along the continental shelf and open ocean (inshore to 200 m) (Rigby et al. 2020).
- Bull shark (*Carcharhinus leucas*): Listed as VU on the IUCN Red List. Bull sharks favour shallow coastal waters but are fully euryhaline and amphidromous. They utilise natural rivers and estuaries as nursery grounds before migrating offshore (Rigby et al. 2021b). They are fished widely for their meat, hides, and oils.
- Pigeye shark (*Carcharhinus amboinensis*): Listed as VU on the IUCN Red List. The species occurs in the tropical, east-Atlantic-Indo-west Pacific. It generally inhabits coastal waters, occasionally entering estuaries. They often stay close to the seabed (Bray, 2017).
- Tawny nurse shark (*Nebrius ferrugineus*): Listed as VU on the IUCN Red List. This is a wide-ranging species in the tropical Indo-Pacific Ocean. This species resides on or near the bottom in sheltered areas i.e., lagoons, channels, crevices, coral and rocky reef edges, seagrass, and sand (SRI, 2022).

6.8.3.2 Rays

- Oceanic manta ray (*Mobula birostris*): Listed as EN on the IUCN Red List (Marshall et al. 2022a). The species is large (to 700 cm disc width) ray with a circumglobal distribution in tropical and temperate waters throughout the Pacific, Indian, and Atlantic Oceans in coastal and pelagic waters from the surface to a depth of 1,000 m. Aggregations are sparsely distributed and while individuals are capable of long-distance movements they do so infrequently and exhibit a degree of philopatry resulting in a high likelihood of local depletion. Global population size unknown, but local and regional abundance has been estimated and is mostly small, numbering less than 500 individuals, except for Ecuador where abundance is estimated at more than 2,000 individuals. Targeted or taken as bycatch in artisanal small-scale fisheries, as well as taken as bycatch in large-scale tuna fisheries. The species has undergone a population reduction of 50 to 79% over the past three generation lengths (87 years).
- Bentfin devilray (*Mobula thurstoni*): Listed as EN on the IUCN Red List (Marshall et al. 2022b). The species has a circumglobal distribution and is found in tropical, subtropical, and temperate waters of the Pacific, Atlantic, and Indian Oceans. The species occurs in neritic and oceanic waters from the surface to depths of 100 m and is a seasonal visitor along productive coastlines with regular upwelling, off oceanic island groups, and near offshore pinnacles and seamounts.
- Spinetail devilray (*Mobula mobular*) Listed as EN on the IUCN Red List (Marshall et al. 2022c). This is a pelagic species of *Mobula* ray with a circumglobal distribution in tropical and subtropical waters, that resides in coastal and continental shelf waters. The species spends the majority of its time in water depths of less than 50 m.
- Sicklefins devil ray (*Mobula tarapacana*): Listed as EN on the IUCN Red List. Sparsely distributed across the tropical and temperate oceans of the world. Primarily oceanic, but also found in coastal waters, and appears to be a seasonal visitor along productive coastlines with regular upwelling in oceanic island groups, and near offshore pinnacles and seamounts. The species has been observed travelling both in schools and in solitude. The global population has undergone a reduction of 50 to 79% over the past three generation lengths (38 years), with a further population reduction suspected over the next three generations due to ongoing demand for high-value products (Marshall et al. 2022d).
- Leopard whiplay (*Himantura leoparda*): Listed as VU on the IUCN Red List. The species is demersal on soft substrates and is mainly found inshore and in coastal areas though it also occurs on the continental shelf to at least 70 m depth (Rigby et al. 2016). Possibly widespread in the Indo-West Pacific, with a distribution including the Caution Bay study area.
- Reef manta ray (*Mobula alfredi*): Listed as VU on the IUCN Red List. The species has a tropical and subtropical distribution throughout much of the Indian and Pacific Oceans in coastal and pelagic waters

from the surface to 432 m deep. The global population size is not known, though some local and regional population sizes have been estimated and are mostly small, at fewer than 1,000 individuals, except for the Maldives where the population is estimated at ~10,000. While individuals are capable of long-distance movements they do so infrequently, consequently aggregations are widely separated with low connectivity resulting in a high likelihood of local depletion. The species has an extremely slow life history, producing only one pup on average every 4 to 5 years, and consequently is likely to have one of the lowest maximum rates of population increase. Marshall et al. 2022e).

- Jenkins' whipray (*Pateobatis jenkinsii*): Listed as VU on the IUCN Red List. The species has a patchy distribution in Indo-west Pacific inshore waters from southern Africa to Australia, New Guinea and north to the Philippines. Across northern Australia it can be found from Western Australia (Ningaloo reef) to the eastern Gulf of Carpentaria in Queensland (Bray, 2018). This stingray inhabits coastal waters (0 to 40 m) and is shelf demersal (40 to 200 m). Levels of exploitation are very high throughout its range in Southeast Asia and in many parts of the Indian Ocean, hence it is under a severe level of threat within most of this range (Matsumoto et al. 2020a).
- Porcupine ray (*Urogymnus asperrimus*) Although very wide ranging, this species appears to be uncommon compared to various species of dasyatid rays which are sympatric with it. Occurrence appears to be patchy with localised hotspots. Juveniles appear to be site-attached, and highly resident to small areas of shallow coastal mud and mangrove habitats. It has been recorded from coral reefs, sandy reef lagoons, beaches, mud flats and mangroves, at depths of approximately 1 m to at least 30 m (Chin and Compagno 2016).
- Mangrove whipray (*Urogymnus granulatus*): Listed as VU on the IUCN Red List. The distribution of this species includes the study area, and it appears to prefer shallow inshore waters, including mangroves, estuaries, sand flats, and broken rocky-sandy substrate, although adults may also move offshore (Matsumoto et al. 2020b).

6.8.3.3 Guitarfish and wedgefish

The IUCN Red List indicates that the following species (listed as CR) have distributions that overlap Caution Bay:

- Bowmouth guitarfish (*Rhina ancylostoma*): Listed as CR on the IUCN Red List (Kyne et al. 2019a). The species occurs from close inshore to depths of at least 70 m on the continental shelf. It occurs on or close to the seabed, mainly over sandy or muddy substrates, and also around coral reefs. The shallow, inshore soft-bottom habitat preferred by the species is threatened by habitat loss and environmental degradation.
- Bottlenose wedgefish (*Rhynchobatus australiae*): Listed as CR on the IUCN Red List (Kyne et al. 2019b). The species is widespread in the Indo-West Pacific from Mozambique to the Solomon Islands and north to Taiwan and occurs from close inshore to depths of at least 60 m on the continental shelf. Severe population reduction is inferred from actual levels of exploitation, as well as several historical accounts and contemporary datasets from Iran, Pakistan, India, Thailand, and Indonesia. While some parts of Australasia provide refuge from intense fishing effort, this proportion of the species' range is not considered to be large enough relative to the global range to lower the assessment. It is inferred that the species has undergone a >80% population reduction over the 45 years.
- Giant guitarfish (*Glaucostegus typus*): Listed as CR on the IUCN Red List (Kyne et al. 2019c). The giant guitarfish occurs from close inshore (including the inter-tidal zone and estuarine reaches of rivers) to depths of at least 100 m on the continental shelf. Although juveniles and adults are known to co-occur within inshore coastal habitats, embayments and coral reef atolls, neonates and juveniles are more common within shallow areas, including the inter-tidal zone. Upon reaching sexual maturity, the species undergoes an apparent change in habitat use as they become less frequent within inshore waters and only return to these areas on a seasonal basis, exhibiting philopatry presumably for reproductive

behaviours. This species was observed at the seagrass reference site near Idihi Island (site SG-13), approximately 15 km southwest of the LNG Plant jetty, in 2019.

6.8.3.4 Sawfish (Pristidae)

A review by White et al. (2017a) of locations where sawfish family Pristidae have been recorded in Papua New Guinea was assessed and yielded no records specific to Caution Bay. This review showed that due to the paucity of detailed catch and observational records available, both historic and contemporary, the status of most sawfishes in Papua New Guinea is largely unknown.

The IUCN Red List indicates that the following species of conservation significance (listed as CR or EN) have distributions that overlap Caution Bay:

- Largetooth sawfish (*Pristis pristis*): Listed as CR on the IUCN Red List. The species occurs at depths of 0 to 60 m, with juveniles occupying freshwater and estuarine habitats, and adults occurring in both estuarine and coastal waters. It is known to be present within Papua New Guinean waters, and has previously been recorded from Yule island, 60 km north of Caution Bay (White et al. 2017a). Although the species may be present in Caution Bay, no specific records are available for the area. There are almost no data on the population status of largetooth sawfish across the Indo-West Pacific; all populations are, however, probably severely depleted. The species is now 'possibly extinct' in 19 of its 60 former range states, and in 14 range states its presence is currently uncertain due to limited survey effort or recent sightings (Espinoza et al. 2022).
- Dwarf sawfish (*Pristis clavata*): Listed as CR on the IUCN Red List. The species is a large (to at least 3.8 m total length) estuarine and coastal shark-like ray. Historically, it was found widely across the Indo-West Pacific, but it is now 'possibly extinct' throughout its east Indian and Southeast Asian range and is now only extant in Papua Province (Indonesia), Papua New Guinea, and northern Australia. Population declines are evident and likely severe in Papua Province (Indonesia) and Papua New Guinea, primarily due to intense gillnet fisheries pressure in estuaries and coastal areas. It occurs in inshore shallow waters of 0 to 20 m depth, with juveniles occurring within estuaries, while adults are thought to mainly use coastal environments (Grant et al. 2022).
- Green sawfish, also known as the longcomb or narrowsnout sawfish (*Pristis zijsron*): Listed as CR on the IUCN Red List. Most common in shallow water coastal and estuarine areas, but occur to depths to over 70 m. There are very limited data available on the size and trend of the population, either at the global or national scale (Harry et al. 2022). Found in the Indo-west Pacific, from South Africa to eastern Australia and Papua New Guinea, to depths of at least 70 m. In Papua New Guinea, it is confirmed from Western, Gulf, Central and East Sepik provinces (White et al. 2017b).
- Narrow sawfish/knifetooth sawfish (*Anoxypristis cuspidata*): Listed as EN on the IUCN Red List and reported from the Gulf of Papua. This is a benthic-pelagic species that occurs from inshore and estuarine areas to offshore habitats in depths of up to 100 m (D'Anastasi et al. 2013). No specific information is available for Caution Bay.

6.8.4 Marine reptiles

Several marine turtle species are known to inhabit the coastal and offshore waters of Papua New Guinea, with the most relevant of these to the Project including the:

- Hawksbill turtle (*Eretmochelys imbricata*), listed as CR on the IUCN Red List
- West Pacific leatherback turtle (*Dermochelys coriacea*), listed as CR on the IUCN Red List and protected under the PNG *Fauna (Protection and Control) Act 1976*.
- South Pacific subpopulation of the loggerhead turtle (*Caretta caretta*), listed as CR on the IUCN Red List.

- Green turtle (*Chelonia mydas*), listed as EN on the IUCN Red List.
- Olive ridley turtle (*Lepidochelys olivacea*), listed as VU on the IUCN Red List.

The IUCN Red List indicates the potential presence of only the green turtle as having an overlapping distribution with a 25 km radius search area centred on the LNG Plant jetty. This suggests that other species may not as readily frequent the area, compared with other locations in Papua New Guinea.

No marine turtles were observed during field surveys between 2007 and 2022. In the Caution Bay study area, the only confirmed record of turtle breeding comes from Idihi Island, situated 15 km south-west of the mouth of the Vaihua River (Coffey 2008). This record comes from local people who claim to have harvested turtle eggs occasionally from the island, with nesting activity by green turtle and west Pacific leatherback turtles said to occur in December. No turtle tracks or nests were seen during a visit to Idihi Island in December 2007 (Coffey 2008). Despite the absence of observations, marine turtles are likely to occur in Caution Bay at various times, particularly due to the presence of seagrass and coral reef areas that provide food and habitat resources for various species, and potential nesting habitat.

No sandy beaches exist in the immediate vicinity of the existing LNG Plant jetty or Papua LNG pipelines route options due to the presence of mangroves, though beaches are present along the coast to the north near Papa and Lea Lea (the closest being approximately one kilometre away). Sandy beach habitats elsewhere in Caution Bay may also serve as rookery sites for one or more species of turtle, however there are no recorded observations of large nesting events. Cape Suckling, located approximately 60 km north of Caution Bay has been identified as an aggregation area for green turtles.

Green turtles are highly migratory and have a circumglobal distribution throughout tropical and subtropical waters of the Atlantic, Indian and Pacific Ocean. They nest in at least 80 countries; however, their movements within the marine environment are less understood. It is thought that green turtles inhabit coastal waters of over 140 countries (Seminoff 2004). This species is heavily pressured, including being caught as bycatch during fishing activities, and used during cultural practices and as a food source. Based on a summary of 32 green turtle nesting rookeries used as Index Sites for the 2003 Marine Turtles Specialist Group Global Green Turtle Status Assessment (Seminoff, 2004), PNG is not recognised as supporting globally significant rookeries of this species. This contrasts with neighbouring Australia, Indonesia and other locations in southeast Asia and the western and central Pacific regions, that historically and currently host some of the largest nesting congregations of green turtles in the world. Green turtles are known to nest across Papua New Guinea, with Work et al. (2020) citing several uninhabited island groups in Manus Province, and Long Island in the Madang Province as major nesting areas, however Caution Bay is not included in this list of sites.

The hawksbill turtle is classified CR by the IUCN (Mortimer & Donnelly 2008). They are omnivorous and consume marine algae, corals, molluscs, tunicates, crustaceans, sea urchins, small fish, and jellyfish, but are often referred to as spongivorous because of their preference for sponges (Porifera). The species has a circumglobal distribution throughout tropical and, to a lesser extent, subtropical waters of the Atlantic Ocean, Indian Ocean, and Pacific Ocean. Hawksbill turtles nest on insular and mainland sandy beaches throughout the tropics and subtropics. They are highly migratory and use a wide range of broadly separated localities and habitats during their lifetimes, undertaking complex movements through geographically disparate areas. Hawksbill nesting occurs in at least 70 countries, although much of it now only at low densities. Their movements within the marine environment are less understood, but hawksbills are believed to inhabit coastal waters in more than 108 countries. With a global distribution range, the species is neither endemic nor range restricted; however, genetic analyses in the Atlantic and Indo-Pacific indicate that nesting populations comprise separate and identifiable stocks that should be treated as separate management units (Bowen et al. 2007). No observations of nesting at Caution Bay have been documented.

The South Pacific subpopulation of the loggerhead turtle is neither endemic nor range restricted. Loggerhead turtles are found in all tropical and subtropical oceans. Adults are carnivores, eating crabs, conchs, whelks, and horseshoe crabs. Hatchlings are omnivores, eating both plant and animal material. They inhabit subtidal

and intertidal coral and rocky reefs and seagrass meadows as well as deeper soft-bottomed habitats of the continental shelf. This species has a global distribution with nesting sites of the south pacific subpopulation found along the eastern Australian coastline (Casale & Tucker 2017). The population trend of this species is declining, and the occurrence of this species in Papua New Guinea is not well documented. This species may also nest on sandy beaches within the study area, although there is no evidence of historical nesting in the Gulf of Papua, with principle nesting sites occurring within the Great Barrier Reef.

Leatherback turtles are referred to as gelatinivores (eating gelatinous prey) because their diet consists exclusively of jellies and other soft-bodied invertebrates like tunicates and sea squirts, therefore are not strongly reliant on seagrass habitat, as adults and are often sighted floating in the deep sea in Papua New Guinea waters. The largest leatherback nesting area in Papua New Guinea is located along the Huon Coast of the Morobe Province and is thought to be the second largest nesting population in the western Pacific. Outside of the Huon Gulf, the greatest nesting aggregations were encountered on south-facing beaches of New Britain Island with 54 nests recorded, while 41 nests were encountered at the previously unsurveyed Bougainville Island. A total of 1,195 leatherback nests were estimated for the surveyed area during entire the 2004 to 2005 season, after applying the error coefficients to the aerial survey results. Within Papua New Guinea, the current population estimate of leatherback turtles is ultimately unknown, however another regional population estimated indicated 1,478 mature individuals for the west Pacific subpopulation (Wallace, Tiwari, & Girondot 2013). This species has a decreasing population trend.

Although not observed during the survey, two species of crocodile, the estuarine or saltwater crocodile (*Crocodylus porosus*) and the freshwater crocodile (*Crocodylus novaeguineae*), occur in the estuaries of Papua New Guinea (Coffey Natural Systems 2009), and can be found within a few kilometres of the shore.

Several species of sea snake (including Hydrophiidae spp.) and sea krait (*Laticauda* spp.), have geographic distributions across the coastal zones of the tropical Indo-Pacific, north-eastern Australia, and Papua New Guinea. None of the species with known distributions that overlap Caution Bay are listed as being of conservation significance by the IUCN. Sea snakes such as *Laticauda guineai* (listed as NT by the IUCN) are likely present at various times given their distributions in shallow waters along coasts and islands. *Laticauda guineai* is restricted to southern Papua New Guinea and has an extent of occurrence of less than 20,000 km² (Lane and Guinea 2010). It is found in coral reef habitats and other shallow habitats. This species is threatened by habitat loss from coastal development and sea level rise throughout its range, especially as it needs to lay its eggs on land. Although no collections have been made in between these two areas, it is assumed that the species occurs in suitable habitat between the known collection locations.

6.8.5 Macrobenthic infauna

Macrobenthic infauna has been sampled at various times from Caution Bay for the PNG LNG Project and for the Papua LNG Project, to characterise the infauna community. Findings from these investigations are discussed in this section.

6.8.5.1 PNG LNG Project

During sampling undertaken for the PNG LNG Project EIS in 2007/2008, a total of 725 individuals from 68 different macrobenthic taxa were collected in Caution Bay across eight sampling locations and indicated a high diversity of fauna. Of these, the majority were crustaceans (28 taxa) followed by polychaetes (23 taxa) with lesser numbers of gastropods, bivalves, echinoderms, and six other taxa represented by one or two individuals. The identifications indicated a high diversity of infaunal macrobenthos, as indicated by the numbers of taxa observed within each sample. The numbers of taxa varied between sampling locations, possibly reflecting the natural sediment characteristics (i.e., different particle size, carbonate content, organic carbon), but the polychaete worms and crustaceans were the dominant macrobenthic infauna taxa of the sediment samples, which is typical of shallow-water sediments (Coffey Natural Systems 2009).

The number of taxa varied between sampling locations, with polychaete worms and crustaceans being the dominant taxa, typical of shallow water sediments. Non-metric multi-dimensional scaling (nMDS) and cluster analysis on data collected in 2007/2008 showed a distinct gradient and grouped macrobenthic infauna into inshore shallow water fauna, nearshore deepwater fauna located in the shipping channel and three individual sites of fauna from carbonate sand regions. While not assessed, this gradient was considered likely to reflect increasing sediment gradient size and decreasing organic inputs (Coffey Natural Systems 2008).

6.8.5.2 2019 infauna analysis

Detailed results from the 2019 macrobenthic infauna analysis are provided in Appendix I and summarised in this section.

The sediment samples taken in April and August 2019, from which macroinvertebrates were picked, sorted, and identified, consisted of silt and shells, with coral rubble also present in sample MI-03. No large deposits of terrestrial organic material were present. Pieces of seagrass leaves were present in some samples but appeared to have been detritus and samples did not appear to have been collected from seagrass beds.

From 16 samples collected in April 2019, 971 macrofauna animals were collected from 74 taxa, indicating a high diversity of fauna, similar to observations made in 2007/2008. One sample, MI-01 contained only four individuals from four taxa. This reference site is located within sandy habitat at Vari Vari Island to the north of the study area. In contrast, 117 animals were collected from 18 taxa from MI-03 at Idihi Island, a similar offshore reference site in sandy habitat.

The next lowest number of individuals in a sample was 22 (MI-17 in silty habitat in deeper water), with the highest being 173 (MI-16 in sandy nearshore habitat). Silty habitats in deeper water typically displayed lower numbers of individuals, with less than 40 individuals per sample. Samples in shallower water and sandy habitat typically displayed higher numbers of individuals, with MI-01 being an exception. Most of the taxa recorded were those expected to be present in samples from Papua New Guinea inshore habitats, with one exception at site MI-16, where 59 of the 178 animals recorded were oligochaetes. Oligochaetes are unusual in marine samples and not expected to occur in large numbers. The samples were also noted to have an absence or low abundances of some common taxa from Papua New Guinean inshore areas, low percentage of snails and bivalve shells and a high proportion of small and immature specimens present. The high proportion of immature specimens suggests that the macrofauna community was in a developmental stage when sampled. Further sampling in the study area may show a different macrofauna community depending on season and life cycle stages (Moverley 2019).

An additional four samples were collected in August 2019. The samples contained 468 macrofauna animals belonging to 58 taxa. A particularly high number of animals (296) was present in sample MI-08, collected within nearshore sandy habitat. The average number of animals in remaining samples was 57, similar to the average of 60 animals from the April 2019 survey. Similar to samples collected in April, some taxa expected to be common in inshore soft-sediment samples were absent or in low abundance. Higher numbers of individuals were again recorded in nearshore sandy habitats, with lower numbers in silty deeper samples. One unexpected taxa was also recorded; 18 Polyplacophora (commonly known as chitons) were collected in sample MI-08 and one individual in MI-20. The individuals collected appeared to be newly settled juveniles. Adult chitons live in rocky habitat rather than soft sediment. Most species collected in April 2019 were immature or juveniles, while samples from August 2019 contained many larger and mature individuals. Many crustaceans in samples collected in August were also observed to be carrying eggs, which was not observed in samples collected in April.

6.8.5.3 2022 infauna analysis

Detailed results from the 2022 macrobenthic infauna analysis are provided in Appendix I and summarised in this section. Six sediment samples were taken in during the 2022 marine survey. The samples consisted

predominantly of thick and sticky mud/clay mixed with broken shell, shell grit and sand. Sed 32 contained anoxic material at the bottom of the sample jar at the time of analysis.

A total of 104 individuals from 33 different macrobenthic taxa were collected. Sed T3 (near the CALM buoy navigational channel) contained the highest species diversity, while Sed T1 (near the junction of the 2022 Papua LNG pipelines route options) contained to lowest species diversity and species richness. Sed 30 (the most seaward infauna sample) supported the greatest species richness.

The faunal composition of Sed T1 and Sed T5 are comparable (with 24% faunal similarity), though the sites are located at opposing extents of the study area (Sed T1 is seaward and Sed T5 is the second-most landward site). Sed 30, Sed 31, Sed 32, and Sed T3 demonstrated similar faunal composition (with 33% faunal similarity) and are all located near/seaward of the CALM buoy.

The three most abundant species across all sample sites were the sea flea (Melitidae; 13 in total), the tanaid (Apseudidae; 13 in total) and the peanut worm (Sipuncula; 10 in total). Macrobenthic fauna observed in the sediment samples included a mixture of smaller individuals and larger, mature individuals. This diversity indicates that the community is an established population that has not experienced any recent environmental disturbances (for example, cyclones, freshwater inundation). Individual counts were distributed evenly among the different species and dominance was low across all sites suggesting that no individual species population dominated the study area.

6.8.6 Molluscs

Richards et al. (2016) noted that the extant molluscan fauna of Caution Bay and surrounds has not been investigated at any stage. For this taxonomic group Richards et al. (2016) compiled a species list based on their ongoing analysis of molluscan assemblages from excavated archaeological sites in Caution Bay. Most of the species represented in their research are widely distributed in the Indo-Pacific region, and their habitat preferences and behaviours are generally well-known from studies elsewhere.

The fringing reef has also been observed to support high densities of the sea urchin *Diadema* sp. (Coffey Natural Systems, 2008), and these were also observed further offshore during the 2022 survey along the Option 15F alignment (transect PLNG-2). Population densities of this species are typically controlled by predatory fish and octopus, and they are known to increase in numbers when overfishing causes a reduction in numbers of these predators (Steiner and Williams 2006). Overgrazing by *Diadema* sp. can hinder the rate of coral settlement and recovery after damage.

6.8.7 Other invertebrates

The ornate rock lobster (*Panulirus ornatus*) migrates from Torres Strait through the Gulf of Papua to breeding grounds at Yule Island, located approximately 75 km northwest of Caution Bay. The species is part of the tropical rock lobster fishery and a known migratory species. There are no marine benthic macroinvertebrates in Papua New Guinea listed as threatened or trade-restricted.

Other important invertebrate fishery species include prawns which are commercially harvested by the Gulf of Papua Prawn Fishery. Prawn species include tiger, banana, and endeavor prawns, which occur throughout the water column from nearshore to the edge of the continental shelf. These species are reliant on mangroves as nursery habitat.

Four species of Holothuroidea (sea cucumbers) most relevant to the Project (based on known distributions and conservation status) are listed on the IUCN Red List (2022), as follows:

- *Holothuria whitmaei*: Listed as EN on the IUCN Red List (Conand et al. 2013a). This species is found along slopes and passes within reef zones and spawns in cooler months. This species is found only in the Pacific, from Australia and the Philippines to Guam and Samoa, and to Hawaii and Johnston Island. In the

Western Central Pacific, this species can be found in reef flats, slopes, and shallow seagrass beds mainly between 0 and 20 m (Kinch et al. 2008). Stocks are depleted in many regions in the southwestern Pacific. In the Philippines, this species is overfished, and is probably depleted based on reduced export. In Australia, this species is overfished in the Torres Strait since the 1990s, and is reduced by 80% in the Great Barrier Reef over the past few decades. Very little is known about the impact of fishing on this species in Indonesia. This species is a very high value species, and due to declines in catch and exports, efforts have switched to lower valued species, and the species is considered overfished in Indonesia. Depletion refers to being commercially unviable, and estimated to represent an approximately 60 to 80% loss or greater, as the species can be found to at least 30 m but probably deeper to 40 or 50 m. However, this species is predominately a shallow water species (accessible to free diving), and only a small fraction of the population is at depths greater than 30 m.

- *Thelenota ananas*: Listed as EN on the IUCN Red List (Conand et al. 2013b). This species has a wide distribution range throughout the Indo-Pacific, excluding Hawaii. It is found along slopes and passes within reef zones and along outer reef flats to depths of 35 m, but is more common in waters from 10 to 20 m. It is common in shallow waters of reef bottom where there is no terrigenous action, at depths from 0 to 20 m. In the Western Central Pacific, they are distributed mainly in shallow coral reef areas, on reef flats, reef slopes and near passes on sandy or hard bottoms with large rubble and coral patches. Larvae are planktonic, juveniles and adults are benthic. Generation length is unknown for this species and body size is not a good indicator of age or longevity. There is some indication, however, that many echinoderms do not go through senescence, but simply regenerate. Therefore, generation length cannot be estimated, but is assumed to be greater than several decades in a natural, undisturbed environment. This species is commercially exploited throughout its range for its medium-high value as beche-de-mer to supply Asian markets globally. Based on several quantitative and qualitative studies, populations are estimated to have declined by 80-90% in at least 50% of its range and are considered overexploited in at least 30% of its range although exact declines are difficult to estimate. In PNG, densities decreased from 8 to 1.4 individuals per hectare (Conand et al. 2013b).
- *Holothuria scabra*: Listed as EN on the IUCN Red List (Hamel et al. 2013). This species has been significantly depleted in at least 50% of its range (e.g., in East Africa, Madagascar, India, Vietnam, Papua New Guinea, Solomon Islands). This species is distributed mainly in low energy environments behind fringing reefs or within protected bays and shores. Individuals prefer ordinary coastal areas to coral reefs, particularly intertidal seagrass beds close to mangroves; however, they are also found along inner reef flats and lagoons. This species is attracted to muddy sand or mud habitats. Juveniles of this species settle in shallow seagrass beds and some may make it to deeper waters. This species has been found to preferentially settle on seagrass species such as *Thalassia hemprichi*. Recent studies on released juveniles have shown that mangrove/seagrass areas were the most suitable habitat for settling juveniles, due mainly to low predation rates. This species is also known to burrow, possibly leading to biased transect data.
- *Holothuria lessona*: Listed as EN on the IUCN Red List (Conand et al. 2013c). In the Western Central Pacific, this species can be found in lagoons over sandy bottoms between 0 and 25 m, but occurs predominately from 0 to 10 m. It can be found over sandy and muddy areas and in reef flats. This species is targeted throughout its range, and fishing pressure has dramatically increased in the past 25 to 50 years, since the 1960s, and is expected to continue, even as stocks are depleted. When this occurs, other species are often targeted in its place. In some areas within its range (New Caledonia and Tonga) where density data is available, statistics show that the species has probably been depleted. It has also probably been depleted in the Philippines, though catch statistics are mixed with *Holothuria scabra*. Given that this species is targeted similarly to *H. scabra*, is larger, rarer and can be more valuable, it is assumed that it is equally as heavily exploited as *H. scabra* throughout its range.

Additional Holothurians, listed as VU and with distributions that overlap Caution Bay, include:

- *Actinopyga mauritania*
- *Actinopyga echinites*
- *Actinopyga miliaris*
- *Holothuria fuscogilva*
- *Stichopus herrmanni*

In the absence of up-to-date population studies for Caution Bay, population estimates for Holothurians relative to the broader population distribution are not possible. Several commercial varieties that widely distributed in the Indo-Pacific, have experienced large-scale population declines and decreasing population trends are evident (IUCN, 2023). Harvesting bans have occurred at various stages, including in 2009 when the National Fisheries Authority, responsible for the conservation and management of PNG's sea cucumber fishery and gazetting the National Bêche-de-mer Management Plan in 2001, enforced a national closure of the bêche-de-mer fishery for three years (Skewes et al. 2011).

There is insufficient information on the taxonomy and ecology of marine macroinvertebrates more broadly, to determine whether locally endemic or restricted-range species occur in Caution Bay, or Papua New Guinea.

6.8.8 Invasive and alien species

Alien or non-native species of marine flora and fauna that had become invasive, spread rapidly, or obviously out-competed native species, were not observed in the 2019 marine survey. This included species of fish, algae, and invertebrates. A specific assessment was planned during the 2019 study of the LNG Jetty infrastructure to identify the potential presence of any colonial invasive marine organisms. This aspect of the marine survey was not completed due to access constraints and poor weather meaning that the intended day of survey was cancelled.

No indications were observed that native species such as the crown-of-thorns seastar (*Acanthaster planci*) had experienced pest-level population level changes (i.e., due to a loss of natural attenuating or controlling mechanisms) or were causing significant environmental effects due to their dominant colonisation, of or impact upon, the Caution Bay ecosystem.

The 2022 investigations of five jetty pylons indicated that they had become colonised by various encrusting organisms including coralline algae, barnacles, sponges, ascidians, and small corals. The dominant organism observed to have colonised and adhered to the pylons was an unidentified species of brown macroalgae. No indication of the presence of invasive species or adverse environmental outcomes associated with the colonisation of the pylons by algae or other encrusting organisms was apparent.

7. WATER QUALITY

This section presents the results of water quality sampling undertaken in Caution Bay in 2019 as part of the baseline assessment.

7.1 WATER QUALITY CRITERIA

Water quality results are compared to environmental limits prescribed in Annex 2 of the Environment Permit for the PNG LNG Project. These limits are based on Papua New Guinea water quality guidelines and pre-construction baseline (or background) data collected in 2009 and 2010. Comment is also made on observations from the PNG LNG EIS from 2007 and 2008.

Environmental water quality guidelines for the protection of marine aquatic life in Papua New Guinea are provided in Schedule 1 of the Papua New Guinea Environment (Water Quality Criteria) Regulation 2002.

The Papua New Guinea water quality guidelines do not include some quality measures for certain analytes. Water quality guidelines for a range of environmental values in Australia published by the Australian and New Zealand governments and Australian state and territory governments (ANZG 2018) have been adopted as an additional assessment framework for previous monitoring undertaken for the PNG LNG Project and are also considered for the Papua LNG Project – Downstream.

7.2 RESULTS

Results from 2019 sampling are compared against the adopted assessment criteria in Table 6.1 for pH, DO, TSS, turbidity and temperature, and Appendix J for the remaining parameters.

Selected results are graphed in this section and compared to historical data including data collected across different seasons and years, and presented in the following reports:

- Baseline water quality data collected for the PNG LNG Project EIS in 2007/2008 (Coffey Natural Systems 2008).
- Water quality data collected as part of pre-, during- and post-construction monitoring for the PNG LNG Project in fulfilment of conditions 92 to 94 of the PNG LNG Project Environment Permit. This includes data from 2009, 2010, 2011, 2012, 2013 and 2014 (Coffey Environments 2014a).
- Laboratory transcripts for monitoring undertaken in 2019 are included in Appendix K.

7.2.1 Physical parameters and TSS

Results for physical parameters measured in 2019 are provided in Table 7.1.

Consistent with previous reports, measurements are discussed for in-situ parameters taken at approximately 1 m depth. In some instances (for conductivity and salinity measurements in 2013/2014 and some turbidity results in 2019), the discussion is supported by the CTD profile data for the entire water column (due to anomalies in measurements taken with the hand-held water quality meter).

TSS and turbidity are displayed graphically and compared against previous monitoring results and the adopted assessment criteria Figure 6.1 and Figure 6.2. Where results are below the detection limit, a value of half of the detection limit has been used in the graphs.

pH

Baseline pH values measured in 2007/2008 generally ranged from 7.9 to 8.2 and were within the expected pH range of 7.5 to 8.5 for sea water. A slightly lower pH value of 7.66 was recorded at WQ09 within the mangrove community of Vaihua River, as expected from an estuarine environment (Coffey Natural Systems 2008).

During the construction phase of the PNG LNG Project, pH values ranged from 7.5 to 8.3. During post-construction, they ranged from 7.2 to 8.7, with an average pH of 8.2, which matched the average pH recorded in 2010. The similar range in pH values was expected given the relatively constant pH of seawater and unlikely sources of pH change due to project activities (Coffey Environments 2014b).

Lower pH values (7.2 to 7.9) more indicative of freshwater were recorded at some sites in 2013 and 2014. Most of the sites were located within 1 km of the shore and may have been influenced by freshwater runoff. Most pH values varied from background pH by less than 1 pH unit, although sites TSS24, TSS25 and TSS34 had unexpectedly low pH levels for marine water (between 6.5 and 7.0), which equated to variations from background pH by between 1.2 and 1.7 pH units. These results were treated as outliers, as the sites were unlikely to be influenced by freshwater and laboratory pH data for the same samples indicated pH values of approximately 8 (Coffey Environments 2014b).

Table 7.1 2019 physical parameter and TSS data

Site ID	Parameter				
	pH ⁺	DO (mg/L)	TSS (mg/L) [†]	Turbidity (NTU) [‡]	Temperature (°C) [§]
Environment Permit Criteria (Seawater)	No alteration to natural pH	Not less than 5 mg/L	50 mg/L or <10% change from background	No alteration greater than 25 NTU or <10% change from background	No alteration greater than 2°C
TSS01/WQ_01	8.39	7.20	<5	1.82	30.3
TSS02	8.24	6.53	<1	2.05	28.4
TSS02 Deep	-	-	<5	-	-
TSS03	8.20	5.61	1	1.02	29.5
TSS04/WQ_02	8.18	5.57	<1	1.76	30.5
TSS05	8.48	6.70	<5	0.85	30.1
TSS05 Deep	-	-	<5	-	-
TSS06/WQ_03	8.19	5.44	<1	1.80	28.8
TSS06 Deep	-	-	1	-	-
TSS07 /WQ_04	8.10	6.96	1	1.17	30.7
TSS08	8.47	6.71	<5	0.89	30.0
TSS08 Deep	-	-	<5	-	-
TSS09	8.65	7.01	<5	0.34	29.8
TSS09 Deep	-	-	<5	-	-
TSS10/WQ_05	8.17	6.93	<1	1.21	29.2
TSS11	8.19	_#	1	1.59	29.4
TSS11 Deep	-	-	<1	-	-
TSS13	8.17	5.17	1	1.23	29.2
TSS15	8.19	_#	<1	1.67	29.4
TSS15 Deep	-	-	2	-	-
TSS16/WQ_06	8.54	6.83	<5	0.46	29.6
TSS16 Deep	-	-	<1	-	-
TSS17	8.18	_#	<1	0.93	29.2
TSS17 Deep	-	-	2	-	-
TSS18	8.18	_#	<5	1.09	29.7
TSS19	8.18	_#	<1	0.80	29.6
TSS20	8.18	_#	<1	1.05	29.5
TSS21	8.17	_#	1	1.19	29.5
TSS23	8.11	_#	1	0.71	30.4
TSS23 Deep	-	-	2	-	-
TSS24	8.19	_#	<1	0.61	28.6
TSS25/WQ_07	8.72	6.88	<1	0.35	30.1
TSS25 Deep	-	-	1	-	-

Site ID	Parameter				
	pH*	DO (mg/L)	TSS (mg/L)†	Turbidity (NTU)‡	Temperature (°C)§
Environment Permit Criteria (Seawater)	No alteration to natural pH	Not less than 5 mg/L	50 mg/L or <10% change from background	No alteration greater than 25 NTU or <10% change from background	No alteration greater than 2°C
TSS26/WQ_08	8.21	6.79	3	0.07	30.2
TSS27	-	_#	<5	_#	-
TSS27 Deep	-	-	<5	-	-
TSS28	8.22	7.09	<5	0.28	25.3
TSS29/WQ_12	8.55	6.87	<5	0.23	29.3
TSS31/WQ_11	8.10	7.2	<5	1.15	32.3
TSS32/WQ_09	8.11	_#	6	24.41	31.3
TSS33	8.26	_#	4	24.41	31.9
TSS34/WQ_10	8.23	7.89	1	0.69	29.4
TSS35	8.20	5.19	<1	1.14	29.6
TSS35 Deep	-	-	<1	-	-
TSS36	8.21	_#	<1	0.95	29.1
TSS36 Deep	-	-	2	-	-
TSS38	8.28	_#	2	0.89	31.9
TSS39	8.18	_#	2	1.22*	29.8
TSS40	8.31	_#	2	_#	32.6
TSS41/WQ_15	8.11	7.04	<1	0.21	31.3
TSS42/WQ_16	8.18	5.24	<1	1.32	30.2
TSS43	8.56	5.25	<5	0.27	29.9
TSS43 Deep	-	-	<5	-	-
TSS44	8.79	5.20	<1	0.64#	29.6
TSS 44 Deep	-	-	<5	-	-
WQ_13	8.25	6.95	<5	1.52	29.6
WQ_14	8.19	6.68	<5	1.39	30.3

* The criterion requiring pH 'not to vary from natural pH' was determined by calculating the average pre-construction monitoring pH result obtained in 2009/2010 on a site-by-site basis and noting any variations greater than 0.5 pH units.

† The criterion for change of less than 10% from background TSS mg/L was calculated using the highest pre-construction monitoring result obtained in 2009/2010 on a site-by-site basis and adding 10%.

‡ The criterion for turbidity of no alteration greater than 25 NTU was calculated using the highest pre-construction monitoring result obtained in 2009/2010 on a site-by-site basis and adding 25 NTU.

§ The criterion for temperature of no alteration greater than 2°C was determined using the average pre-construction monitoring temperature result obtained in 2009/2010 on a site-by-site basis and adding/subtracting 2°C.

|| Reading sourced from the average value of CTD data obtained at each site, due to hand-held water quality meter malfunction.

Reading not obtained due to water quality meter malfunction.

In 2019, pH levels ranged from 8.1 to 8.8. The average value of 8.3 was similar to previous years and remained within the range expected for sea water. Values above 8.5 were recorded at TSS09, WQ_06, WQ_07, WQ_12, TSS43 and TSS44 in April 2019 and appeared unusually high for these sites. In the absence of any apparent sources of alkaline runoff, these results may be due to the pH probe calibration drifting. Values differed by less than 1 pH unit from those recorded prior to construction, with the only variation from background pH of greater than 0.5 at WQ_07 (variation of 0.52 pH units). These sites were re-sampled in August 2019 and had pH levels between 8.17 and 8.21.

Dissolved oxygen

No pre-construction data is available for dissolved oxygen for the PNG LNG Project.

Levels below the Environment Permit criterion of 5 mg/L were recorded at some sites during each of the construction and post-construction monitoring events, except during monitoring undertaken in February 2012. Sites which displayed levels below 5 mg/L consistently included TSS28, TSS32 and TSS33 with the lowest recorded level of 3.4 mg/L. These sites are in shallow, estuarine locations close to shore (see Figure 3.7). TSS32 and TSS33 are in the mouth of the Vaihua River, an area prone to lower dissolved oxygen levels due to the reduced flow and mixing rates associated with the meeting of sea and freshwater, as well as elevated levels of nutrient input and organic matter from the river. Accordingly, the lower concentration is to be expected and likely to exhibit variability depending on weather and other environmental conditions. Similar conditions are likely to occur at site TSS28 given its shallow location close to land (Coffey Environments 2014b).

Concentrations of dissolved oxygen recorded in 2019 were above the Environment Permit criterion at all sites, ranging from 5.17 mg/L at TSS13 to 7.89 mg/L at WQ_10.

Total suspended solids

Suspended solids from measurements taken in 2007/ 2008 ranged from 2 mg/L at WQ_5 to 68 mg/L at WQ_7 (Coffey Natural Systems 2008).

TSS levels are displayed for monitoring undertaken from pre-construction surveys in 2009 to recent monitoring in 2019 in Figure 7.1.

Results in all years were below the Environment Permit criterion of 50 mg/L. TSS concentrations in 2019 ranged from below detection limits at around half of the sites, to 6 mg/L at WQ_09. At most sites concentrations were below or similar to background levels. Where concentrations were above background levels, the increase was minor and within the range of values observed in previous monitoring years.

As TSS levels were all less than the 50 mg/L criterion at each site, the criterion of less than 10% change from background levels is not considered relevant, particularly with background levels at or below detection limit.

Turbidity

Turbidity measurements in 2007/2008 and those obtained during construction from 2011 to 2013 showed similar values, ranging from 0 to 8.5 NTU. The consistency in results indicated that construction contributed negligible levels of sediment to the sampling sites (Coffey Natural Systems 2008, Coffey Environments 2014b). Turbidity measurements post construction in 2014 remained below 4.96 NTU at all sites (Coffey Environments 2014b).

In 2019, field and CTD measurements of turbidity ranged from 0.21 NTU to 24.41 NTU. Values of up to 24.21 NTU were observed in the Vaihua River and river mouth, a mangrove environment with fine sediment and murky water. Excluding the Vaihua river environment, the highest levels of turbidity elsewhere in the study area were 2.05 NTU at TSS2. Figure 7.2 presents results from monitoring undertaken during pre-

construction surveys in 2009, through to current monitoring in 2019. No results are above the Environment Permit criterion of more than 25 NTU change from baseline levels (defined as 25 NTU above the highest historical value recorded at the site in 2009 and 2010) in any of the years of monitoring.

The criterion of no more than a 10% change from background has limited applicability to such low levels of turbidity as very minor turbidity changes are greater than 10% of the already low background levels. Such changes are also typically within the instrument error margin between measurements (Coffey Environments 2014b). Background levels are also determined from a data set of only two to three recordings for each site in 2009 and/or 2010 and is unlikely to capture fluctuations in turbidity associated with a range of weather conditions.

Temperature

Baseline water temperatures measured in 2007/2008 ranged from 28.1°C to 30.9°C (Coffey Natural Systems 2008). Temperatures monitored during construction ranged from 25.2°C to 32.8°C and the monitoring undertaken in 2014 showed a range of 28.2°C to 33.3°C (Coffey Environments 2014b). This consistency in temperatures across the sampling periods was expected as there have been no thermal impact sources from the PNG LNG Project and tropical temperature variations are generally low (Coffey Environments 2014b).

Water temperature has been higher than a 2°C change from background temperatures in some instances during previous monitoring rounds. Minor variations between 2.1 and 3.6°C above background levels have occurred and likely arose due to variability of measurement depth and calibration of the temperature probe. The accuracy of the Aquaread temperature probe used during previous monitoring was 0.5°C and temperature readings above background temperatures were within the total error range of 1°C (Coffey Environments 2014b).

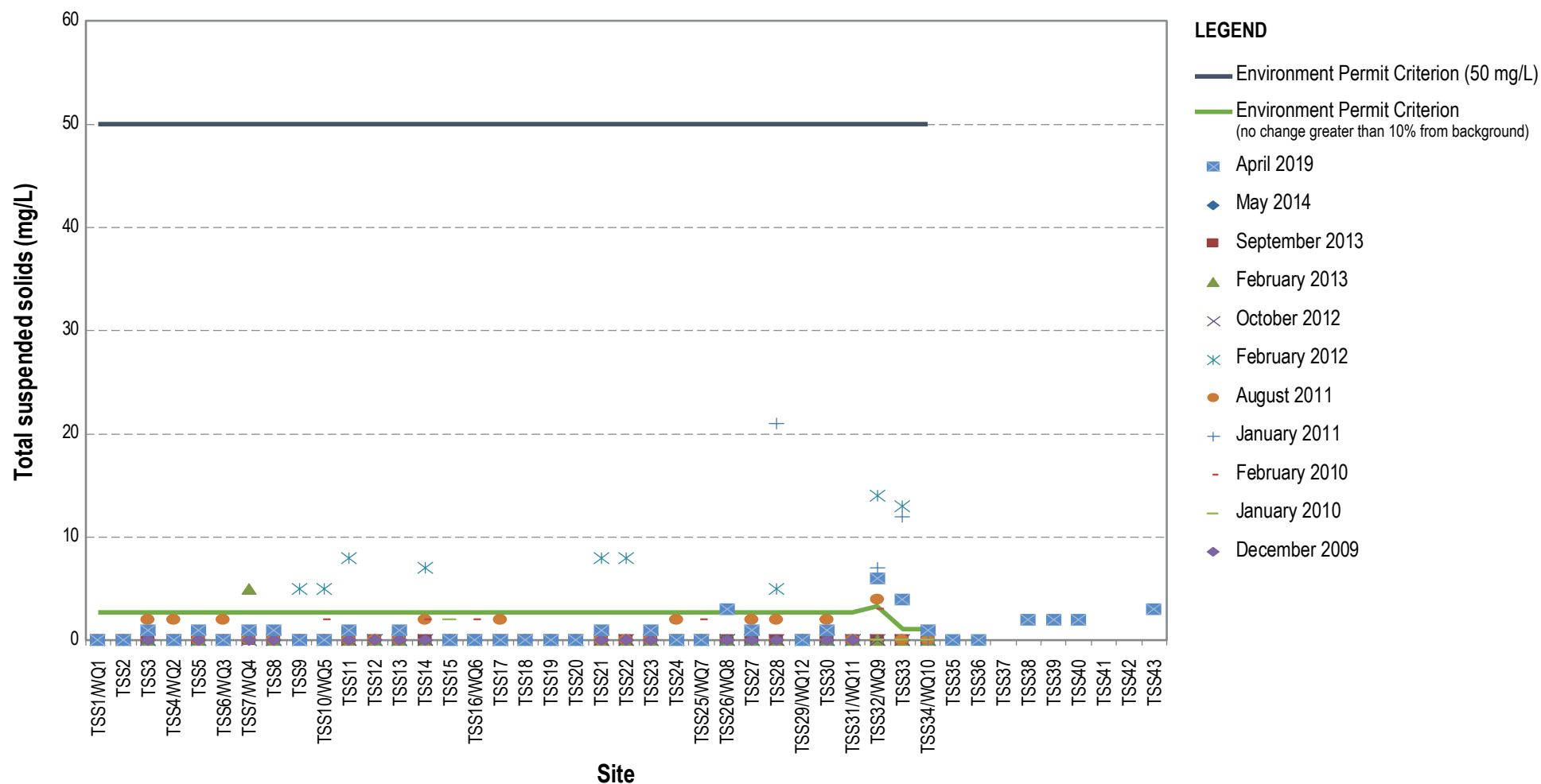
Temperatures recorded in 2019 ranged from 28.6°C to 32.6°C with an average of 30.0°C across all sites, similar to observations in previous years. Sites WQ_12 and WQ_10 recorded temperatures of approximately 4°C above background temperatures at these sites (recorded previously). Sampling site WQ_12 is located near Idihi Island, approximately 15 km west of the LNG plant, in shallow water with limited current-induced movement. There is no other apparent reason why temperatures would be higher at this site.

Similarly, site WQ_10 is located in the shallow, brackish waters of the Vaihua River, which are also influenced by freshwater outflows and surrounding land usages, including a package sewage treatment plant that services Edai Town and community living upstream.

Other physical parameters

Other parameters measured by hand-held meter, for which no Environment Permit criteria exist included conductivity and salinity.

In 2019, conductivity readings were similar to baseline data collected during the PNG LNG Project EIS and ranged from 24.6 mS/cm at WQ_15 to 58.6 mS/cm at TSS33, with an average of 55.7 mS/cm across all sites. Values were similar to those observed during pre-construction monitoring in 2011 and post-construction monitoring in 2014 (Coffey Environments 2014b).

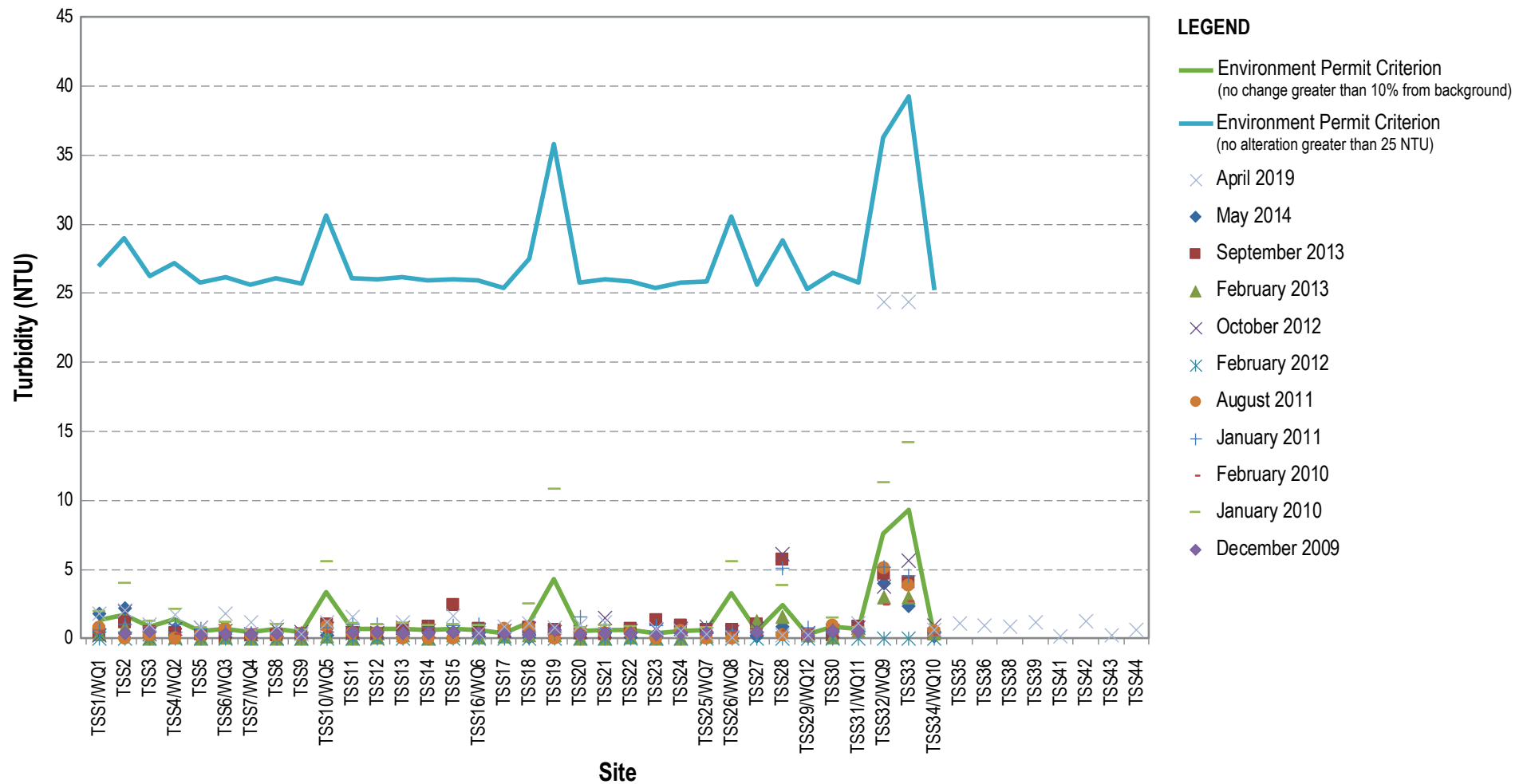


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PAPUA LNG PROJECT – DOWNSTREAM

FIGURE 7.1

Total suspended solids monitoring
results from 2009 to 2019



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PAPUA LNG PROJECT – DOWNSTREAM

FIGURE 7.2

Turbidity monitoring results from 2009 to 2019

In 2019, salinity ranged from 13.1 PSU at WQ_09 (in brackish water in the Vaihua River) to 34.4 PSU at WQ_15, with an average across all sites of 33.7 PSU. The average salinity was similar to that recorded in 2007/2008 for the PNG LNG Project EIS, and similar to readings obtained during construction, which showed sites near the coast having lower salinity indicative of freshwater mixing. Results in 2019 were also similar to post-construction monitoring which showed average salinity ranging from 17.4 to 34.0 PSU.

7.2.2 Laboratory analysis parameters

Results for laboratory analysis of samples collected in 2019 that have Environment Permit criteria are summarised in Appendix J. Laboratory transcripts for all parameters are provided in Appendix K.

Consistent with previous reports, results are discussed for samples collected at approximately 1 m water depth. Selected parameters are displayed graphically with comparison against previous monitoring results and the adopted assessment criteria in Figure 7.3, Figure 7.4, Figure 7.5 and Figure 7.6.

7.2.2.1 Chemical and biological oxygen demand

Due to short holdings times, chemical and biological oxygen demand (COD and BOD) were not measured in water quality samples collected for the PNG LNG Project EIS. In 2010 and 2011 levels were generally at or below laboratory detection limits (<100 mg/L for COD and <2 mg/L for BOD).

In 2014, concentrations of both parameters at most sites were higher than levels recorded pre-construction. BOD was recorded at levels up to 93 mg/L and was above the Environment Permit criterion of 25 mg/L at several sites (Figure 7.3). COD was recorded at levels up to 950 mg/L and were also above the Environment Permit criterion of 125 mg/L at several sites (Figure 7.3). The elevated levels in 2014 were considered likely due to the analytical methods used rather than increased presence of bacterial and organic material (and subsequent increased oxygen demand) in the samples. Analyses on seawater samples are less common than for freshwater samples and require many dilutions. This increases the limits of detection, along with the likelihood for error and anomalous results. Dissolved oxygen concentrations at the sites were not substantially reduced as would be expected with elevated COD and BOD concentrations. Levels of nutrients and faecal coliforms, which can be conducive to elevated oxygen demand, were also low (Coffey Environments 2014b).

In 2019, COD levels were above Environment Permit criteria at sites WQ_03, WQ05, WQ_08, WQ_11 and WQ_14, however, levels remained below those observed in 2014. Levels of BOD were below detection limits at all sites in 2019.

7.2.2.2 Nitrate as N, potassium and sulphide

Nitrate as N has remained below the analytical detection limit and below the Environment Permit criteria at all sites during baseline monitoring undertaken for the PNG LNG Project EIS and on all further monitoring occasions, including in 2019.

Concentrations of potassium have remained below the criterion in the Environment Permit (600 mg/L) during all monitoring rounds, noting that sampling for this parameter was not undertaken in 2014.

Sulphide concentrations have been below the laboratory limit of detection (<0.1 mg/L in 2019) at all sites during all monitoring rounds. The laboratory-achievable limit of detection for all monitoring rounds has been above the Environment Permit criterion of 0.002 mg/L, meaning that determination of compliance is not possible.

7.2.2.3 Oil and grease

Oil and grease has remained below detection limits at all sites during baseline, construction and operations monitoring undertaken for the PNG LNG Project. No observations have been made of visible sheens on the water surface. Oil and grease was below detection limits in all samples tested in 2019.

7.2.2.4 Phenol and pentachlorophenol

Phenols have remained below detection limits at all sites during baseline, construction and operations monitoring undertaken for the PNG LNG Project. Phenol and pentachlorophenol were below detection limits (<0.002 mg/L) in all samples tested in 2019.

7.2.2.5 Faecal coliforms

Faecal coliforms were below detection at all sites in monitoring undertaken in 2010 and 2011 and were not analysed in 2013 or 2014 as holding times were exceeded prior to analysis (Coffey Environments 2014a).

Faecal coliforms were tested at five sites in August 2019: WQ-05 to WQ-08, and WQ-14. Total coliforms ranged from 870.4 to >2419.6 most probable number (MPN)/100 mL. *Escherchia coli* ranged from 116.9 to 186 MPN/100 mL and Enterococci ranged from 549.3 to >2,419.6 MPN/100 mL. Highest levels of total coliforms and *E. coli* were present at WQ-05, WQ-06 and WQ-26, and the highest levels of Enterococci were observed at WQ-08 with all of these sample results >2419.6 (MPN)/100 mL.

Given the locations of the elevated levels of coliforms in samples in 2019 e.g., WQ-05 is located inshore near the northern extent of the lease area boundary and WQ-06 is located at the northern seaward extent of the LNG Plant jetty, the results may be associated with various sources. These potential sources include LNG Plant discharge or runoff locations¹³, vessel discharge activities near the LNG Plant jetty, and various potential inputs to the Vaihua River including a package sewage treatment plant servicing housing estates in Edai Town that discharges into a creek flowing into the Vaihua River, adjacent to the LNG Plant. Construction of Edai Town started in 2010 with ongoing expansion resulting in hundreds of houses on site. The sewage treatment plant is privately operated under approval from Water PNG. The plant also operates under a permit from CEPA for the discharge of sewage.

7.2.2.6 Other laboratory parameters

Other parameters that were analysed by the laboratory, for which no Environment Permit criteria exist include the following:

- **Nutrients.** Total Kjeldahl nitrogen and total nitrogen have been below analytical detection limits at all sites during baseline monitoring undertaken for the PNG LNG Project EIS and on all further monitoring occasions including in 2019. Ammonia concentrations have generally ranged from below detection limits to 0.055 mg/L, with one higher reading of 1.1 mg/L at WQ_06 in 2011 (Coffey Natural Systems 2008; Coffey Environments 2014b). The concentration of ammonia in natural waters is variable, with typical concentrations in seawater ranging from 0 to 0.17 mg/L (Johansson & Weddbourg 1980).

¹³ In early 2018 the LNG Plant sewage treatment plant was shut down and no discharge to the retention pond and mixing pit has occurred since. A temporary treatment plant was commissioned and discharged via the ground. The repaired STP discharges via a leach field to ground in the camp area. Subsequent sampling occurred at the LNG Plant retention pond and mixing pit in the absence of any source which could potentially contain human bacteria entering the retention pond or mixing pit and indicated no bacteroides / human based bacteria, yet continued to consistently return positive results for faecal coliform above the freshwater criteria of 200 MPN / 100 mL, and *Enterococci*. Based on these results, in 2019 CEPA agreed that there was no basis for continuing to monitor faecal coliforms at these sites, unless conditions change whereby human bacteria may be discharged.

- **Fluoride.** Fluoride levels in 2019 were similar to, or higher than, previously recorded levels. The lowest levels of fluoride generally occurred in 2010, with the highest levels in 2019 generally less than 0.2 mg/L above the pre-construction levels measured.
- **Total cyanide.** Total cyanide concentrations were below detection in all sampling rounds, including in 2019.
- **Piperazine.** Piperazine was tested at five sites in August 2019: WQ-05 to WQ-08, and WQ-14. Levels were below detection limits (100 µg/L) at each site.

7.2.2.7 Metals

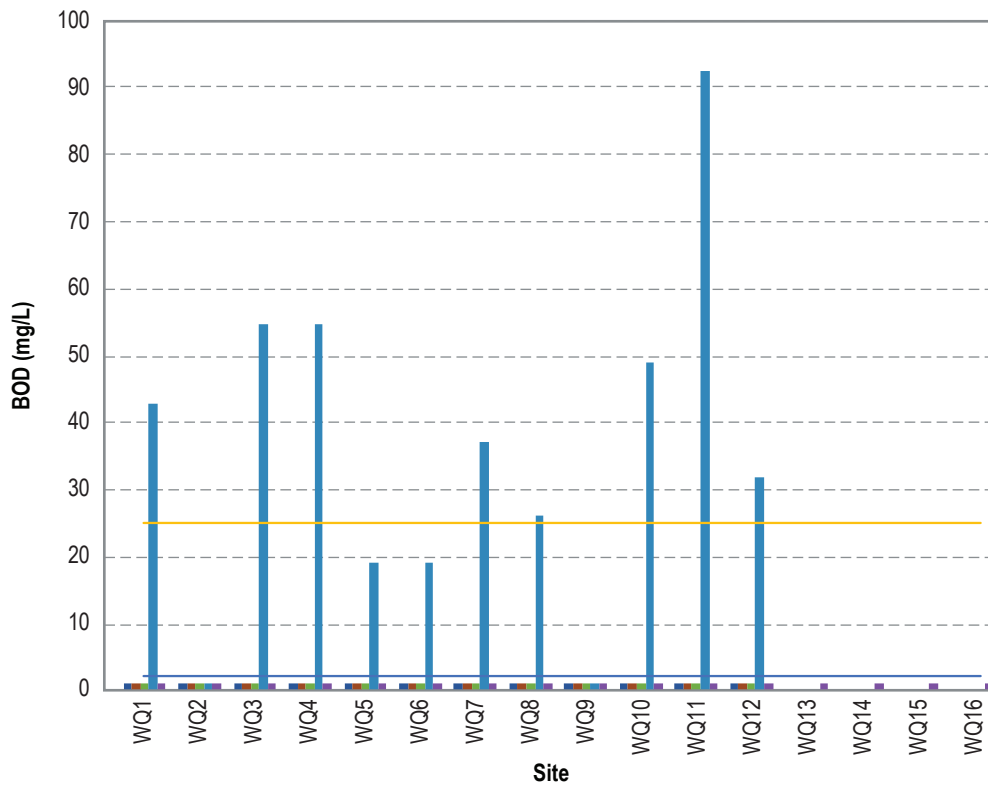
Dissolved metal concentrations are summarised in Appendix J. Metals that displayed values above or close to applicable guideline limits in 2019 or earlier years are illustrated in Figure 7.4, Figure 7.5 and Figure 7.6. Where results are below the detection limit, a value of half of the detection limit has been used in the graphs.

In 2007/2008, most water samples had concentrations of cobalt, chromium, copper, nickel, lead, selenium and zinc below the analytical detection limits (<0.001 mg/L for sampling in these years). Aluminium, iron, arsenic, cadmium, manganese and silver concentrations were above the detection limits at some sites but remained below the applicable criteria (Coffey Natural Systems 2008).

In 2010/2011 and 2014, barium, boron and tin were added to the list of metals to be analysed. Most metals concentrations were at or below detection limits, and/or below the Environment Permit criteria (where applicable). An exception was levels of cobalt in 2011, which was above the Environment Permit criterion but remained below the ANZECC/ARMCANZ (2000) 95% species protection guideline. Another exception was one lead concentration of 0.0046 mg/L at WQ1 in 2014, which was marginally above the Environment Permit criterion of 0.004 mg/L (Coffey Environments 2014b).

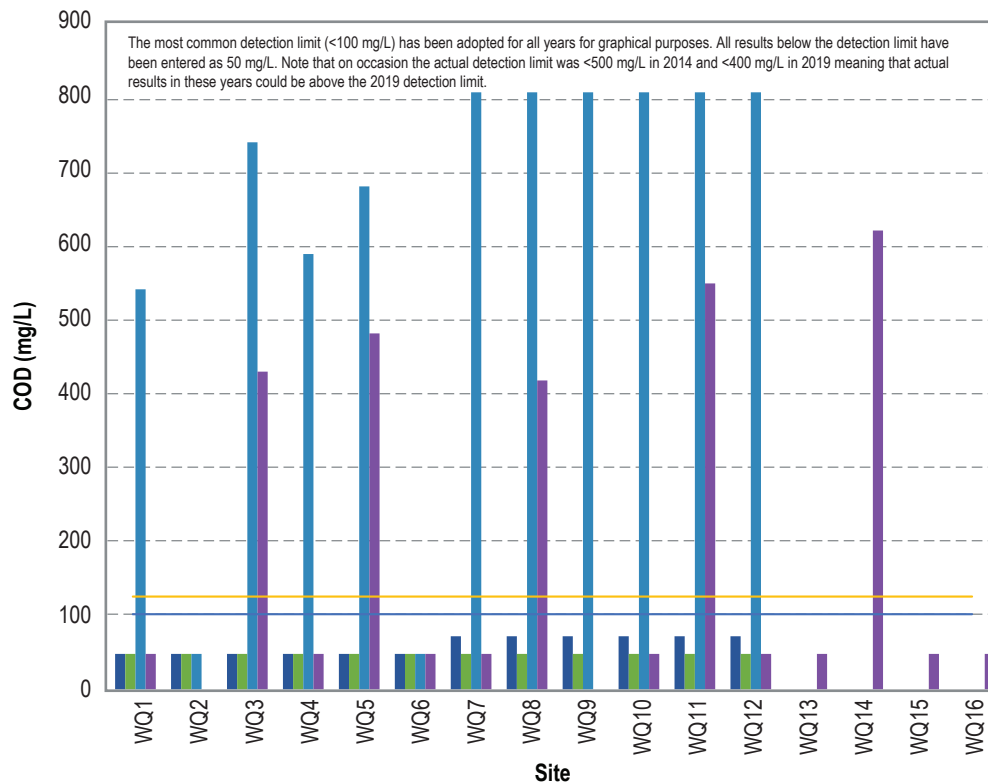
In 2019, the sampling results displayed a similar pattern with most parameters either below the applicable detection limit for each parameter, or below the Environment Permit criteria, ANZG (2018) 95% species protection and Schedule 1 guideline values. An exception was chromium at WQ_03 which reported a concentration of 0.078 mg/L. This level is above the Environment Permit criteria of 0.01 mg/L and was a significant outlier, possibly due to cross contamination of the sample or laboratory error. No obvious source of contamination has been identified near this site and all other water quality sites showed levels close to or below the detection limit, across all sampling years. Levels of silver at this site were above the ANZG (2018) 95% guideline of 0.0014 mg/L (but below the Environment Permit criterion of 0.5 mg/L), while results at other sites were below the detection limit (<0.0001 mg/L).

Biochemical oxygen demand (BOD)



LEGEND ■ 2010 result (Jan) ■ 2010 result (Feb) ■ 2011 result ■ 2014 result ■ 2019 result — Environment Permit Criterion — Detection Limit

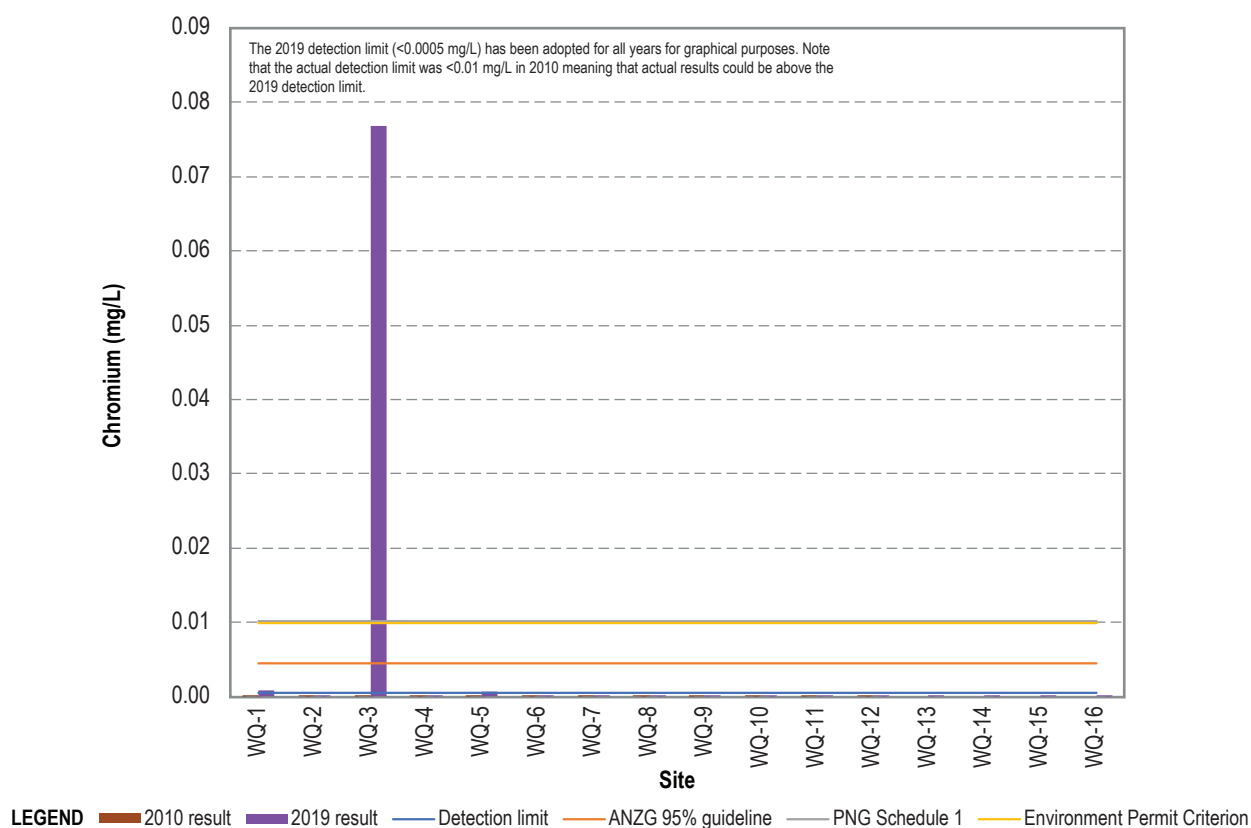
Chemical oxygen demand (COD)



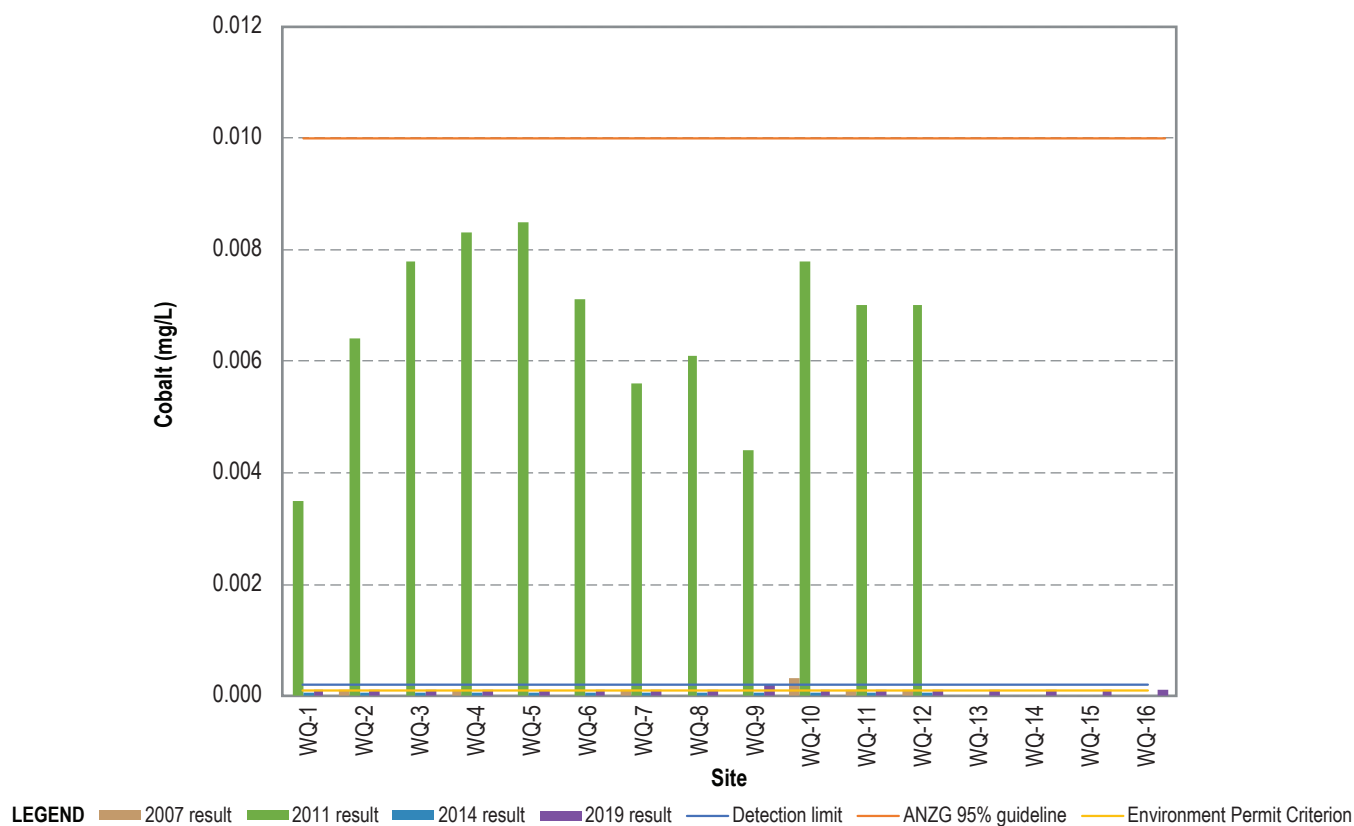
LEGEND ■ 2010 result ■ 2011 result ■ 2014 result ■ 2019 result — Environment Permit Criterion — Detection Limit

Note: Where results are below the detection limit values have been entered as half the detection limit i.e., a detection limit of <1 mg/L will be displayed as 0.5 mg/L.

Dissolved chromium concentration

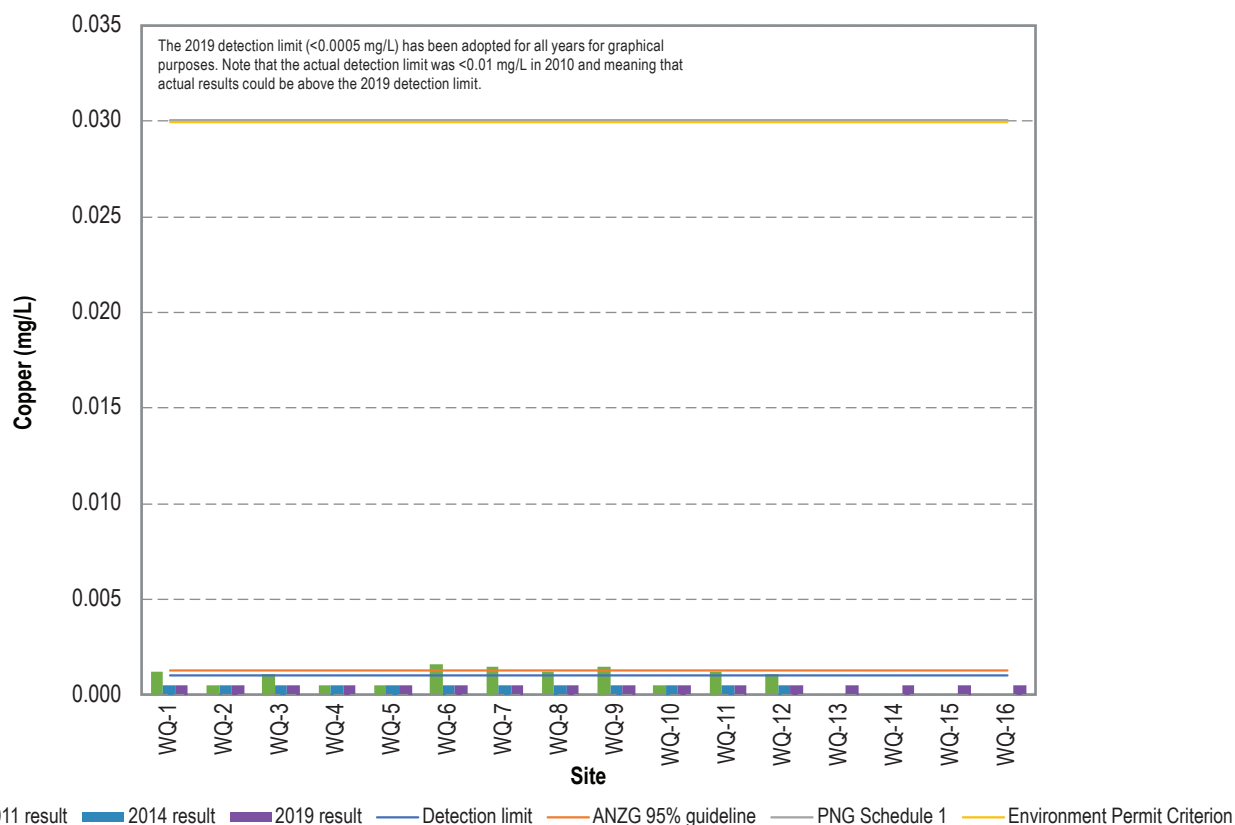


Dissolved cobalt concentration

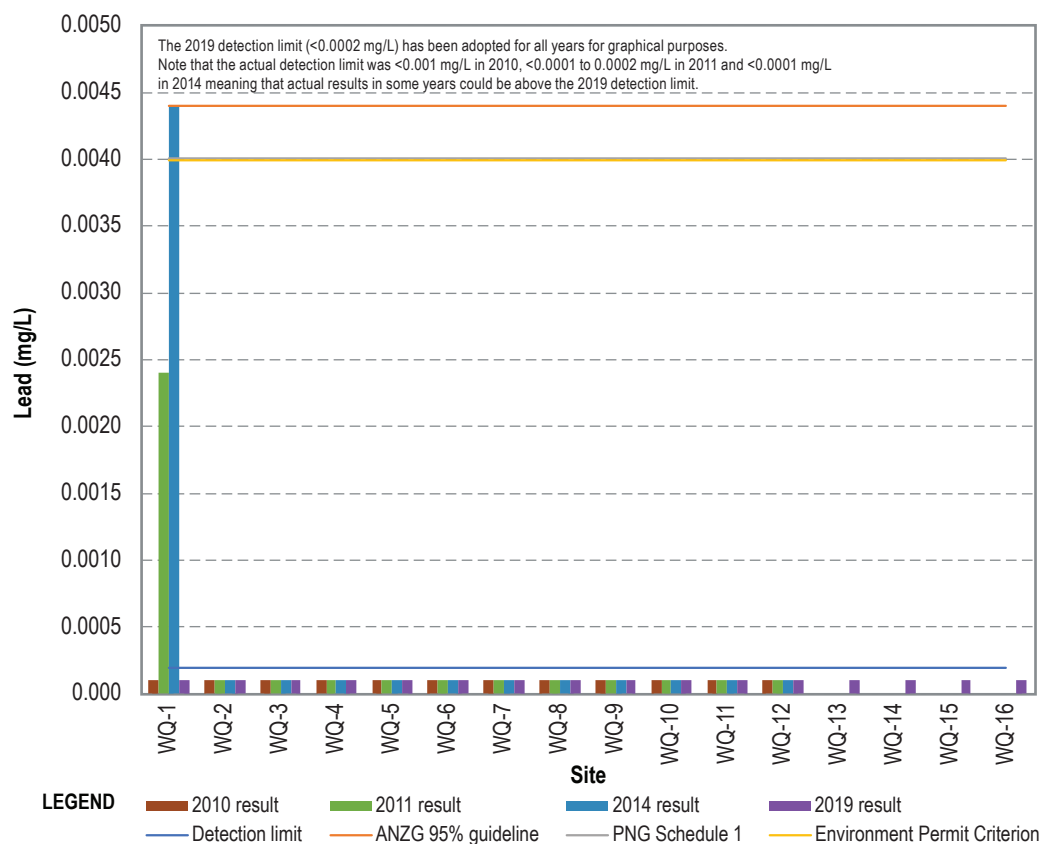


Note: Where results are below the detection limit values have been entered as half the detection limit i.e., a detection limit of <1 mg/L will be displayed as 0.5 mg/L.

Dissolved copper concentration

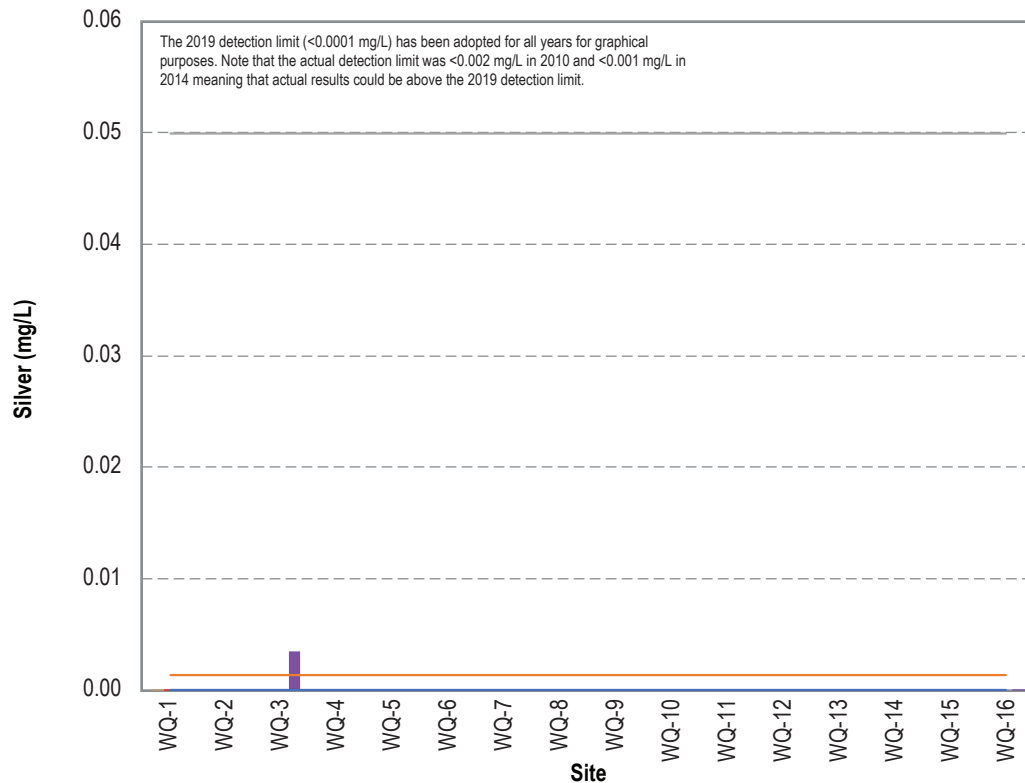


Dissolved lead concentration



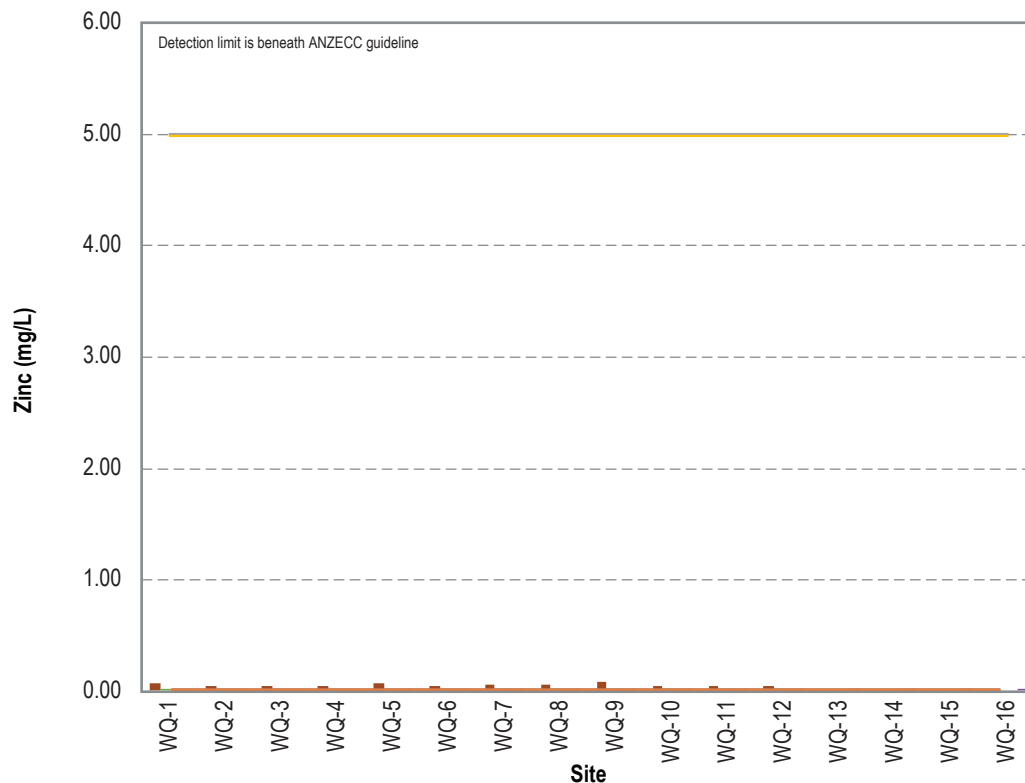
Note: Where results are below the detection limit values have been entered as half the detection limit i.e., a detection limit of <1 mg/L will be displayed as 0.5 mg/L.

Dissolved silver concentration



LEGEND 2007 result 2014 result 2019 result Detection limit ANZG 95% guideline Environment Permit/Schedule 1 guideline

Dissolved zinc concentration



LEGEND 2010 result 2011 result 2014 result 2019 result
Detection limit ANZG 95% guideline PNG Schedule 1 Environment Permit Criterion

Note: Where results are below the detection limit values have been entered as half the detection limit i.e., a detection limit of <1 mg/L will be displayed as 0.5 mg/L.

8. SEDIMENT QUALITY

The results from sediment sampling undertaken in 2019 and 2022 are presented in this chapter and are compared to pre-construction sampling results from 2007/2008 and sediment quality criteria, where available and relevant. Photographs illustrating the main types of sediment encountered during sampling in 2019 and 2022 are presented in Plate 8.1 to Plate 8.4.

Comparison is also made to sediment sampling undertaken prior to the 2009 pipeline trenching program and jetty construction for the PNG LNG Project. This sampling was undertaken near the LNG Plant jetty and PNG LNG pipeline landfall as part of a geotechnical program that used a drill rig to collect samples. Samples in 2009 were taken at depth intervals up to 5 m (rather than surface sampling, employed for the collection of samples in other years). Historical sampling locations are shown on Figure 3.2.

As sediment quality guidelines have not been established by regulatory authorities in Papua New Guinea, the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018) has been used to compare the sediment sampling results. There are two sediment quality guideline (SQG) values, a default guideline value (herein referred to as DGV) and an upper guideline value GV-high. The sediment DGVs indicate the concentrations below which there is a low risk of unacceptable effects occurring, and should be used, with other lines of evidence, to protect aquatic ecosystems. In contrast, the 'upper' guideline values (GV-high), provide an indication of concentrations at which you might already expect to observe toxicity-related adverse effects. As such, the GV-high value should only be used as an indicator of potential high-level toxicity problems, not as a guideline value to ensure protection of ecosystems¹⁴.

Laboratory analysis documents for 2019 and 2022 sediment sampling are presented in Appendix J.

8.1 PARTICLE SIZE RATIO AND CARBON CONTENT

Particle size ratios and organic/inorganic carbon content for samples collected in 2019 and 2022 are presented in Table 8.1 and Table 8.2, respectively. Particle size ratios for 2019 are illustrated graphically in Figure 8.1 to Figure 8.5 and compared to results from 2007/2008 where the same site has been sampled previously. Particle size ratios for 2022 are shown in Figure 8.6 and Figure 8.7.

8.1.1 Particle size distribution

Most sediment samples collected within Caution Bay in 2007/2008 were represented by sediments between 63 µm and 2,000 µm, although this varied with the type of seafloor habitat sampled. Approximately one-third of particle size distributions were in the greater than 2000 µm sediment fraction in the samples obtained from areas dominated by coral reefs (Sed 9, 10, 12, 13 and 16), which consist mainly of coral rubble and shell debris. Sediment samples collected from the shipping channel in Caution Bay (Sed 1, 2 and 3), at Idihi Island and in the mangrove communities of Vaihua River were dominated by particle sizes below the 63 µm fraction, and between the 63 µm and 2,000 µm sediment fraction.

Analysis of sediment samples collected in 2009 near the LNG Plant jetty and PNG LNG pipeline landfall (prior to trenching) showed sediments mainly comprised of silt (2.0 µm to 60 µm) and sand (0.06 mm to 2.0 mm), with these fractions making up between 71% and 87% (by weight) of the total particle composition in each sample. Clay was also a major component comprising between 11% and 25% of the total particle composition in each sample. Sites further offshore generally had a slightly higher proportion of clay (approximately 20%), when compared with nearshore sites (less than 20%).

¹⁴ Additional information regarding the derivation and application of toxicant default guideline values for sediment quality is available at: <https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/sediment-quality-toxicants>

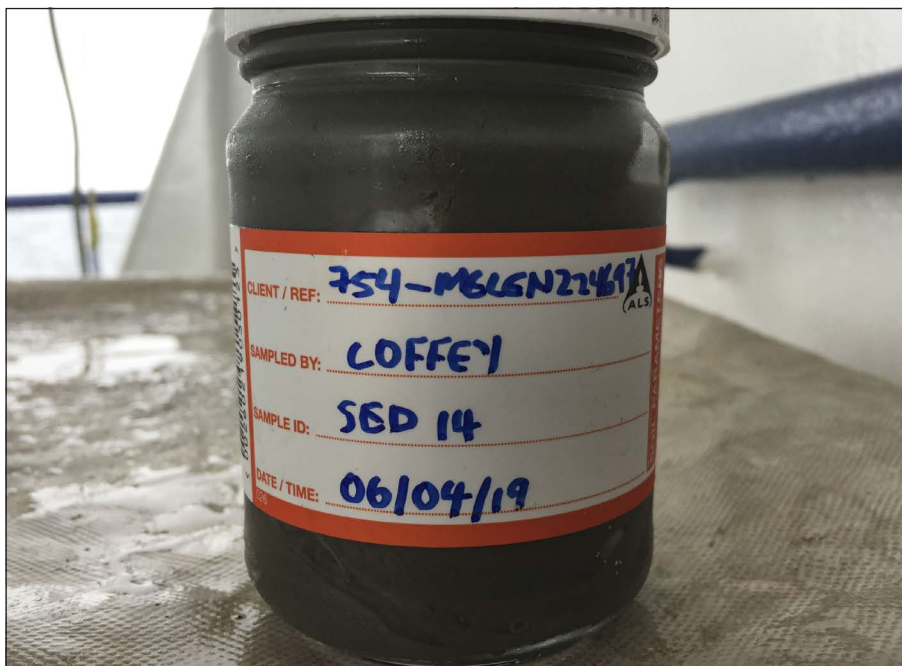


Photo credit: Tetra Tech Coffey

Plate 8.1
Silty material at SED_14 (2019)



Photo credit: Tetra Tech Coffey

Plate 8.2
Sandy material at SED_15 (2019)



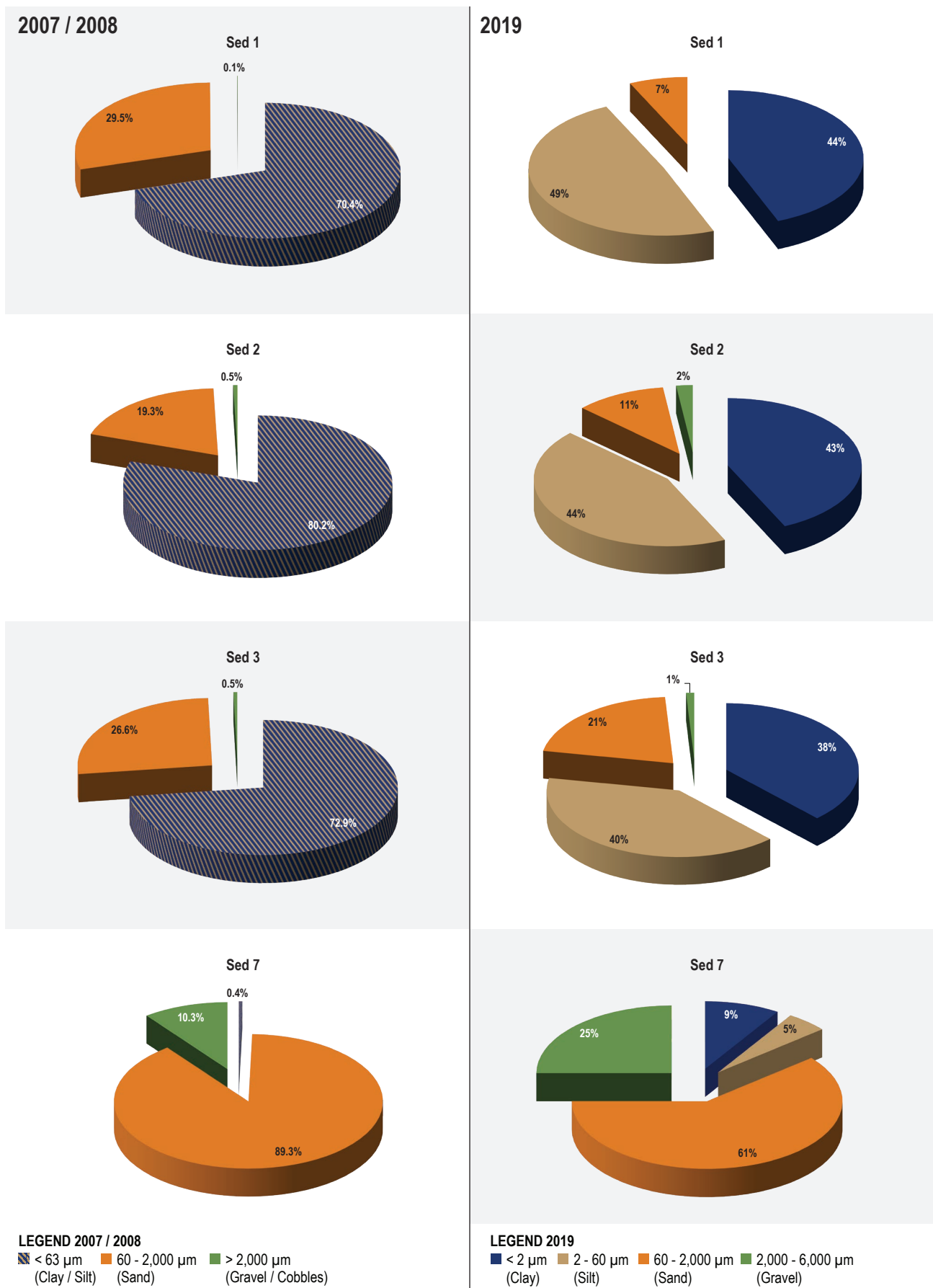
Photo credit: Tetra Tech Coffey

Plate 8.3
Silty material at Sed 34 (2022)



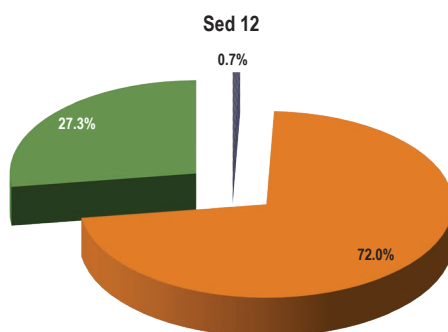
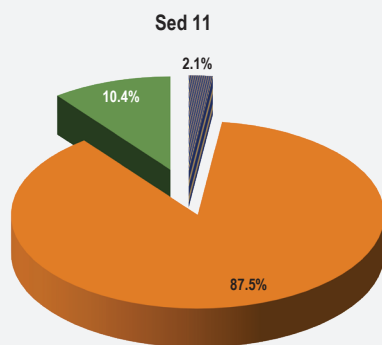
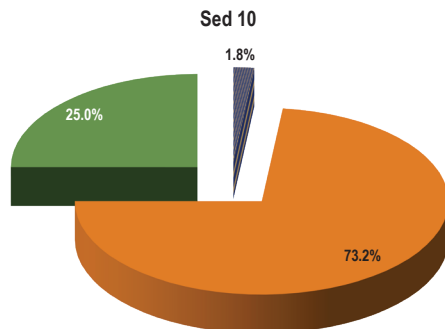
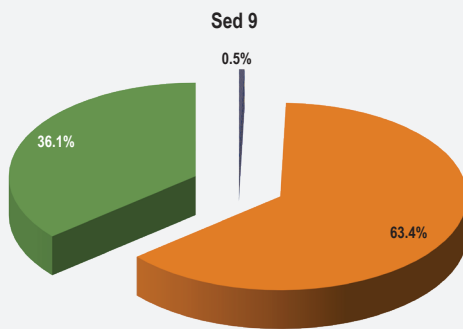
Photo credit: Tetra Tech Coffey

Plate 8.4
Sandy material at Sed T5 (2022)



Note: The blue/green striped segments for 2007/2008 results are equivalent to the separated blue and green segments for 2019 results

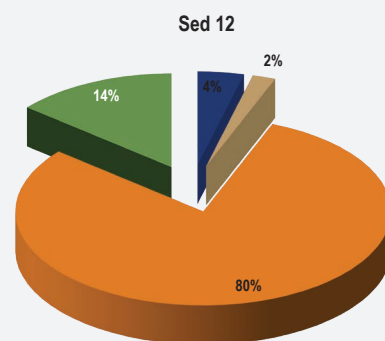
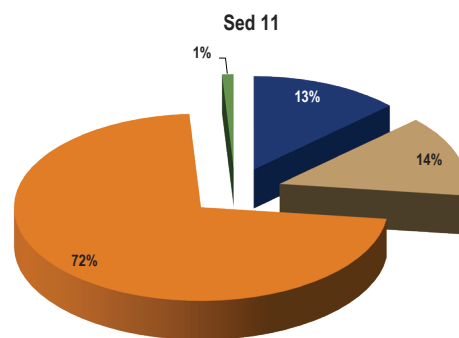
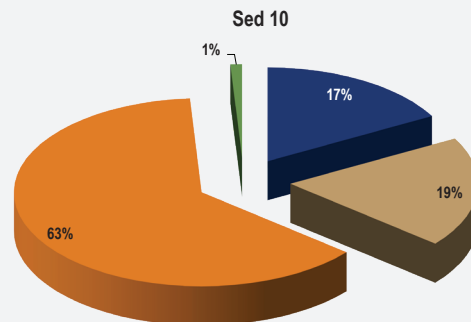
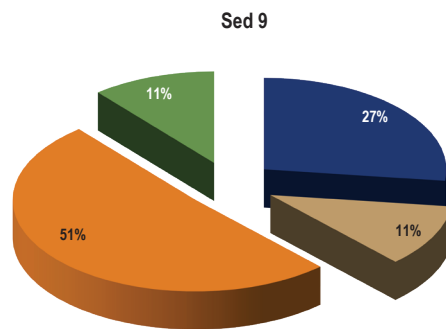
2008



LEGEND 2008

< 63 µm (Clay / Silt)
 60 - 2,000 µm (Sand)
 > 2,000 µm (Gravel / Cobbles)

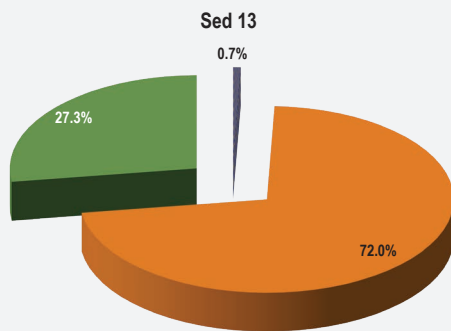
2019



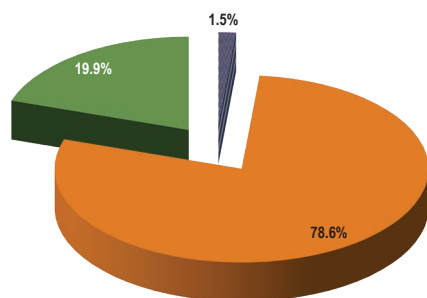
LEGEND 2019

< 2 µm (Clay)
 2 - 60 µm (Silt)
 60 - 2,000 µm (Sand)
 2,000 - 6,000 µm (Gravel)

2008

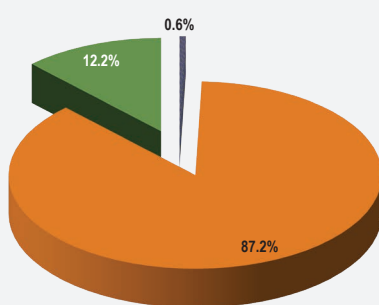


Sed 13

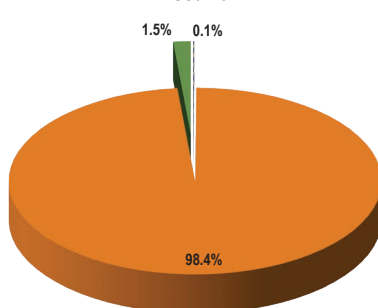


Sed 14

Sed 15



Sed 16

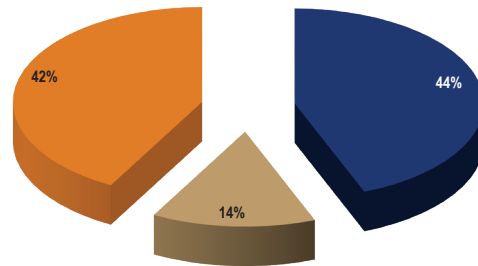


LEGEND 2008

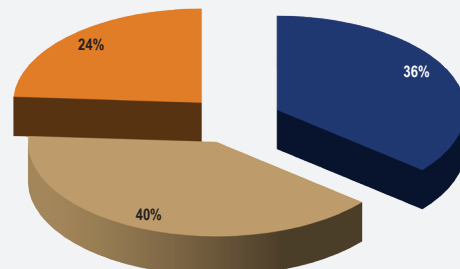
< 63 μm (Clay / Silt)
 60 - 2,000 μm (Sand)
 > 2,000 μm (Gravel / Cobbles)

2019

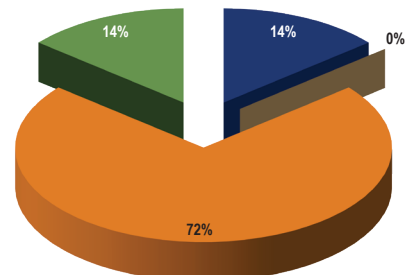
Sed 13



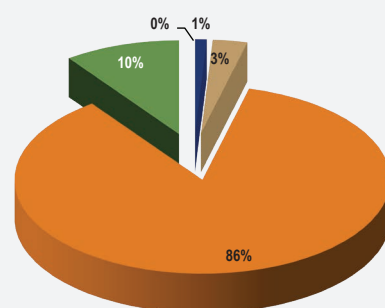
Sed 14



Sed 15



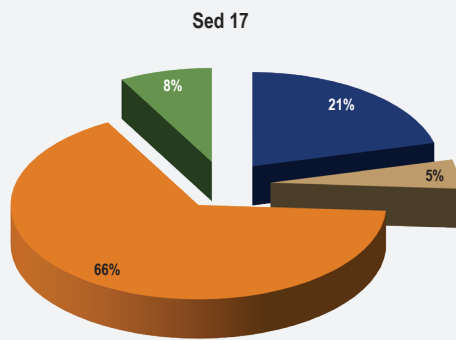
Sed 16



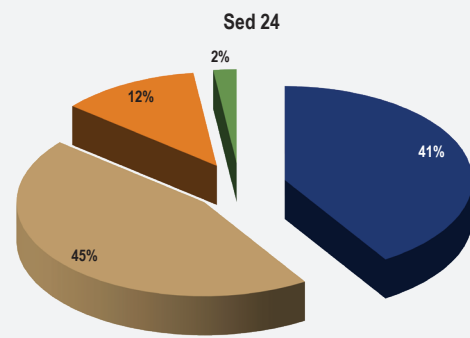
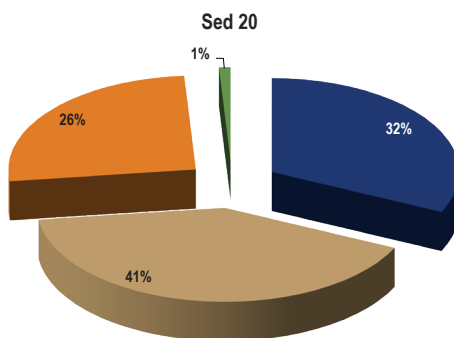
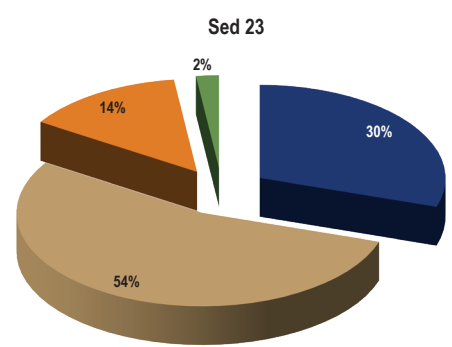
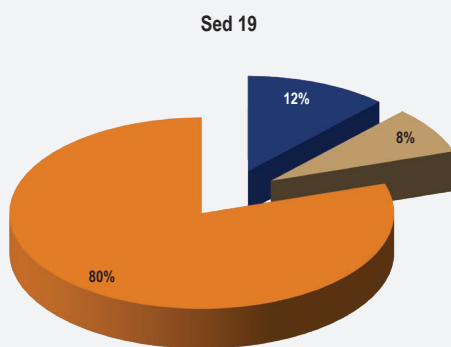
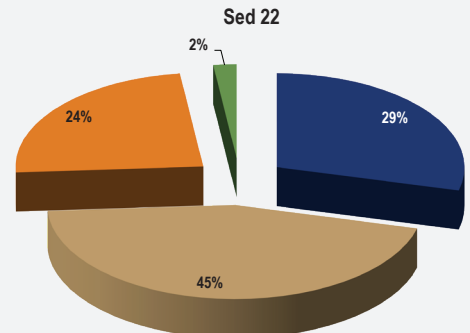
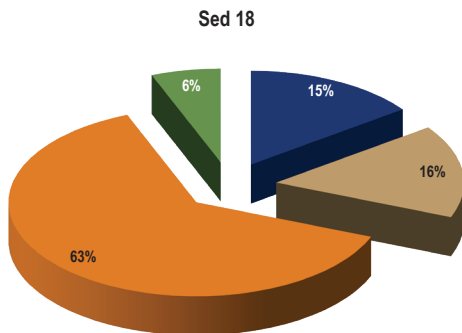
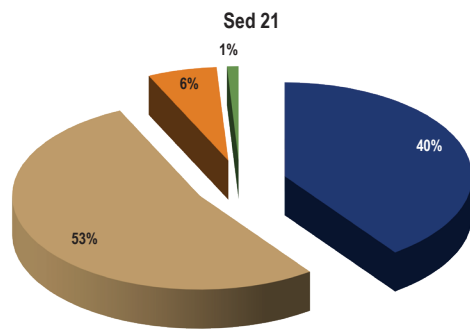
LEGEND 2019

< 2 μm (Clay)
 2 - 60 μm (Silt)
 60 - 2,000 μm (Sand)
 2,000 - 6,000 μm (Gravel)

2019

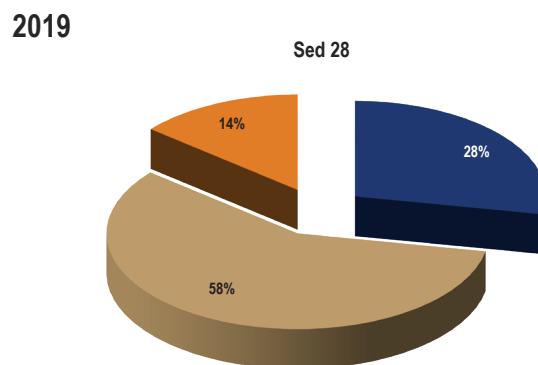
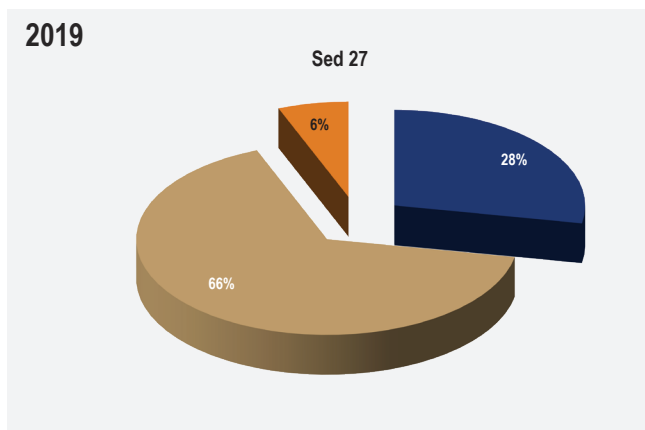


2019



LEGEND 2019

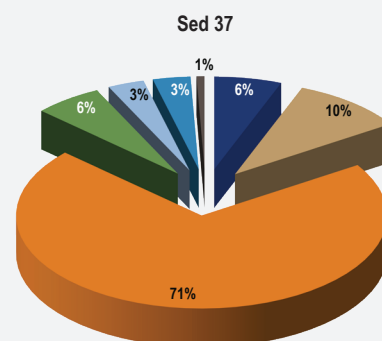
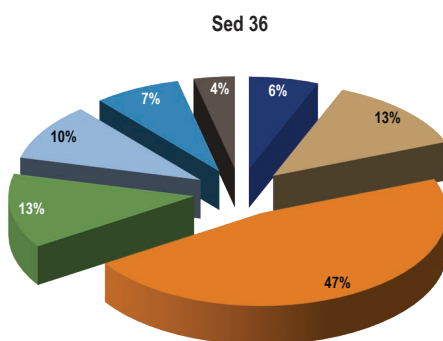
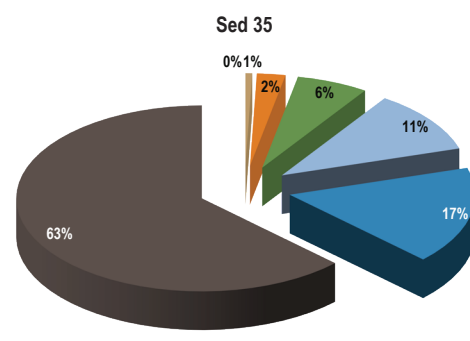
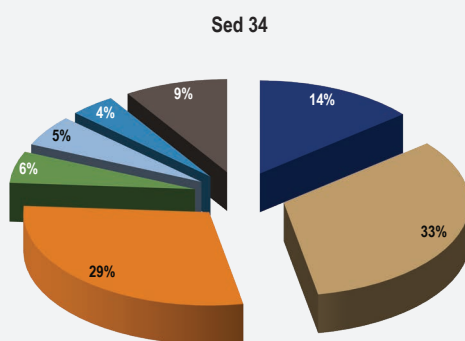
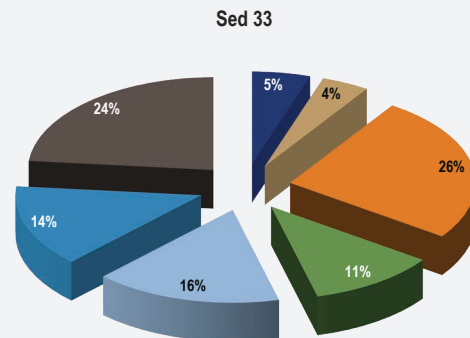
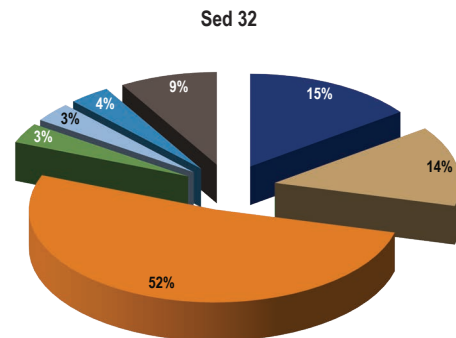
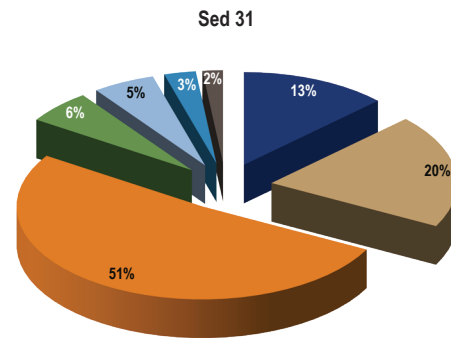
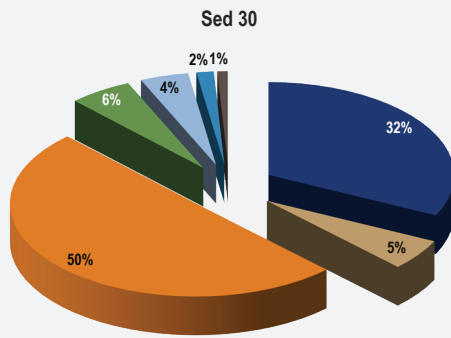
■ < 2 µm (Clay)
 ■ 2 - 60 µm (Silt)
 ■ 60 - 2,000 µm (Sand)
 ■ 2,000 - 6,000 µm (Gravel)



LEGEND 2019

■ < 2 µm (Clay)
 ■ 2 - 60 µm (Silt)
 ■ 60 - 2,000 µm (Sand)
 ■ 2,000 - 6,000 µm (Gravel)

2022



LEGEND 2022

■ < 63 µm ■ 63 - 125 µm ■ 125 - 250 µm ■ 250 - 500 µm ■ 500 - 1000 µm ■ 1000 - 2000 µm ■ > 2000 µm

EXXONMOBIL PNG ANTELOPE LIMITED

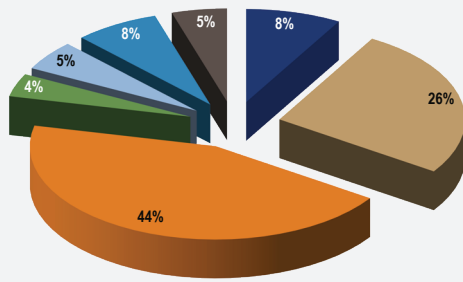
PAPUA LNG PROJECT – DOWNSTREAM

FIGURE 8.6

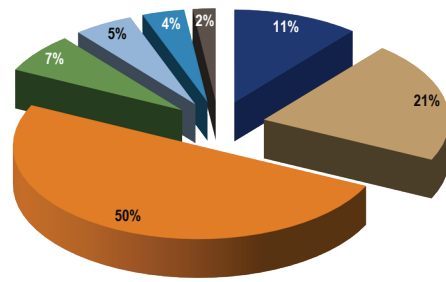
**Sediment particle size distribution –
Sed 30 - 37**

2022

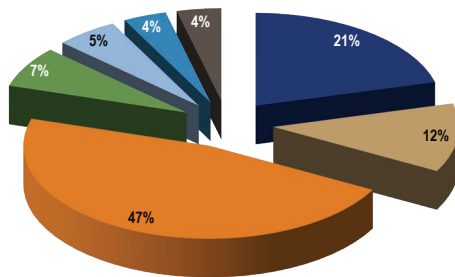
Sed 38



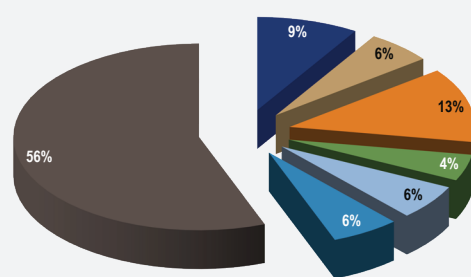
Sed T1



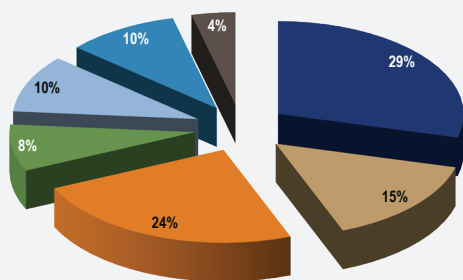
Sed T2



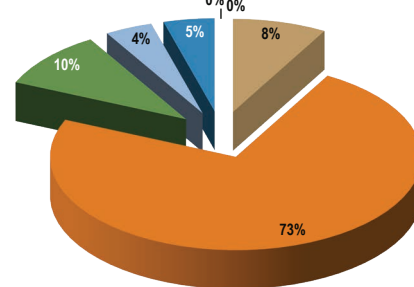
Sed T3



Sed T4



Sed T5



LEGEND 2022

■ < 63 µm ■ 63 - 125 µm ■ 125 - 250 µm ■ 250 - 500 µm ■ 500 - 1000 µm ■ 1000 - 2000 µm ■ > 2000 µm

Nearshore sites had greater proportions of silt/sand (approximately 80% or higher) when compared to sites further offshore (less than 80%) (Coffey Natural Systems 2009).

In 2019 most of the sediment samples were represented by sediments between 63 µm and 2,000 µm. The proportion of coarser fractions in some of the sites differed to that observed in 2007/2008, particularly at sites Sed 9, Sed 10, and Sed 11. This may have been due to small adjustments to the sample sites which were required, particularly in locations near the LNG Plant when the sampler was unable to pick up material at the exact point sampled previously.

In 2022, the size composition in sediment samples varied, and obvious spatial trends were not clear, suggesting local scale heterogeneity. The most common sizing was 125 µm to 250 µm, including in samples collected furthest from the shoreline, aside from at Sed 35 and Sed T3, where the >2000 µm was predominant. The highest proportion of fines (<63 µm) was observed in sample Sed 30, the most seaward sample collected approximately 15 km from shore. The lowest proportion of fines was observed in samples T5 (collected 1 km from shore) and Sed30 (collected 8.5 km from shore). The coarser fractions of materials were mainly observed at sites near coral reefs, where substrates consist mainly of sands, and coral rubble and debris. Sand/silt constituted a smaller proportion of the samples, particularly at sites closest to the shoreline. Due to a difference in analytical sieving techniques between 2019 and 2022 (laboratories using different size categories), direct comparisons of particle size could not be made between sampling periods.

Table 8.1 Sediment quality organic/inorganic content and particle size distribution 2019

Site ID	Total Organic C (%)	Total Inorganic C (%)	Sieving				
			Clay < 2 µm	Silt 2 – 60 µm	Sand 60 - 2,000 µm	Gravel 2,000 - 6,000 µm	Cobbles > 6,000 µm
Sed 1	2.81	1.97	44	49	7	<1	<1
Sed 2	5.12	4.33	43	44	11	2	<1
Sed 3	0.7	5.21	38	40	21	1	<1
Sed 7	9.17	8.91	9	5	61	25	<1
Sed 9	0.31	7.87	27	11	51	11	<1
Sed 10	1.44	1.09	17	19	63	1	<1
Sed 11	9.91	9.69	13	14	72	1	<1
Sed 12	0.16	11	4	2	80	14	<1
Sed 13	6.97	6.57	44	14	42	<1	<1
Sed 14	0.93	4.21	36	40	24	<1	<1
Sed 15	0.1	11.6	14	<1	72	14	<1
Sed 16	0.18	10.0	1	3	86	10	<1
Sed 17	8.26	7.96	21	5	66	8	<1
Sed 18	7.85	7.54	15	16	63	6	<1
Sed 19	0.38	3.02	12	8	80	<1	<1
Sed 20	3.5	2.82	32	41	26	1	<1
Sed 21	4.96	4.31	40	53	6	1	<1
Sed 22	3.49	2.93	29	45	24	2	<1
Sed 23	5.61	4.93	30	54	14	2	<1
Sed 24	0.55	5.84	41	45	12	2	<1
Sed 27	<0.02	4.84	28	66	6	<1	<1
Sed 28	<0.02	5.36	28	58	14	<1	<1

Table 8.2 Sediment quality organic/inorganic content and particle size distribution 2022

Site ID	Total Organic C (%)	Total Inorganic C (%)	Sieving					
			<63 µm	63 – 125 µm	125 – 250 µm	250 – 500 µm	500 – 1000 µm	>2000 µm
Sed 30	1.1	3.1	32	5.4	50	5.5	4.2	0.9
Sed 31	1.2	<0.1	13	20	52	5.9	5.5	1.8
Sed 32	4.6	2.5	15	14	52	3.5	3.4	8.5
Sed 33	6.3	2.1	6	4.1	25	11	16	23
Sed 34	3.1	4.1	14	33	29	5.5	5.4	9
Sed 35	2.7	1.2	<0.1	0.6	2.5	6.3	11	63
Sed 36	1.8	1	6.1	13	47	13	10	3.6
Sed 37	2.2	1.5	5.9	10	71	6	3.2	0.7
Sed 38	0.8	3.1	8.3	26	44	4	5.2	4.8
Sed T1	2.0	<0.1	11	21	50	6.9	5.2	2
Sed T2	1.4	1.3	21	12	47	7.2	5.5	3.9
Sed T3	3.7	1.5	8.9	5.8	13	4.6	6.1	56
Sed T4	9.1	<0.1	29	15	24	8.1	10	3.8
Sed T5	0.8	<0.1	<0.1	8.3	74	10	4.2	<0.1

8.1.2 Carbon content

Proportions of total organic carbon in sediment samples collected in 2007/2008 ranged from 2.2% to 10.8%. Total inorganic carbon ranged from 1.2% to 10.7%. There was no clear pattern in terms of carbon content and site location.

Total organic carbon in samples collected in 2009 prior to the pipeline trenching program near the PNG LNG pipeline landfall and prior to construction of the jetty ranged from 0.12% to 0.68%. Levels of organic carbon were found to generally decrease with increasing sediment depth interval (Coffey Natural Systems 2009).

In 2019, the proportions of total organic carbon content in samples ranged from <0.02% at Sed 27 and Sed 28 near the proposed jetty extension, to 9.91% at Sed 11 at the southern extent of the study area (see Table 7.1). Total inorganic carbon content ranged from 1.09% at Sed 10 inland of Kido Peninsula, to 11.6% at Sed 15 at Idihi Island.

In 2022, the proportion of total organic carbon content in samples ranged from 0.8% at Sed 38 (near the LNG Plant jetty) and Sed T5 (13 km offshore near the alternate CALM buoy location), to 9.1% at Sed T4 along the proposed naphtha and condensate pipeline route at a depth of approximately 10 m. Total inorganic carbon ranged from <1% at Sed T5, Sed T4, Sed 31 and Sed T1 to 4.1% at Sed 34.

No clear patterns were apparent in terms of carbon content and site location in either 2019 or 2022, and no trends were observed in terms of changes to carbon content over time.

8.2 PH

Sediment pH was similar across all sediment samples collected in 2009, ranging from 8.9 to 9.5. The relatively high pH, indicative of basic sediment conditions, is reflective of the high levels of natural calcium carbonates present in the sediment.

In 2019 pH values ranged from 8.4 to 9.0, and in 2022 the range of pH values was between 7.1 (Sed T5) and 8.5 (Sed 33). There were no apparent trends between pH and sample site location or sample depth interval in 2009 (Coffey Natural Systems 2009), nor in the 2019 and 2022 sampling. An exception to this was the lowest pH value of 7.1 at Sed T5 in 2022. This sample was taken closest to shore and near the Vaihua River mouth. The relatively low pH is likely due to the presence of relatively anoxic conditions, muds, and the aeration of soil sulphates (as also found in the nearby mangroves). This sample also had the lowest phosphorus content recorded of all samples in 2022 (180 mg/kg).

8.3 TOTAL POLYCHLORINATED BIPHENYLS

Polychlorinated biphenyl (PCB) analysis undertaken for sediment samples collected in 2009 near the LNG Plant jetty showed concentrations below the laboratory detection limit (Coffey Natural Systems 2009).

Similarly, sediment sampling in 2019 at Sed 3, Sed 16, Sed 18, Sed 19, Sed 21, Sed 22, Sed 27 and Sed 28 in nearshore environments along the proposed pipelines route options and near the LNG Plant jetty showed PCBs to be below detection limits at all sites and below the ANZG (2018) DGV (34 µg/kg dry weight) and GV-high (280 µg/kg dry weight) criteria (see Appendix J).

Analysis of sediment samples collected in 2022 within the proposed Project infrastructure location footprints, as well as a control site to the south of the proposed CALM buoy site, also showed PCBs to be below the detection limits at all sites and below the ANZG (2018) criteria.

8.4 ORGANOCHLORINE PESTICIDES

Testing for organochlorine pesticides in 2009 near the LNG Plant jetty measured concentrations of dichlorodiphenyldichloroethane (DDD), dichlorodiphenyldichloroethylene (DDE), total dichlorodiphenyltrichloroethane (DDT), dieldrin, chlordane, lindane and endrin below the respective detection limits in all samples (Coffey Natural Systems 2009).

Sediment sampling in 2019 at Sed 3, Sed 16, Sed 18, Sed 19, Sed 21, Sed 22, Sed 27 and Sed 28 in nearshore environments along the proposed pipelines route options and near the LNG Plant jetty also showed organochlorine pesticides to be below detection limits (and below the ANZG (2018) DGV of 1.2, 1.4, 3.5, 24.5, 2.8, 2.7, and 0.9 µg/kg dry weight respectively for total DDT, DDE, DDD, chlordane, dieldrin, endrin, and lindane) (see Appendix K).

Sediment sample analysis in 2022 near the location of the proposed Project infrastructure sites reported organochlorine pesticide concentrations below the detection limits for all samples.

8.5 HYDROCARBONS

Sediment samples collected in 2009 near the LNG Plant jetty showed total petroleum hydrocarbons (TPH) concentrations below laboratory detection limits of <10 mg/kg (for C6-14 fractions) and <50 mg/kg (for C15-C36 fractions) (Coffey Natural Systems 2009).

TPH and total recoverable hydrocarbon values in sediment samples collected in 2019 at Sed 3, Sed 16, Sed 18, Sed 19, Sed 21, Sed 22, Sed 27, Sed 28 and Sed 29 in the nearshore environment along the proposed pipelines route options and near the LNG Plant jetty were also below detection limits. Benzene, toluene, ethylbenzene, and xylenes (BTEX) were below detection limits at all sites.

Sediment sampling in 2022 showed that total recoverable hydrocarbons (TRH) and BTEX values in sediment samples collected across all sites in the nearshore marine environment and along the proposed pipelines route options were below their respective detection limits.

8.6 RADIONUCLIDES

Radionuclide analysis undertaken in 2009 on sediment samples from sites near the LNG Plant jetty and PNG LNG pipeline landfall showed radionuclides concentrations in all samples below the relevant screening level, as set forth in the National Assessment Guidelines for Dredging (NAGD). The maximum radiation concentration of 330 Bq/kg was below the NAGD screening level of 350 Bq/kg (Coffey Natural Systems 2009). Interpretation of the results by Queensland Health Scientific Services indicated that concentrations were typical of naturally occurring radioactive material in marine sediments (Kleinschmidt pers. Comm. 2009).

In 2019, radionuclide analysis was undertaken for selected sediment samples collected nearshore near the LNG Plant and LNG Plant jetty at Sed 3, Sed 16, Sed 18, Sed 19, Sed 21, Sed 22, Sed 27 and Sed 28. Radionuclides were below the detection limit of <500 Bq/kg dry weight (DW) at all sites.

Further radionuclide testing was not undertaken in 2022.

8.7 TRIBUTYLTIN

Tributyltin analysis of sediment samples was undertaken taken in 2009 from sites near the LNG Plant jetty and PNG LNG pipeline landfall. Concentrations of tributyltin and the metabolite by-products dibutyltin and monobutyltin were below the respective detection limits (and DGV of 9 µg/kg dry weight) at all sites (Coffey Natural Systems 2009).

In 2019, tributyltin analysis was undertaken for selected sediment samples collected along the proposed pipelines route options and near the LNG Plant jetty at Sed 3, Sed 16, Sed 18, Sed 19, Sed 21, Sed 22, Sed 27, Sed 28 and Sed 29. Concentrations of tributyltin were below detection limits and below SQG criteria (being 9 µg/kg for the default guideline value and 70µg/kg for the guideline value high) at all sites.

Analysis of tributyltin was not performed on samples in 2022.

8.8 METALS

Metal concentrations were analysed from the sub 2,000 µm fraction of all sediment samples.

Sediment sampling undertaken pre-construction of the LNG Plant jetty and prior to the PNG LNG pipeline trenching program in 2009 showed no metal concentrations above the relevant SQG criteria, although nickel concentrations at one site were equal to the ANZG (2018) DGV (21 mg/kg). Metal concentrations were generally similar between sites and at different depth intervals (Coffey Natural Systems 2009).

Results for selected total metals from sampling in 2019 and 2022 are provided in Table 8.3 and illustrated in Figure 8.8 to Figure 8.10 alongside historical results and ANZG (2018) criteria, where they exist.

Results from 2019 and 2022 are summarised as follows and are compared to results from 2007/2008 (where the site had been sampled previously):

- Nickel concentrations in sediment sample Sed 20 in 2019 (23 mg/kg) were reported above the DGV guideline of 21 mg/kg but remained below the GV-high value (52 mg/kg). This site was not sampled in 2007/2008, however other sites displayed similar concentrations, up to 11 mg/kg at Sed 9. Nickel concentrations in 2022 varied across samples; two sites (Sed35 and SedT5) had concentrations below the laboratory detection limit (<5 mg/kg), seven sites had concentrations below the DGV (21 mg/kg), and six sites had concentrations above the DGV (21 mg/kg) but below the GV-high (52 mg/kg). It is not uncommon for nickel concentrations in nearshore marine sediment to be above guideline values (Forstner and Salomons 1984).
- Arsenic, copper, chromium, lead, and zinc concentrations were typically above the detection limits in 2007/2008, 2019 and 2022, but all results were below the applicable ANZG (2018) DGV.

- Cadmium and silver concentrations were below detection limits in 2019. The achievable laboratory detection limit for silver (<2 mg/kg for most samples) was higher than the DGV (1 mg/kg), therefore comparison of silver concentrations to the DGV was not possible. Silver concentrations in 2019 were below the GV-high value of 4 mg/kg. In 2022, all samples of silver and cadmium were below the laboratory detection limit of 1 mg/kg, and therefore also below the ANZG (2018) DGV.
- Cobalt concentrations ranged from <2 mg/kg (Sed 15) to 12 mg/kg (Sed 20) in 2019, and from <5 mg/kg (Sed T5 and Sed 35) to 16 mg/kg (Sed T1) in 2022. There are no ANZG (2018) DGVs for cobalt.
- Iron and manganese levels were variable, being higher at some sites in 2007/2008, while higher at other sites in 2019 and 2022, with no clear spatial pattern observed. In 2019 iron levels ranged from 300 mg/kg (Sed 15) to 34,400 mg/kg (Sed 20). In 2022, iron levels ranged from 7,000 mg/kg (Sed T5) to 50,000 mg/kg (Sed T1). In 2019, manganese levels ranged from 49 mg/kg at Sed 15 to 529 mg/kg at Sed 21, while in 2022 manganese levels ranged from 120 mg/kg at Sed T5 to 780 mg/kg at Sed T1. Differences may be due to natural variation over time or slight variations in sampling locations between the surveys. There are no ANZG (2018) DGVs for iron or manganese.
- The highest and second highest concentrations of barium, chromium, cobalt, iron, lead, manganese, nickel, zinc, and vanadium from both the 2019 and 2022 surveys were all recorded in 2022 at Sed T1 and Sed T2 respectively.

8.9 ACID SULPHATE SOILS

Acid sulphate soil (ASS) testing was undertaken in 2009, with 22 sediment samples collected in shallow soil profiles within the foreshore environment at the LNG Plant site and tested for ASS indicators. Further ASS testing was not undertaken in 2019 or 2022. Sample locations included soils from nearshore beach ridges, back swamps, mangrove swamps and mudflats as well as the intertidal seaward reef (Coffey Geotechnics 2009). The results of the study in 2009 showed that:

- Nearshore land and beach ridges and shallow soils within the mudflats (0 m and 0.5 m) were non-ASS and non-potential acid sulphate soils (non-PASS).
- Deeper soil profiles between 0.75 m and 2.5 m within the mudflats and back swamp soils were PASS containing oxidizable sulfur which could potentially release acid if disturbed in aerobic conditions. The natural acid neutralising capacities of these soils, measured as CaCO₃ in the form of shell and/or coral fragments, were around 10 times and 50 times the average acid generating capacity respectively, meaning the soils would not create any acid if disturbed. It was determined that no treatment would be required.
- Soil profiles within the mangrove swamp were PASS but non-ASS. It was recommended that disturbance should be undertaken in accordance with an ASS management plan for any excavations greater than 100 m³ or fill placement greater than 500 m³ within the mangrove swamp area.
- Soils of the seaward reef were PASS but non-ASS. The natural neutralising capacity of the reef soil was around 150 times greater than the acid generating capacity meaning that the soils would not create acid if disturbed.

Table 8.3 Sediment – metals analysis in 2019 and 2022 (mg/kg)

Site	As	Ba	Be	B	Cd	Co	Cr	Cu	Fe	Mn	Hg	Ni	Pb	Se	Ag	Sn	V	Zn
Sed 1	8	20	<1	<50	<1	11	32	26	33,700	473	<0.1	20	13	<5	<2	<5	40	62
Sed 2	6	20	<1	<50	<1	8	26	18	26,600	389	<0.1	15	10	<5	<2	<5	26	45
Sed 3	7	10	<1	<50	<1	7	22	14	22,300	349	<0.1	13	8	<5	<2	<5	21	38
Sed 7	10	10	<1	<50	<1	5	13	<5	16,600	388	<0.1	9	5	<5	<2	<5	13	20
Sed 9	6	10	<1	<50	<1	7	18	7	27,400	408	<0.1	11	7	<5	<2	<5	15	27
Sed 10	<5	<10	<1	<50	<1	5	10	7	15,400	165	<0.1	7	<5	<5	<2	<5	12	24
Sed 11	5	10	<1	<50	<1	2	11	<5	8,140	142	<0.1	5	<5	<5	<2	<5	6	17
Sed 12	<5	<10	<1	<50	<1	1.9	3	<5	1,930	76	<0.1	<2	<5	6	<2	<5	<5	12
Sed 13	5	<10	<1	<50	<1	3	13	6	10,800	156	<0.1	7	7	<5	<2	<5	8	22
Sed 14	10	20	<1	<50	<1	10	29	25	30,400	446	<0.1	17	13	<5	<2	<5	35	52
Sed 15	10	<10	<1	<50	<1	<2	4	<5	300	49	<0.1	<2	<5	5	<2	<5	<5	14
Sed 16	8	<50	<1	<50	<1	<5	4	<5	5,160	223	-	2	<5	<5	<5	<5	<5	<5
Sed 17	8	<10	<1	<50	<1	5	13	6	14,600	250	<0.1	7	5	<5	<2	<5	9	23
Sed 18	8	10	<1	<50	<1	6	15	7	18,000	287	<0.1	8	6	<5	<2	<5	11	58
Sed 19	<5	<40	<1	<50	<1	<4	4	<5	3,580	156	-	<2	<5	<5	<4	<5	<5	<5
Sed 20	8	20	<1	<50	<1	12	35	22	34,400	504	<0.1	23	13	<5	<2	<5	40	58
Sed 21	7	20	<1	<50	<1	10	33	22	30,800	529	<0.1	20	13	<5	<2	<5	37	54
Sed 22	5	10	<1	<50	<1	7	23	13	20,800	360	<0.1	14	8	<5	<2	<5	22	36
Sed 23	6	20	<1	<50	<1	9	29	19	27,300	440	<0.1	18	12	<5	<2	<5	39	48
Sed 24	5	20	<1	<50	<1	8	26	17	23,700	424	<0.1	16	10	<5	<2	<5	27	43
Sed 27	7	<30	<1	<50	<1	7	24	16	25,600	409	-	15	8	<5	<3	<5	26	34
Sed 28	7	<20	<1	<50	<1	8	26	19	28,100	430	-	17	8	<5	<2	<5	31	39
Sed 30*	7.2	31	-	50	<1	13	49	29	39,000	620	<0.1	31	15	<5	<1	<5	60	69
Sed 31*	5.0	26	-	47	<1	8.8	35	19	26,000	480	<0.1	19	11	<5	<1	<5	39	46

Site	As	Ba	Be	B	Cd	Co	Cr	Cu	Fe	Mn	Hg	Ni	Pb	Se	Ag	Sn	V	Zn
Sed 32*	4.4	21	-	43	<1	8.5	32	18	25,000	420	<0.1	19	9.1	<5	<1	<5	36	42
Sed 33*	7.2	25	-	51	<1	10	37	21	30,000	520	<0.1	25	11	<5	<1	<5	44	51
Sed 34*	7.0	29	-	68	<1	12	44	24	34,000	570	<0.1	27	13	<5	<1	<5	51	60
Sed 35*	4.8	8.5	-	36	<1	<5	7.7	<5	8,700	180	<0.1	<5	<5	<5	<1	<5	10	10
Sed 36*	8.4	24	-	57	<1	9.1	31	15	27,000	460	<0.1	17	9.6	<5	<1	<5	32	40
Sed 37*	8.4	12	-	39	<1	6.5	20	8.5	18,000	270	<0.1	11	6.1	<5	<1	<5	18	31
Sed 38*	7.3	26	-	56	<1	9.2	34	19	29,000	480	<0.1	19	11	<5	<1	<5	37	49
Sed T1*	11	38	-	63	<1	16	59	36	50,000	780	<0.1	37	19	<5	<1	<5	72	87
Sed T2*	21	36	-	57	<1	15	57	35	46,000	700	<0.1	36	18	<5	<1	<5	67	83
Sed T3*	7.0	31	-	57	<1	13	46	24	38,000	590	<0.1	27	14	<5	<1	<5	51	61
Sed T4*	9.3	23	-	51	<1	8.9	29	13	27,000	440	<0.1	16	8.8	<5	<1	<5	28	37
Sed T5*	3.6	8.2	-	35	<1	<5	8.5	<5	7,000	120	<0.1	<5	<5	<5	<1	<5	<10	11
DGV	20	-	-	-	1.5	-	80	65	-	-	0.15	21	50	-	1	-	-	200
GV-High	70	-	-	-	10	-	370	270	-	-	1	52	220	-	4	-	-	410

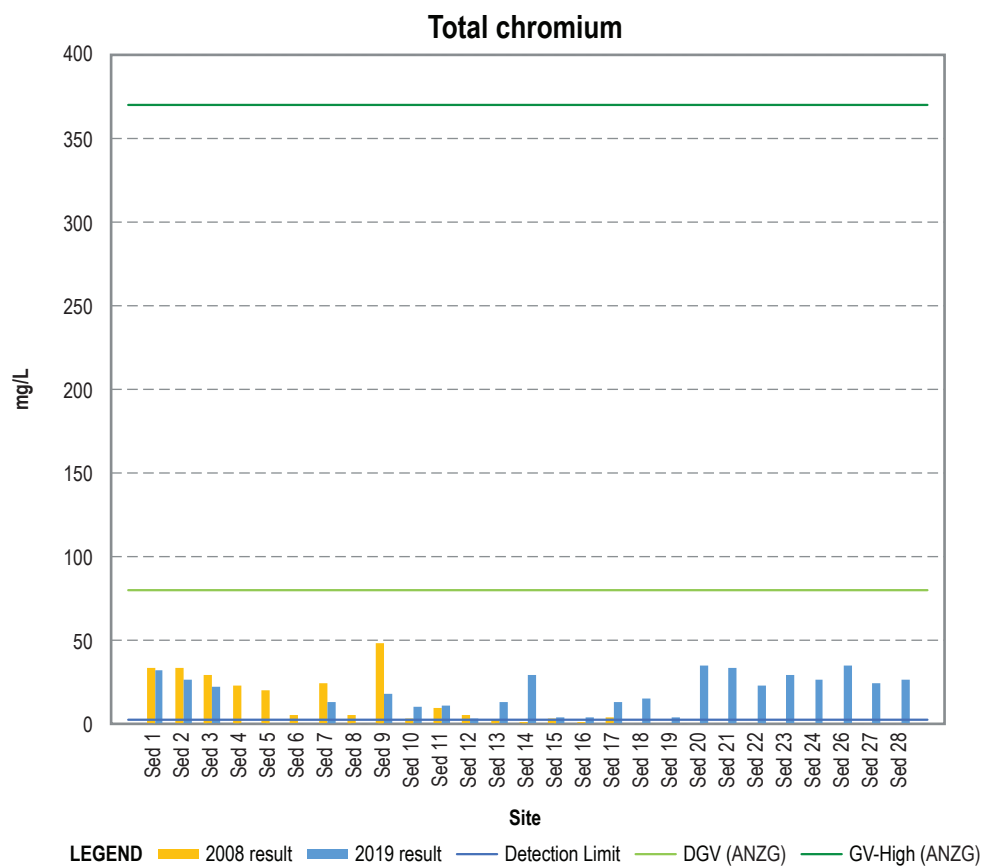
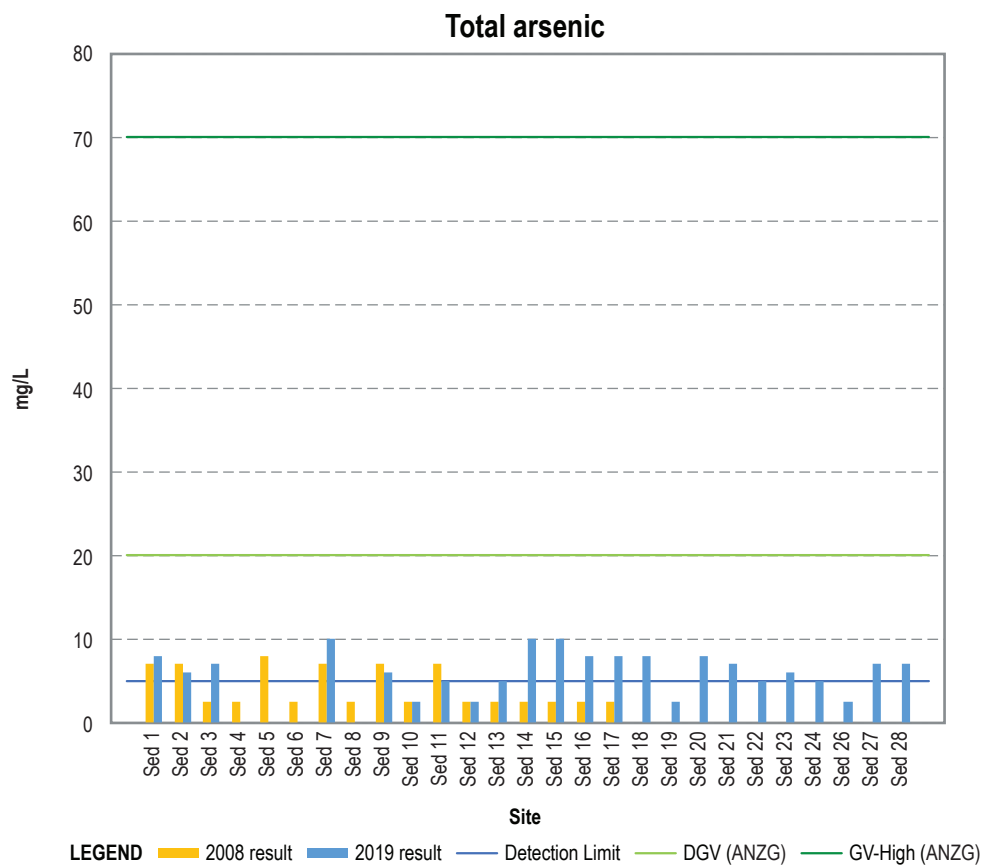
Sediment quality criteria source: ANZG 2018.

Bold text: Indicates concentrations above the DGV. No values were above the GV-high.

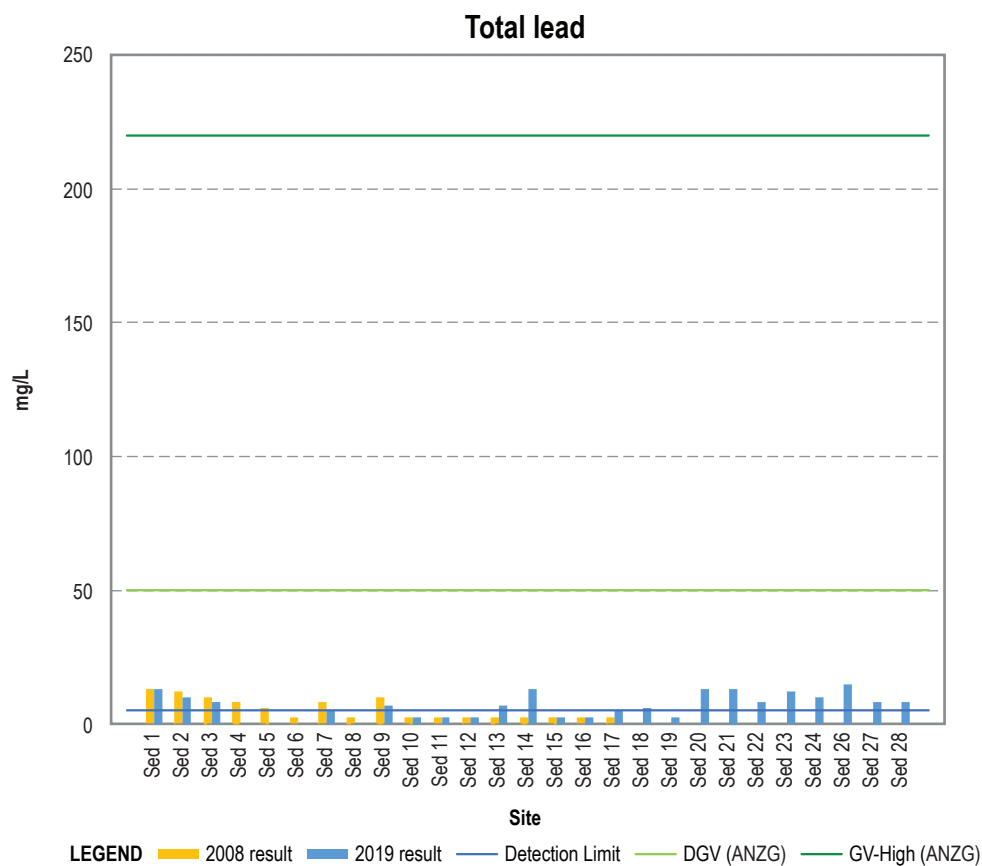
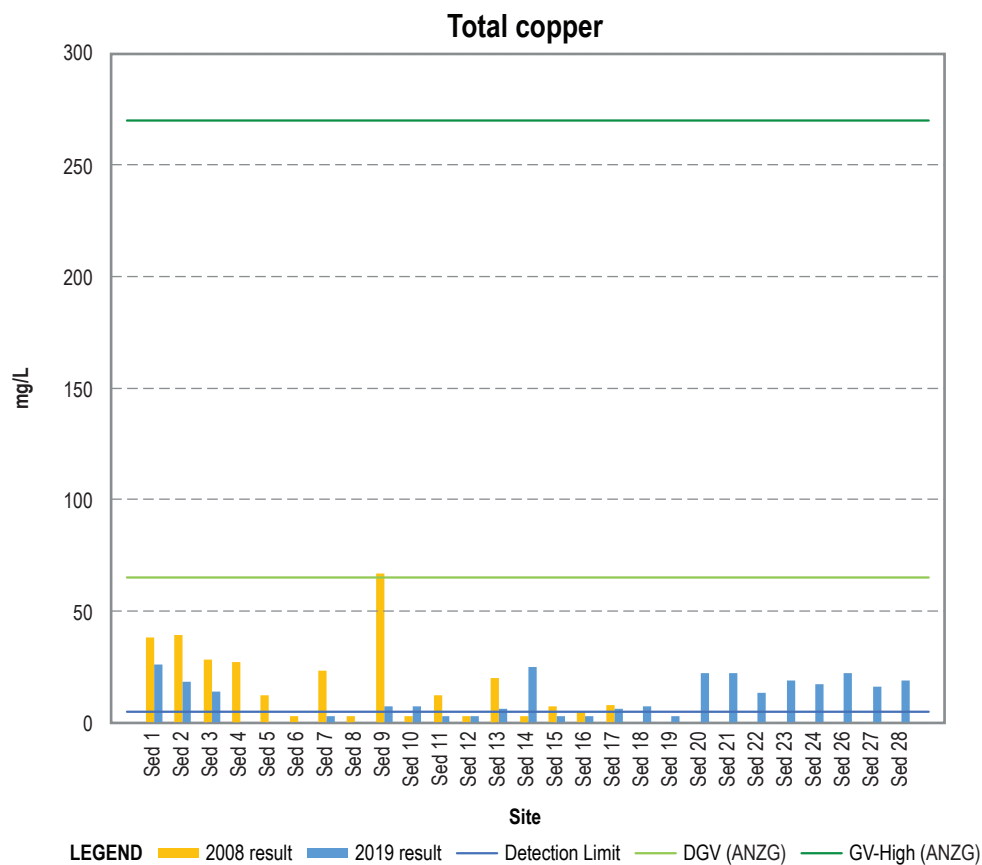
Sed 8 was unable to be sampled in 2019 due to poor weather preventing use of a small vessel to access the Vaihua River.

Analyses were undertaken on the less than 2,000 µm fraction.

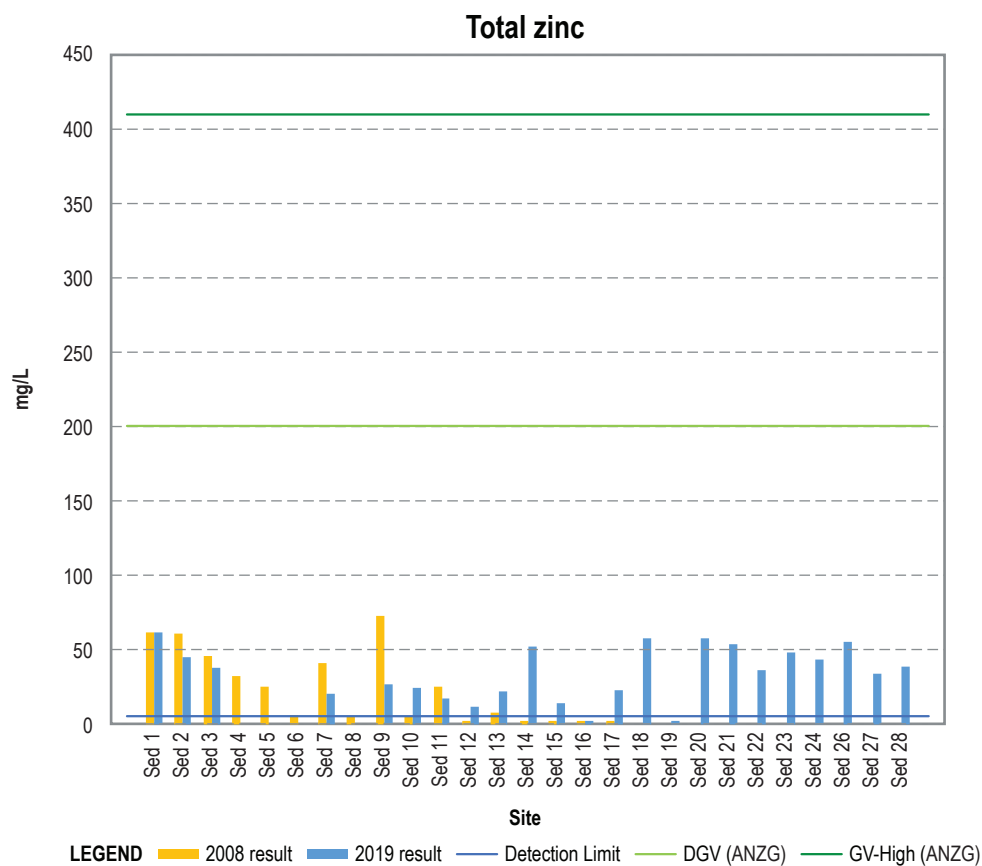
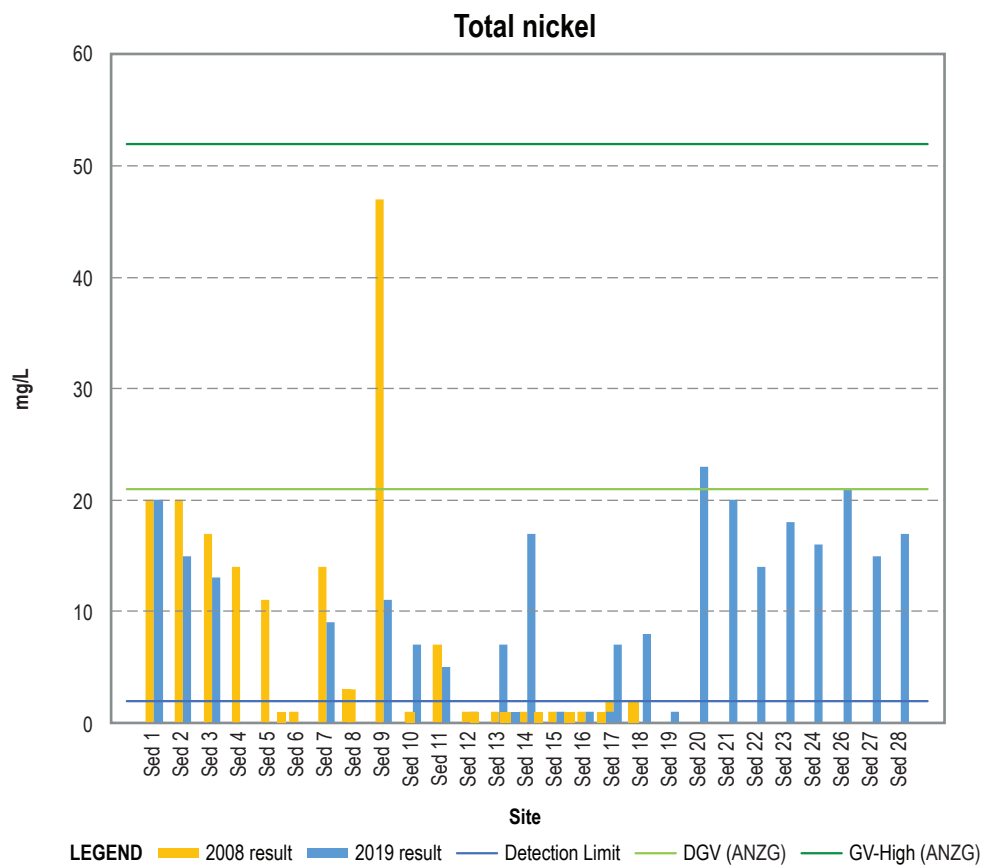
* Denotes sample collected in 2022.



Note: Where results are below the detection limit values have been entered as half the detection limit i.e., a detection limit of <1 mg/L will be displayed as 0.5 mg/L.



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8.10 SEDIMENTATION

Sedimentation in the Caution Bay study area for the Project is largely dependent on wind direction and strength, tidal state, and local current which may resuspend sediment, as well as seasonal river flows which will introduce sediment to the coastal system (Coffey Natural Systems 2008).

Sediment tubes were deployed on reefs to determine sedimentation rates for the PNG LNG Project EIS from December 2007 to February 2008 and February to April 2008. No pattern in sedimentation rates was observed over various sites across the sampling period, with a range in values possibly reflecting localised conditions (Coffey Natural Systems 2008). Sediment tubes were not deployed during further monitoring programs or during field work undertaken in 2019. Video footage obtained during marine ecology transects in 2019 did not show accumulation of sediment on the reef and it is possible that the material collected in the tubes was not indicative of what was permanently settling on the reefs.

Sedimentation rates in 2007 and 2008 ranged from 0.02 mg to 29.17 mg/cm²/day. The results of calcium carbonate determination were highly variable but indicated that as much as 60 to 80% of material was likely of marine origin at sites located at Idihi Island, Vari Vari Island and the shipping channel on the southern side of Haidini Island. In samples close to the eastern coastline of Caution Bay, the proportion of calcium carbonate was low indicating sedimentation of terrestrial origin. Sampling was mostly undertaken in the wet season and lower rates would be expected in the dry season. Detailed results are available in the PNG LNG Project Nearshore Marine Baseline and Impact Assessment (Coffey Natural Systems 2008).

9. QUALITY ASSURANCE

A quality assurance/quality control (QA/QC) program was implemented for both the fieldwork and laboratory components of the study. Procedures including those for collecting and/or analysing equipment rinsates, blanks, duplicates, reference materials and spiked samples. The QA/QC results are included in Appendix M.

9.1 MINIMISING CONTAMINATION

The following methods were used to minimise contamination of water and sediment samples:

- Sample bottles and jars were prepared at the analytical laboratory.
- Sample bottles, jars and sample bags were kept in clean plastic bags and stored in eskies before and after sampling events.
- Water was collected directly into the sample bottles, thereby minimising the potential for cross contamination.
- Bowls and spoons used to collect sediment were decontaminated with Decon 90 and rinsed with deionised water prior to collection of each sample.
- Powder-free disposable gloves were worn to avoid contact with skin and changed between samples.
- Care was taken not to touch the internal surfaces of the bottles, jars or lids, or otherwise contaminate the samples.

9.2 SAMPLE PRESERVATION AND TRANSPORTATION

Water and sediment samples were labelled with sampler's name, sample ID number, date and time of collection. Samples were refrigerated whilst held onboard the research vessel and stored in an esky with freezer blocks during transportation to Australian Laboratory Services (ALS) Laboratory Group, Brisbane (in 2019) and Eurofins in Melbourne (in 2022).

Macrobenthic infauna samples were initially fixed with formalin before being rinsed then preserved with ethanol prior to shipping, then refrigerated and transported to benthic taxonomy specialists contracted to undertake the analysis. Analysis was conducted by Dr John Moverley in Australia in 2019 and Benthic Australia in 2022.

9.3 FIELD QUALITY ASSURANCE PROGRAM

The following samples were collected as part of the field quality assurance programme, and are described in this section:

- Duplicate samples for water and sediment quality samples.
- Field blanks for water quality samples.
- Equipment rinsates.

9.3.1 Duplicates

Duplicate samples of water and sediment were collected for at least one in every 20 primary samples collected and submitted to the laboratory for analysis to measure the repeatability of the sampling method and analysis. Duplicate samples were analysed for the same parameters as primary samples. Duplicate samples were not collected in 2022 due to survey time and logistics constraints that necessitated field survey effort be focused on benthic video characterisation activities.

A duplicate sample collected in 2019 at Sed 27 (Sed 29) near the proposed jetty extension displayed gross beta radionuclides of 540 Bq/kg DW. Results for duplicate analyses of water and sediment samples are presented in Appendix L and include the samples listed in Table 9.1.

Table 9.1 Duplicate sample dates and locations 2019

ID	Date 2019
WQ_17 (duplicate of WQ_01/TSS01)	6 April
WQ_18 (duplicate of WQ_13)	12 April
WQ_26 (duplicate of WQ_14)	29 August
TSS47 (duplicate of TSS09)	26 August
Sed 25 (duplicate of Sed 2)	16 April
Sed 26 (duplicate of Sed 14)	6 April
Sed 29 (duplicate of Sed 27)	25 August

Detailed analysis of the results of field duplicate samples is provided in Appendix L and includes the calculation of the relative percentage difference (RPD) between the primary and duplicate samples, using the formula shown below.

where: C_o = concentration of the original sample
 C_s = concentration of the duplicate sample

$$RPD = \frac{(C_o - C_s)}{\frac{(C_o + C_s)}{2}} \times 100$$

If both results were below the laboratory reporting limit, an RPD was not calculated. Where one result was above and one was below, RPDs were calculated assuming 100% of the laboratory reporting limit for the non-detectable concentration.

A RPD of $\leq 20\%$ generally indicates an acceptable result for water quality duplicates, provided the result is five to ten times the analytical detection limit. If the result is close to the LOR, the RPD may exceed 20%. The

acceptable RPD can be strongly influenced by the analyte and matrix and in some cases a higher RPD is acceptable. The Australian Standard for Soils (AS 4482.1-2005) is applicable to sediments and states that an RPD of 30-50% is acceptable, noting that variation is generally higher for organic than inorganic parameters (DES 2018).

Duplicate samples showed that most of the results were similar to those from the primary sample and within the acceptable RPD range. This means that the results show a high degree of replication of, and consistency in, analytical processes. Where results were above the generally acceptable RPD range, this variation is likely due to low values detected leading to increases in relative errors, as well as the natural heterogeneity of metal concentrations in sediment and soils. The results are considered acceptable for the purposes of the scope of work.

9.3.2 Field blanks

Field blanks were prepared during the water sampling program to monitor for possible contamination during field sampling procedures. This process involved filling a set of sample bottles from a bulk sample of distilled deionised water in a manner as close as possible to that used for the primary water sample i.e., blanks were preserved and handled in the same way as for the primary sample bottles. Field blanks were analysed for the same parameters as primary samples.

Results for water quality sample field blanks are presented in Appendix J and include the samples listed in Table 9.2. The results from a further sample identified as 'DI Water Marine' are included in laboratory transcripts in Appendix K. This sample was collected from a fresh container of deionised water in April 2019.

For the sampling undertaken in April 2019, deionised water was not provided alongside the sample bottles from ALS Laboratories and was instead purchased from a supplier in Port Moresby. In August 2019, field blanks were prepared using ultra-pure (milli-Q) deionised water supplied in sealed containers by ALS laboratories.

Table 9.2 Field blanks

ID	Date 2019
WQ19	17 April
TSS46	26 August
WQ24	28 August
WQ27	29 August

Low levels of some metals were detected in field blanks collected in April 2019, while all parameters tested in field blanks collected in August 2019 were below detection limits.

Results from testing the fresh batch of deionised water indicated that it had low levels of manganese (0.0007 µg/L), tin (0.0011 µg/L) and zinc (0.009 µg/L) in it. These levels are apparent in trace levels of these contaminants in the results for field blanks WQ_18 and WQ_19 from April 2019 and appears due to contaminants in the deionised water from the supplier, rather than due to handling of the samples in the field.

Through deploying the open Niskin bottle to the desired depth at each sampling location, the bottle was thoroughly washed with seawater after cleaning with deionised water, and before collecting the sample. Levels of contaminants in the deionised water were low enough that small amounts of deionised water in the samples would not have significantly affected results, and results for these parameters were all below applicable criteria. Results are therefore considered acceptable for the field quality control.

9.3.3 Equipment rinsates

Equipment rinsates were also collected to test the effectiveness of the cleaning of sampling equipment. Rinsate samples were collected from equipment that was cleaned using Decon90 detergent followed by rinsing with deionised water. Once cleaned, fresh deionised water was poured over the sampling equipment e.g., water quality meter, and into the sample bottles. Equipment rinsates were tested for the same parameters as primary samples.

Results for equipment rinsates for water quality samples in 2019 are presented in Appendix J and include the samples listed in All parameters tested in equipment rinsates were at or below analytical detection limits. Results are considered acceptable for the field quality control.

Table 9.3.

All parameters tested in equipment rinsates were at or below analytical detection limits. Results are considered acceptable for the field quality control.

Table 9.3 Rinsate samples

ID	Date
TSS47	26 August 2019
WQ_25	28 August 2019
WQ_28	29 August 2019

9.4 LABORATORY QUALITY ASSURANCE PROGRAM

Quality control undertaken in the laboratory during analysis of water and sediment samples included:

- Method blanks: Laboratory blanks were prepared to monitor potential cross contamination in the laboratory. At least one blank was analysed per 20 samples.
- Laboratory duplicates: Intra-laboratory split samples were randomly selected from the sample batch to provide information on method precision and sample heterogeneity. At least one duplicate was analysed per 10 samples.
- Laboratory control samples: A known, interference free matrix spiked with target analytes or certified reference material was analysed with each batch of samples to monitor method precision and accuracy independent of the sample matrix.
- Matrix spikes: Matrix spikes involve intra-laboratory split samples spiked with a representative set of target analytes. This quality control parameter was included to monitor potential matrix effects on analyte recoveries.

Results for method blanks, duplicates and spike recoveries for water and sediment quality are shown in Appendix L. Most laboratory quality control analyses showed acceptable results with the occasional variance within the bounds of the laboratory method boundaries of error. A further breakdown of results along with notes on observations is provided on laboratory transcripts in Appendix L.

9.5 HOLDING TIMES

The holding times specified by laboratories for the analysis of certain parameters present a challenge in terms of the shipment of samples from the marine site location in Papua New Guinea to the laboratories in Australia. When holding times are exceeded, some under-reporting of water and sediment quality parameters may occur. Time sensitive parameters include biological oxygen demand and nitrate, which need to be analysed within 48 hours of collection, and coliforms which need to be analysed within 24 hours. To manage this issue,

in 2019 these samples were collected the day before, or morning of departure from Papua New Guinea and transported by person to the laboratory.

For samples collected in 2019, holding times were exceeded for certain parameters due to samples not being analysed because of delays during shipment or in the laboratory. A small number of samples analysed for total suspended solids and sulphides exceeded recommending holding times by up to one day. Sediment samples collected during the field survey breached holding times for analysis of pH. Measurements of pH were also taken in-field. All other parameters remained within holding times.

The limited number of short exceedances are unlikely to represent any substantial influence on the results.

For samples collected in 2022, Eurofins laboratory noted that all samples were received in good condition and provided with adequate time to commence analysis in accordance with the relevant holding times. Sample containers for volatile analysis were received with zero headspace, as required.

10. CONCLUSION

This nearshore marine baseline study indicates that environmental conditions in Caution Bay in the vicinity of the proposed Papua LNG Project – Downstream marine infrastructure and pipeline route options, appear to be similar to those observed during previous studies conducted for the PNG LNG Project.

Sediment and water quality analysis indicates that contamination has largely not been detected from 2009 to 2022, and most results do not exceed applicable regulations and criteria. Where exceedances have occurred, these are primarily due to the natural variation and occurrence of various metals and metalloids in the environment.

The general composition of subtidal habitats observed in 2019 and 2022 shows discernible zonation, with associated ecological communities being primarily related to depth and distance from shore. Where present, seagrass communities are typically well established, while fringing reef habitat has generally been observed in a variable, but typically degraded state. Given the substantial amount of *Sargassum* and turf algal cover observed to be present on much of the rocky and rubble substrates proximal to the fringing reef, it appears that the effects of habitat disturbance have contributed to a low abundance and diversity of fish and live corals. Beyond the fringing reef crest, substrates are largely homogeneous and of low complexity and habitat value, comprising soft sediments and silt, aside from at locations that are punctuated with occasionally well-established coral communities present as patch reefs and isolated bommies that support various hard and soft corals (particularly sea fans and gorgonians), and typical reef fish fauna. Aggregations of large fish and marine mammals or other marine megafauna, have not been observed during field surveys in proximity to the LNG Plant jetty.

The Project study area does not presently support the same level of coral and fish biodiversity as has been observed at other locations, ecoregions, bioregions, and functional seascapes of the Coral Triangle, particularly those recognised as 'hot spots' (such as those areas supporting more than 500 species of hard coral). Coral recovery is apparent in some locations, and occasional large corals are present in the study area, however these corals are likely to be widely distributed across the Indo-Pacific. Natural sedimentation due to the presence of nearby riverine habitats also appears to influence reef development in some parts of Caution Bay.

The mangrove species observed during field surveys adjacent the LNG Plant are commonly recorded elsewhere in Papua New Guinea and neighbouring countries, with the majority of survey transects hosting healthy mangrove communities typical of the Australasian/southeast Asian bioregion. Localised mangrove dieback has been observed in various areas in the vicinity of the LNG Plant over time, including adjacent and downstream of the LNG Plant retention pond mixing pit, as well as to the south of the LNG Plant jetty and LNG Plant pipeline disturbance areas. The mangrove species observed to be the most affected by dieback

are the yellow mangrove and Indian mangrove (*Ceriops* spp.), that primarily inhabit the landward edge of the mangrove habitat.

Change analysis in 2022 indicated that mangrove coverage increased within the LNG Plant retention pond discharge areas from 2010 to 2022, primarily attributable to an increase in *Avicennia marina* density, a species suited to frequent tidal inundation. This was most likely due to the construction and operation of the retention pond and mixing pit and the resultant increase in water discharge or flow.

The findings of a subsequent tracer dye investigation in 2023 indicated that the pooling of discharge waters from the LNG Plant mixing pond that flow into low lying areas and influence hydrodynamic flows, may be resulting in localised plant stress and mortality in *Ceriops* spp, while supporting conditions that have resulted in growth of other mangroves including *Avicennia marina*.

There are various factors influencing mangrove dieback, however direct causal links explaining all instances of dieback elsewhere in the mangroves adjacent the LNG Plant have not been determined, and investigations are ongoing.

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APPENDIX A: SAMPLING LOCATIONS

Table 1 Corner coordinates of areas of interest

Area	North-west	North-east	South-east	South-west
Area 1	500131 E 8968762 N	500771 E 8968751 N	500762 E 8968259 N	500123 E 8968269 N
Area 2	500242 E 8968195 N	500889 E 8968184 N	500878 E 8967542 N	500231 E 8967553 N
Area 3	500312 E 8967527 N	501278 E 8967511 N	501268 E 8966880 N	500301 E 8966897 N
Area 4	501257 E 8966580 N	502050 E 8966567 N	502041 E 8966045 N	501258 E 8966058 N
Area 5	500124 E 8969532 N	500747 E 8969541 N	500764 E 8968887 N	500136 E 8968870 N
Area 6	500506 E 8966790 N	501705 E 8966911 N	501717 E 8966633 N	500514 E 8966618 N

Table 2 Mangrove sampling locations

Site	Point	Easting	Northing
T1	1	501383	8966316
T2	2	501471	8966382
T3B	3	502000	8966371
T4	4	500363	8967628
T5	5	500497	8968686
T6	6	500368	8968510
T7	7	500596	8968147
T8	8	500833	8967374
T9	9	500715	8967123
T10	10	501085	8967171
T11	11	501143	8967155
T12	12	500340	8969033
T13	13	500336	8969336
T14	14	501387	8966821
T15	15	501038	8966706

Table 3 Intertidal mudflat ecology (macroinvertebrate and pore water sampling locations)

Site	Easting	Northing
T1 & T2	501449	8966349
T3B	502054	8966460
T4	500353	8967633
T5	500482	8968677
T6	500386	8968523
T7	500593	8968158
T8	500852	8967377
T9	500764	8967158
T10	501077	8967204
T11	501144	8967170
T12	500350	8969037
T13	500342	8969339
T14	501439	8966785
T15	501045	8966708

Table 4 Marine ecology coral and fish transect monitoring locations

Site	Position	Status	Easting	Northing
CF-01	Start	Existing	486871	8978437
CF-01	End	Existing	486886	8978308
CF-02	Start	Existing	495572	8974407
CF-02	End	Existing	495604	8974286
CF-03	Start	Existing	496815	8969256
CF-03	End	Existing	496932	8969246
CF-04	Start	Existing	499323	8969604
CF-04	End	Existing	499350	8969373
CF-07	Start	Existing	499569	8968175
CF-07	End	Existing	499558	8968088
CF-07 to CF-10*	Start	Existing	499612	8967336
CF-07 to CF-10*	End	Existing	499569	8968175
CF-09	Start	Existing	499625	8967906
CF-09	End	Existing	499630	8967788
CF-11	Start	Existing	498046	8967059
CF-11	End	Existing	498173	8967047
CF-12	Start	Existing	493117	8965169
CF-12	End	Existing	493234	8965166
CF-13	Start	Existing	498686	8965302
CF-13	End	Existing	498827	8965258
CF-14	Start	Existing	499446	8964366
CF-14	End	Existing	499577	8964296
CF-15	Start	Existing	500284	8964304
CF-15	End	Existing	500326	8964150
CF-16	Start	Existing	503855	8960453
CF-16	End	Existing	503830	8960349
CF-17	Start	Existing	486478	8958898
CF-17	End	Existing	486477	8958777
CF-18	Start	Added 2019	146°59'09.93"	9°20'11.47"
CF-18	End	Added 2019	146°59'09.50"	9°20'13.96"

Table 5 Water quality sampling locations

Site ID	Easting	Northing
TSS01/WQ_01	486803	8978707
TSS02	488707	8974642
TSS03	491186	8972705
TSS04/WQ_02	495505	8974317
TSS05	492541	8971268
TSS06/WQ_03	496191	8971778
TSS07/WQ_04	485967	8967875
TSS08	492531	8968976
TSS09	489732	8965155
TSS10/WQ_05	499301	8969516
TSS11	497098	8968445
TSS13	498965	8968764
TSS15/proposed water quality	497412	8967902
TSS16/WQ_06	498337	8968055
TSS17	498944	8968270
TSS18	499357	8968335
TSS19	499551	8968162
TSS20	496013	8966924
TSS21	497097	8967348
TSS23	499100	8967800
TSS24	498182	8967060
TSS25*/WQ_07	498536	8967273
TSS26/WQ_08	499700	8967500
TSS27	498787	8965392
TSS28	500898	8964080
TSS29/WQ12	486441	8958765
TSS30	501722	8956418
TSS31/WQ11	503445	8954725
TSS32/WQ_09	501310	8966401
TSS33	500947	8966246
TSS34/WQ10	501579	8960696
TSS35	497760	8966732
TSS36	497973	8969404
TSS38	500102	8966521
TSS39	499832	8968581
TSS40	500373	8966605
TSS41	495326	8964359
TSS42	494753	8967532
WQ_13	497416	8967843

Site ID	Easting	Northing
WQ_14	499557	8966166
WQ_15	495811	8964315
WQ_16	495238	8967532

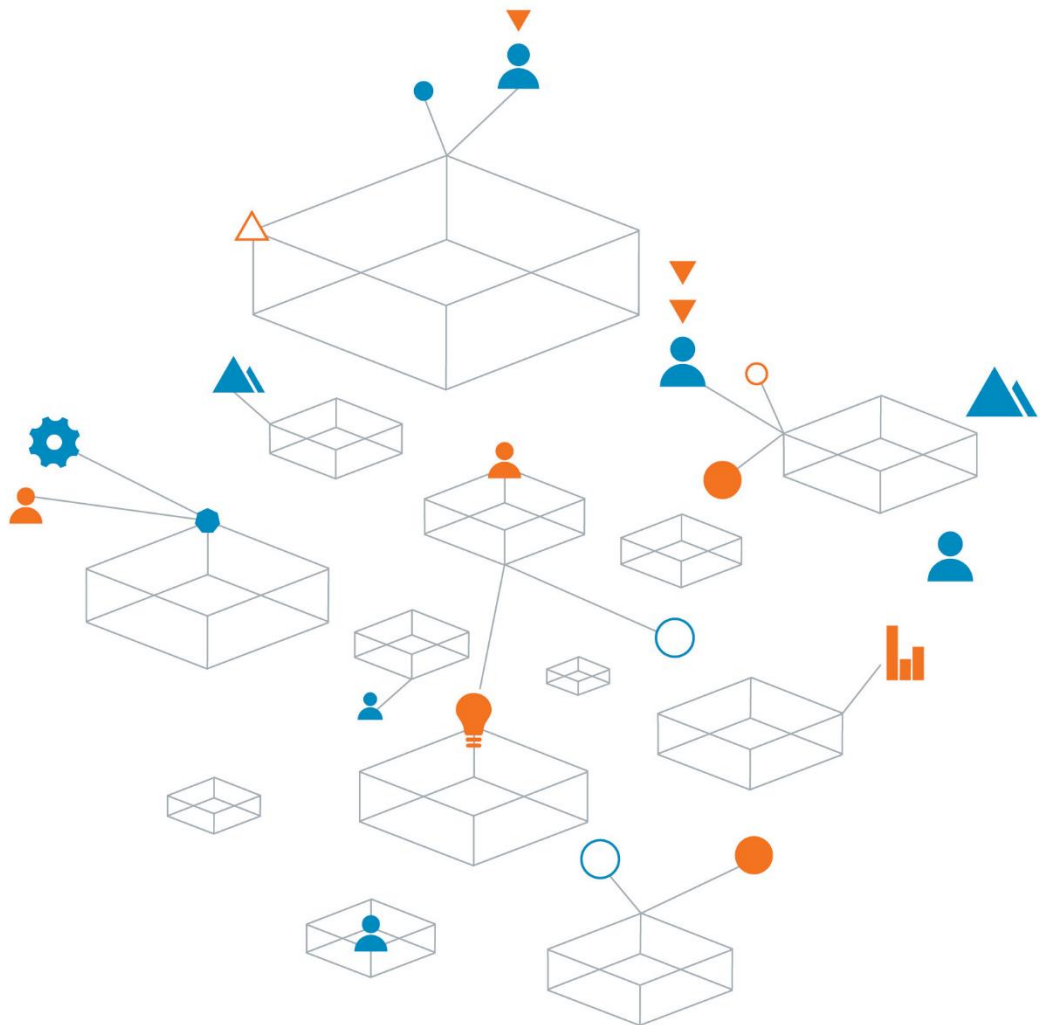
Table 6 Sediment quality and macrobenthic infauna sampling locations

Site ID	Easting	Northing
Sed 1/MI-5*	491072	8972578
Sed 1A	491072	8972578
Sed 2/MI-6*	496810	8971054
Sed 3/MI-7*	499032	8968776
Sed 7	499703	8963571
Sed 8	501869	8966271
Sed 9	498697	8965524
Sed 10/MI-2*	495341	8974157
Sed 11/MI-4*	503270	8954817
Sed 12	500461	8964585
Sed 13/MI-12*	503910	8960162
Sed 14/MI-1*	486832	8978654
Sed 15/MI-3*	486469	8958685
Sed 16/MI-8*	499531	8968187
Sed 17/MI-9*	499309	8967396
Sed 18/MI-16*	499377	8966855
Sed 19/MI-10*	500143	8966217
Sed 20/MI-13*	487646	8970372
Sed 21/MI-15*	495042	8967362
Sed 22/MI-14*	495446	8964197
Sed 23/MI-17	497109	8968953
Sed 24/MI-18	497524	8966525
Sed 27/MI-19	498500	8967972
Sed 28/MI-20	498307	8968423
Sed 30*	485619	8964616
Sed 31*	495199	8964543
Sed 32*	488710	8962588
Sed 33	487757	8964463
Sed 34	490102	8964114
Sed 35	492405	8964251
Sed 36	497321	8965464
Sed 37	499464	8966486
Sed 38	498442	8968098
Sed T1*	489415	8969412
Sed T2	491658	8968215
Sed T3*	494062	8966239
Sed T4	498540	8965905
Sed T5*	499879	8966392

* These sediment sample sites were also sampled for macrobenthic infauna.

APPENDIX B: MARINE WATER AND SEDIMENT QUALITY MONITORING MANUAL

Water and Sediment Sampling Manual



Trust is the
cornerstone
of all our
projects

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26 March 2019

Quality information

Revision history

Revision	Description	Date	Originator	Reviewer	Approver
v1	Draft	20/03/2019	Erica Colley	Kristen Hall	Emma Waterhouse
v2	Final	26/03/2019	Erica Colley	Kristen Hall	Kristen Hall

Distribution

Report Status	No. of copies	Format	Distributed to	Date
v2	N/A	PDF	ExxonMobil PNG Limited	26/03/2019

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1. Introduction

1.1. Purpose

This document is intended for use by Coffey personnel working in and around the Caution Bay area in Papua New Guinea (PNG) for the purpose of marine water quality and marine sedimentation studies.

This field manual describes the methods that will be used for all marine water and sediment sampling campaigns for the project. This document should be used as a guide when working in both the field and the office.

1.2. Contact details

1.2.1. Coffey

Contact details for Coffey are:

Port Moresby office

Nelson Sukwainomb

Phone: +675 325 2867

Fax: +675 325 2875

Email: nelson.sukwainomb@coffey.com

Melbourne Office

Kristen Hall

Phone: +613 9290 7049

Fax: +613 9418 0650

Email: kristen.hall@coffey.com

1.2.2. ALS Laboratory Group (ALS)

Water and sediment samples will be analysed by ALS Laboratory Group (ALS). An AQIS permit has been provided by ALS (Appendix A).

Contact details for ALS are:

ALS Environmental Division

2 Blyth St

Stafford,

Queensland 4053

Australia

Contact Charles Tibbitts, Client Services Manager

Phone: +61 7 3552 8659 Fax: + 617 3352 3662

Email: charles.tibbitts@alsglobal.com

1.2.3. Commonwealth Scientific and Industrial Research Organisation (CSIRO)

Samples that require analysis for microbial parameters (including faecal coliforms, enterococci and *Escherichia coli*) are included within ALS quotes and ALS will ship empty sample bottles to Coffey. However, samples must be returned directly to CSIRO for analysis.

Contact details for CSIRO are:

Simon Toze/Jatinder Sidhu

CSIRO O&A – Ecosciences Precinct

B3 Loading dock (Joe Baker St)

41 Boggo Rd

Dutton Park, Queensland 4102

Australia

Emails: Simon.toze@csiro.au; Jatinder.Sidhu@csiro.au

2. Water and sediment sampling

2.1. Location

The water and sediment sampling locations (including figures) are detailed in the Nearshore Marine Survey Plan. New sampling locations are approximate sampling locations based on the proposed infrastructure for the project. The precise locations will be recorded during the survey and the tables and figures updated for future reference.

2.2. Equipment required

The following equipment is required to undertake marine water and sediment sampling.

2.2.1. Water quality sampling

- Acid- and detergent-washed, deionized-water-rinsed, 1.7-L Niskin bottle.
- Marked nylon rope with weight for measuring approximate water depth.
- Niskin bottle messengers (x 2).
- Marked nylon rope for lowering the Niskin bottle (approximately 30 m).
- Van veen grab sampler
- Nylon rope for lowering grab sampler
- Lab prepared and pre-labelled sample bottles and jars/sample bags.
- Field log sheets.
- Gloves (powder-free).
- Chain of custody log sheets and a waterproof field notebook
- An import permit (an AQIS permit) and permission to use letter from the laboratory.
- Permanent markers, pens, pencils, packing tape and plastic pockets.
- Water quality meter to record in-situ parameters (TPS 90-FLMV).
- Deionised or distilled water.
- Hand-held global positions system (GPS).
- Syringes and filters as required.
- Water filtering apparatus.
- Eskies and pre-chilled freezer blocks, keep cool and fragile stickers.

2.2.2. Sediment sampling

- Petite Ponar grab sampling device.
- Box corer.
- Marked nylon rope with weight for measuring approximate water depth.
- Marked nylon rope for lowering the sampler.
- Lab prepared and pre-labelled sample jars/bags.
- Stainless steel mixing bowl and spoon.
- YSI Model 63 multimeter for insitu parameters.
- Field log sheets.
- Gloves (powder-free).

- Chain of custody log sheets and a waterproof field notebook
- An import permit (an AQIS permit) and permission to use letter from the laboratory.
- Permanent markers, pens, pencils, packing tape and plastic pockets.
- Hand-held global positions system (GPS).
- Eskies and pre-chilled freezer blocks, keep cool and fragile stickers.

2.3. Sampling parameters

Sample parameters are detailed in the Nearshore Marine Survey Plan.

2.4. Sampling method

2.4.1. Marine water sample collection

Wherever possible, the sampling site will be approached from downcurrent and downwind and samples are collected with the bow of the boat facing upwind and up current to minimise site disturbance. As long as it is safe, the engine will be cut prior to sampling. Duplicate field samples will be collected as close as possible in time and space (and from the same Niskin bottle deployment).

At each sampling site, the site name and number, the GPS coordinates, the date and time of sample collection and in-situ profiling location, the weather and sea conditions, the total water depth and the identity of the samples collected will be recorded on a log sheet.

Niskin bottle

The Niskin bottle is a plastic cylinder with stoppers at each end that are connected by an elastic cord.

The stoppers are held open by plastic cords attached to a release mechanism. Two clamps on the side of the cylinder are used to attach the bottle to a nylon rope so that it can be lowered to a defined depth in the water. When a small weight encircling the nylon rope (the messenger) is released down the line it strikes the release mechanism and the two stoppers are pulled into the ends of the cylinder, thereby trapping water from that depth. Operational instructions are detailed here:

- To deploy the Niskin bottle, hitch it open and lower it to 1m below the water surface. Once at the required depth, hook the messenger around the nylon rope and release it. Once the messenger has contacted the Niskin bottle, the Niskin bottle will close, thus trapping the water from the desired depth. Once the Niskin is closed, retrieve the Niskin bottle by hauling it up and over the edge of the boat.
- On retrieval, two people are required to fill the sample bottles, one to hold the Niskin upright and one to fill the bottles using the valve at the base of the bottle.
- When filling the sample bottles, ensure that the bottles do not contact the Niskin bottle valve as it may contaminate the sample.
- Following completion of sample collection, discard the remaining water from the Niskin bottle and rinse the Niskin bottle and valve with deionised water.

Filling sample bottles

Sample containers are to be prepared by the laboratory contracted to undertake the sample analysis.

High-purity acid, which acts as a preservative for the samples to be analysed for metals (nitric acid) and nutrients (sulfuric acid), is added to the sample bottles at the time of preparation, where appropriate.

The sample bottles are to be labelled prior to deployment to the field and preferably covered with clear tape to ensure the label does not rub off when collecting the sample. Samples will be filled from the Niskin bottle and transferred directly into sample bottles using the following method:

- Wear powder-free latex gloves and take care not to touch the internal surfaces of the bottles or bottle caps.
- Record the sample depth using either a weighted rope with meter increments or using the nylon rope attached to the Niskin bottle.
- Where sample bottles do not contain a preservative or fixing chemical, sample bottles are to be rinsed three times with the sampling water before collecting a sample.
 - Collect nutrient samples before metal samples to prevent possible contamination from nitric acid fumes emanating from metal sample bottles.
 - Remove the sample bottle cap and fill from the Niskin bottle being careful that the bottles do not touch the Niskin bottle valve.
- Fill all sample bottles to the top to reduce contact of the sample with atmospheric oxygen.
- Place samples into the esky immediately after sampling. The use of freezer blocks is recommended over wet ice.
- Record all the required details on the chain of custody log sheet.
- Ensure all sample sheets are completed entered into the electronic database and backed up daily.

Measuring in-situ parameters

A water quality meter will be used to measure pH, temperature, conductivity, dissolved oxygen, turbidity, salinity and temperature. These measurements are to be taken in conjunction with Niskin bottle sampling at each site during the water quality sampling. Prior to making measurements in the field, the water quality meter must be calibrated by the suppliers and tested in the office prior to departure to the field.

2.4.2. Marine sediment sample collection

Wherever possible, the sampling site will be approached from downcurrent and downwind and samples are collected with the bow of the boat facing upwind and up current to minimise site disturbance. If it is safe, the engine will be cut prior to sampling.

At each sampling site, the site name and number, the GPS coordinates, tidal cycle, the date and time of sample

collection and in-situ profiling location, the weather and sea conditions, the total water depth and the identity of the samples collected will be recorded on a log sheet.

The grab sampler will be cleaned daily with dilute detergent and thoroughly rinsed in seawater after each sampling event. The grab sampler will be lowered slowly into the water before being released for free-fall to the seabed.

Three replicate samples will be undertaken at each location which will be mixed in a clean stainless-steel bowl to obtain a homogeneous composite sample. The homogenised sample will be transferred via a stainless-steel scoop into the sample containers.

Measuring in-situ parameters

In situ pH measurements will be obtained using a hand-held meter. The probe will be inserted into each composite sediment sample and the reading allowed to stabilise. The probe will be rinsed with distilled water and visually checked prior to each use. It will be pre-calibrated prior to departure.

Observations regarding sediment colour, form and composition will be recorded and photos taken.

2.5. Sample identification (labelling)

Water sample bottles are to be labelled with the following information using permanent, waterproof markers at the start of each sampling day:

- Client ID: Coffey. PNG JDD Project.
- Site Ref: Unique site number (e.g., TSS site 10 - TSS_010, WQ_010).
- Sample ID: Sample number / Sample parameter / Sample date (e.g., 002_TSS_101209).
- Date: Sample date (e.g., 10 Dec 2019).

A duplicate water sample taken at TSS site 10 for analysis for TSS on the same date would be labelled as the next consecutive number:

- Client ID: Coffey. PNG LNG JDD Project.
- Job number: Unique job number (754-MELEN224697).
- Sample ID: Sample number / Sample parameter / Sample date (e.g., 011_TSS_100319).
- Date: Sample date (e.g., 10 Mar 2019).

A field blank water sample taken at TSS site 10 for analysis for TSS on the same date would be labelled:

- Client ID: Coffey. PNG LNG JDD Project.
- Job number: Unique job number (754-MELEN224697).
- Sample ID: Sample number / Sample parameter / Sample date (e.g., 012_TSS_100319).
- Date: Sample date (e.g., 10 Mar 2019).

2.6. Sample storage and transportation

Appropriate bottles, jars and bags (specific to each parameter to be analysed) will be supplied by the analytical laboratory.

Samples will be refrigerated until transported to the analytical laboratory. At the end of the survey, once ready for transportation to the laboratory, samples will be packed into eskies with ice bricks to keep samples cool. To prevent any breakage from glass jars, bubble wrap will be used to assist in packing them securely. All bottles will be kept upright to minimise spillage and or breakage.

The samples will be sent to Brisbane via TNT with each esky clearly labelled with address, AQIS permit and COC documentation inside the first esky.

2.7. Field quality assurance and quality control

2.7.1. Rinsate blanks

During the water sampling event, one rinsate blank sample will be collected per day. A piece of water sampling equipment e.g., water meter probe will be cleaned according to standard operating procedures including use of Decon90 followed by rinsing with deionised water. Deionised water will then be poured over the piece of equipment into the sample bottle, using the same sample handling methods as for the main sample to reduce the likelihood of sample contamination. Transportation and storage of the rinsate blanks will be in the same way as the sample bottles.

2.7.2. Field blanks

During the water sampling event, one field blank sample will be collected each day. The suite of sample bottles is to be filled with distilled or deionised water on site, using the same sample handling methods as for the main sample to reduce the likelihood of sample contamination. Transportation and storage of the field blanks will be in the same way as the sample bottles.

2.7.3. Field duplicates

One duplicate sample (for both water and sediment) is to be obtained for every 10 primary samples collected and submitted to the laboratory as a discrete sample. This provides information on the precision of the results and sample heterogeneity. Note that the objective of these samples is to monitor laboratory precision rather than determining site (or sample) heterogeneity.

3. Transporting samples to Australia

3.1. Transport documentation

When the samples are ready to be sent to the laboratory for analyses, transfer the samples into an esky surrounded by pre-chilled freezer blocks. Samples are to be packed with sufficient packaging to ensure no movement during transit. Ensure the samples are well contained.

The following documentation must be appended to the outside of each esky (in plastic pockets) within the consignment:

- Australian Customs Declaration on the Coffey letterhead, stating that the samples have a declared value for customs of \$AUD100 and that they are being shipped to Australia for analytical testing.
- Laboratory AQIS Permit to import quarantine material for the laboratory. Attach a copy of this permit to the Customs Declaration along with the permit to use letter.
- A printed address label to ALS Laboratories or CSIRO (for microbial parameters) (see Section 1).
- A TNT consignment note attached to the esky (remember to record the number so that the esky can be tracked). This needs to be completed with delivery address and the TNT account number. This is the TNT account number for Coffey International Development in PNG # 288079.

Provide TNT with five copies of customs declaration, the consignment contents and a copy of AQIS permit.

A copy of the consignment note and customs declaration should be faxed to the laboratory and marked clearly for the attention of Sample Receipt.

Note that \$AU40 may be required to store the samples at the airport until they are picked up by TNT.

4. Data processing and reporting

4.1. Water quality meter results and CTD casts

Data is downloaded from the water quality meter following procedures described in the instrument instruction manual and converted to Excel format.

The CTD data should be downloaded after each sampling event or cast and checked to ensure it has logged and recorded successfully. Refer to the instrument instruction manual and the CNS CTD manual for specific instruction and guidance on this instrument.

Data should be reviewed carefully and any obvious extraneous spikes in the data edited (but retained in the original data record). Always ask yourself, does the data make sense? If not, why?

4.2. Laboratory data

A copy of the chain of custody form and a sample receipt advice is to be provided by the laboratory upon receipt of the samples. Analytical results are to be reviewed immediately upon receipt of the certificate of analysis to check that all required analyses have been satisfactorily completed. This review is to include appraisal of quality assurance program results and sample results to identify any anomalous measurements. Any anomalous results are to be queried with the analytical laboratory and repeat analyses requested to confirm results, as deemed necessary. When satisfied with the reported results, data is to be entered into the project database. Electronic copies of the laboratory reports are to be archived and hard copies kept on file.

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APPENDIX C: BASELINE MANGROVE SURVEY 2011-2019



Baseline Mangrove Survey: 2011-2019



Coffey Environments

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CITATION

This report should be cited as:

Vision Environment (2020). *Baseline Mangrove Survey: 2011-2019*. Vision Environment, Gladstone Australia.

DOCUMENT CONTROL

Document draft	Originated by	Edit and review	Date
Interim Draft issued to Coffey Environments	RA	FM	29/07/2019
Draft issued to Coffey Environments	RA	FM	22/08/2019
Draft 2 issued to Coffey Environments	EW	FM	27/08/2019
Draft issued to ExxonMobil		FM/RA	09/03/2020
Final issued to client	EC	FM	17/03/2020

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**FILE REFERENCE**

17032020 FINAL Baseline Mangrove Survey 2019_VE

EXECUTIVE SUMMARY

A survey of the mangrove communities within the lease area of the ExxonMobil Papua New Guinea (PNG) Liquefied Natural Gas (LNG) Plant was undertaken in May 2019. The survey followed a pre-construction survey undertaken in 2011 (Alquezar and Boyd, 2011a) and a post-construction survey undertaken in 2014 (Vision Environment, 2014). The LNG Plant lies within the coastal fringes of Caution Bay, approximately 20 km north-west of Port Moresby, Papua New Guinea.

The objectives of the survey were to re-establish baseline conditions of the mangrove and tidal flat habitat near the LNG facilities, against which future conditions can be compared; as well as compare mangrove parameters to previous monitoring campaigns. The baseline will inform impact assessment for planned expansion including construction of a new offshore pipeline and associated landfall, and potential extension of the LNG Plant jetty.

Mangrove monitoring in May 2019 was undertaken in a similar manner to the 2011 and 2014 surveys. An additional four transects were established in two additional areas of interest, totalling 15 transects across six areas. Standard mangrove sampling methodologies were used.

The survey supported habitat mapping which used Geoeye satellite images from 2010, 2013 and 2018. Image processing and classification was carried out using ESRI® ArcGIS Pro™ 2019 Geographical Information System (GIS) software. One benthic macroinvertebrate sample was also collected from the landward edge of each mangrove transect.

Dominant mangrove communities in 2019 were *Rhizophora stylosa*/*Brugeria gymnorhiza* forest, with a smaller proportion of *Avicennia marina* dominated forest and *Ceriops tagal* shrubland, similar to what was recorded in 2011 and 2014. Stable mangrove communities were evident as no significant temporal variation in mangrove parameters or diversity indices were observed since previous surveys.

Crabhole density varied across the three surveys, with higher numbers reported in 2019, compared to 2014 and 2011. The fluctuation in crabhole densities was consistent across all areas and may be indicative of natural influences as opposed to local anthropogenic effects. Significant spatial variation in mangrove parameters was evident only for seedling density, with Area 2, which encompasses the LNG Plant jetty, consistently exhibiting significantly higher seedling numbers during each survey.

Mapping of the mangrove area was carried out in 2011, 2014 and 2019, using Geoeye images from 2010, 2013 and 2018, respectively. Image processing, classification and change in vegetation analysis was carried out using ESRI® ArcGIS Pro™ 2019 Geographical Information System (GIS) software.

During the construction phase of the LNG Plant (2010 to 2013), a loss of approximately 9.3% of the mapped mangroves was recorded. An increase in mangrove area in the landward zones was then recorded between 2013 and 2018, leading to residual loss of 4.3 % of the mapped mangrove vegetation between 2010 and 2018. Some localised areas of mangrove dieback were observed during the 2019 survey groundtruthing, particularly in Areas 3 and 6, adjacent to the plant and discharge points, with some leaf defoliation and discoloration recorded in Areas 2, 3, 4 and 6. Changes in the water flow or tidal regime due to earlier construction

activities may have occurred, causing dieback of some mangroves and colonisation of new mangrove areas. However further investigation is required to determine the causal link.

Nine taxa of macroinvertebrate organisms were recorded from the fifteen samples collected across the six areas, including crustaceans, molluscs, chordates and annelids. No organisms were encountered in seven of the samples, which is typically found when sampling in mangrove forests. The low number of macroinvertebrate organisms per sample indicates a more intensive sampling effort is required to fully characterise the macroinvertebrate communities in the mangrove habitats within the lease area.

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1 INTRODUCTION

Mangroves are communities of halophytic (salt-tolerant) trees that exist in intertidal zones, often fringing estuarine creeks and river banks (Blasco *et al.*, 1998). Mangrove forests are highly productive, play an important role in nutrient cycling and act as nursery areas for a diverse array of organisms, providing food for a number of juvenile fish and crustacean species (Jones *et al.*, 2000, Laegdsgaard and Johnson, 2001).

Mangrove biodiversity is influenced by key parameters, such as tidal exposure and inundation. Some species of mangroves live on the upper reaches of creeks and rivers, and prefer different water quality attributes to those that inhabit the lower reaches (Lovelock, 1993, Ridd *et al.*, 1990). Mangrove biodiversity is also influenced by geographical location, with highest biodiversity found in the warmer parts of the world (Duke, 1992, Duke *et al.*, 1998a, Duke *et al.*, 1998b, Government of Papua New Guinea, 2015).

There are over 30 species of mangroves found in Papua New Guinea (Paijmans and Rollet, 1977, Raga, 2006, Robertson *et al.*, 1991, Shearman, 2010), with an estimated 592,900 ha of mangroves distributed along the coastline (Faunce and Serafy, 2006, Joyce, 2005, Robertson *et al.*, 1991). Table 1 lists some of the more common mangrove species found in Papua New Guinea.

Table 1. Common mangrove species found in Papua New Guinea (Ellison, 1997, 2009).

Species name	Common name
<i>Acanthus ilicifolius</i>	Holly mangrove
<i>Acrostichum speciosum</i>	Mangrove fern
<i>Aegialitis annulata</i>	Club mangrove
<i>Aegiceras corniculatum</i>	River mangrove
<i>Avicennia marina</i>	Grey mangrove
<i>Bruguiera gymnorhiza</i>	Large-leafed orange mangrove
<i>Bruguiera parviflora</i>	Small-leafed orange mangrove
<i>Ceriops tagal</i>	Yellow mangrove
<i>Crinum pedunculatum</i>	Mangrove lily
<i>Cynometra iripa</i>	Wrinkle pod mangrove
<i>Excoecaria agallocha</i>	Milky mangrove
<i>Heritiera littoralis</i>	Looking-glass mangrove
<i>Hibiscus tiliaceus</i>	Native hibiscus
<i>Lumnitzera racemosa</i>	Black mangrove
<i>Osbornia octodonta</i>	Myrtle mangrove
<i>Sonneratia alba</i>	Mangrove apple
<i>Rhizophora apiculata</i>	Tall-stilted mangrove
<i>Rhizophora stylosa</i>	Red mangrove
<i>Xylocarpus granatum</i>	Cannonball mangrove
<i>Xylocarpus mekongensis</i>	Cedar mangrove

The Papua New Guinea Liquefied Natural Gas (LNG) Plant operated by ExxonMobil PNG Limited lies within the coastal fringes of Caution Bay, approximately 20 km northwest of Port Moresby. The LNG Plant receives gas via onshore and offshore pipelines from Hela and the Western Provinces of Papua New Guinea and processes it into LNG for export.

Mangrove communities exist in the intertidal area between the onshore facilities, including the LNG Plant, and facilities in the marine environment including the gas pipeline and LNG Jetty. A baseline assessment of the mangrove communities was undertaken to inform the PNG LNG

Project environmental impact statement in 2011 and monitoring has since been undertaken during construction and operation of the project (Alquezar and Boyd, 2011, Vision Environment, 2014). Expansion activities are planned at the site including construction of new offshore pipelines and associated landfalls, and potential extension of the LNG Plant jetty.

A survey of the mangrove communities within the lease area of the LNG Plant was undertaken from 10 to 18 May 2019 to inform impact assessment for planned expansion including construction of a new offshore pipeline and associated landfall, and potential extension of the LNG Plant jetty.

The survey followed on from a pre-construction survey undertaken in February 2011 and a post-construction survey undertaken in March 2014 (Alquezar and Boyd, 2011b, Vision Environment, 2014).

The objectives of the survey were to:

- Re-establish baseline conditions against which future conditions can be compared; and;
- Compare current condition of the mangrove habitat to results of monitoring conducted during previous monitoring campaigns.

The mangrove survey was undertaken at the request of Coffey Environments Pty Ltd. The field team consisted of representatives from Vision Environment, Coffey and Exxon Mobil PNG Limited environment and security teams.

2 METHODOLOGY

2.1 Fieldwork

The survey design, used in 2019, was similar to that used for the 2011 and 2014 surveys (Alquezar and Boyd, 2011b, Vision Environment, 2014). Eleven transects within four areas, originally established in 2011, and between 100 and 200 m in length, were resurveyed in 2019, with an additional four transects established within two additional areas (Areas 5 and 6). At 50 m intervals along each transect, 25 m² quadrats were established (Table 2; Figure 1).

Sampling methods were adopted from standard protocols derived from worldwide authorities, including Australian and New Zealand Standards, Australian and New Zealand National Water Quality Management Strategy (ANZECC/ARMCANZ, 2000), the Queensland (Australia) Department of Environment and Science (DES) Monitoring and Sampling Manual (DES, 2018), and the Queensland (Australia) Department of Employment, Economic development and Innovation (DEEDI) Data collection protocol for mapping and monitoring mangrove communities in Queensland (DEEDI, 2011). Strict quality assurance and quality control measures were in place for all work undertaken.

2.1.1 Mangroves

Fifteen transects were surveyed. Transects were between 100 and 200 m in length and grouped into six main areas of interest (Figure 1, Table 2). Eleven of the transects within the areas of interest were surveyed previously for the PNG LNG Project (Alquezar and Boyd, 2011, Vision Environment, 2014). Four new transects were added to obtain greater coverage across an expanded survey area for the current survey.

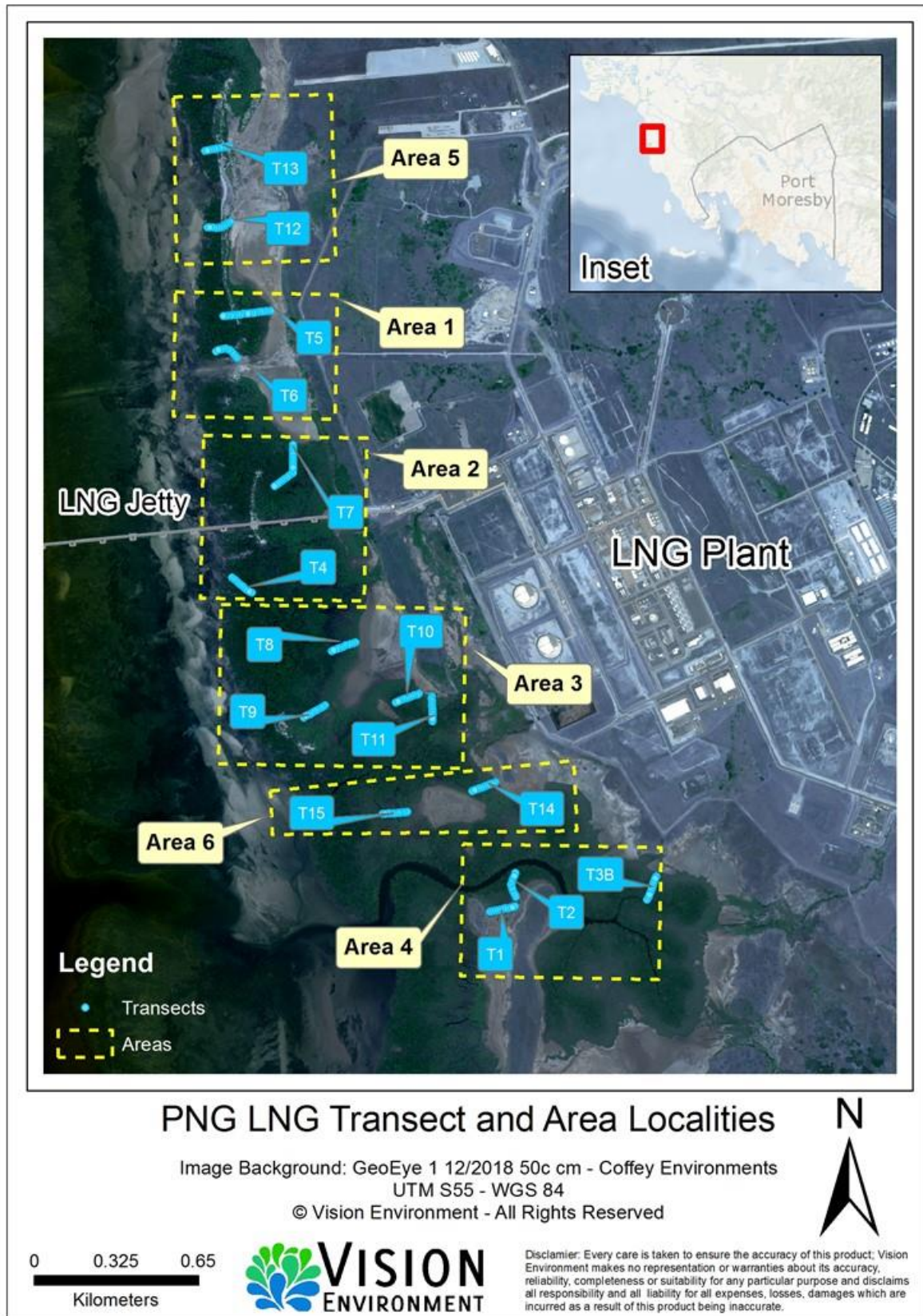


Figure 1. Map of study site areas and transect localities.
Imagery provided by Coffey. Note the new areas of interest – Areas 5 and 6.

Table 2. Corner co-ordinates of areas of interest.*Projection: WGS85 UTM Zone 55S*

	Northwest	Northeast	Southeast	Southwest
Area 1	500131 E 8968762 N	500771 E 8968751 N	500762 E 8968259 N	500123 E 8968269 N
Area 2	500242 E 8968195 N	500889 E 8968184 N	500878 E 8967542 N	500231 E 8967553 N
Area 3	500312 E 8967527 N	501278 E 8967511 N	501268 E 8966880 N	500301 E 8966897 N
Area 4	501267 E 8966580 N	502050 E 8966567 N	502041 E 8966045 N	501258 E 8966058 N
Area 5	500124 E 8969532 N	500747 E 8969541 N	500764 E 8968887 N	500136 E 8968870 N
Area 6	500506 E 8966790 N	501705 E 8966911 N	501717 E 8966633 N	500514 E 8966618 N

At 50 m intervals along each transect, 25 m² quadrats were established. Quadrat boundaries were marked using a tape measure and all trees (> 1 m height) and seedlings (< 1 m height) were identified and counted within each quadrat to determine mangrove species richness, density and diversity indices. Canopy cover was determined within each quadrat using vegetation Projective Foliage Cover (PFC) estimates. A total of 20 readings were taken at random locations within each quadrat using a PFC tube. Cover was classified as open (0-5%), sparse (6-25%), moderate (26-50%) or dense (>50%).

Live Basal Area (LBA) was calculated as the sum of tree girths at breast height (diameter of each tree) within each 25 m² quadrat. Values were then calculated as square meter (m²) of cross-sectional tree area per hectare. Mangrove composition and relative canopy cover was also estimated at 10 m intervals for mapping groundtruthing purposes.

Crab hole densities were determined by randomly placing ten replicate 0.25 m² quadrats on the substrate and counting crab holes. Density was calculated as the number of crab holes per unit area.

2.1.2 Macroinvertebrates

One macrobenthic grab sample was collected using a Petite Ponar Grab Sampler (0.0005m³) at the landward edge of each transect (Figure 2). Benthic samples were sieved through a 1 mm mesh sieve bag, *in situ*, as per APHA (2005) with the larger particles then transferred to individually labelled cotton bags. Samples were then preserved in 70% ethanol, as per the DES (2018), prior to being transported to Australia for analysis by Benthic Australia Pty Ltd.

Macrobenthic organisms were sorted and identified to the lowest taxonomic level (species level where possible). Sorting and taxonomy were done by an experienced taxonomist with appropriate taxonomic expertise (Level 3 Expertise as per Australian Marine Pest Monitoring Guidelines (DAFF, 2010) using compound and dissecting microscopes where applicable. Suitable taxonomic references, guides and keys were used. Ten percent of samples were re-sorted by a second taxonomist for quality assurance purposes.

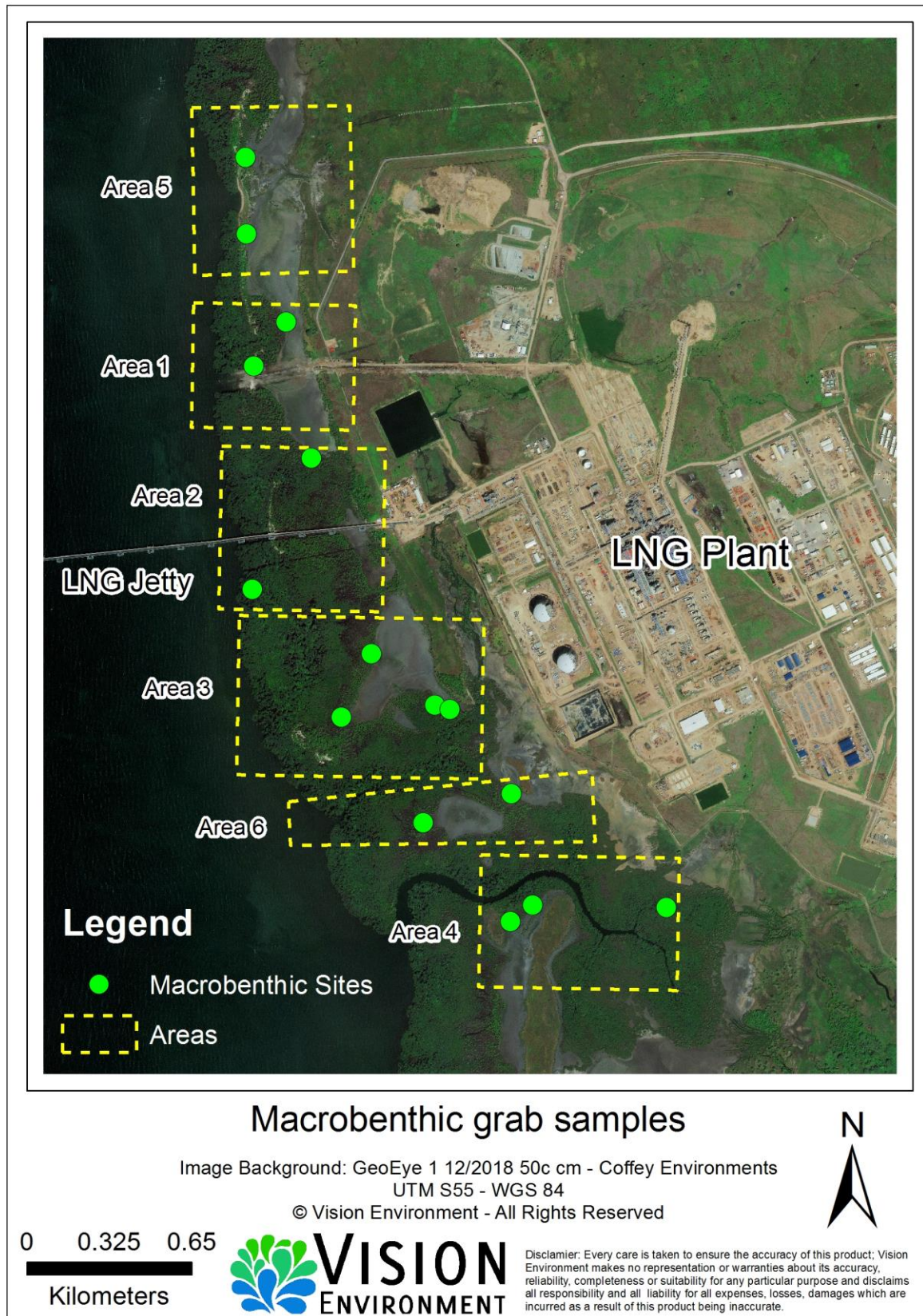


Figure 2. Map of study site areas and macrobenthic sites
Imagery provided by Coffey.

2.2 Data Analysis

A low level of replication of macroinvertebrate samples, and the low return of organisms in each sample, meant that the statistical analysis was limited. Macroinvertebrate data from transects within each area was therefore pooled to calculate organism abundance, species richness and Shannon-Weiner Diversity (the proportion of the total represented by a species, calculated using the Shannon-Weiner diversity index). As such, care should be taken when interpreting the macroinvertebrate diversity results.

Using the mangrove data collected, a number of diversity indices were calculated (Cai et al., 2006, Hill, 1973a, b, McClatchie et al., 1997, Nero and Sealey, 2005, Shannon and Weaver, 1948, Simpson, 1949, Zar, 1996), including Shannon-Weiner Diversity (the proportion of the total represented by a species, calculated using the Shannon-Weiner diversity index), and Evenness (how evenly abundance is spread among the various taxa that make up an assemblage).

Spatial (between the six main areas of interest) and temporal (2011, 2014 and 2019 surveys) variation in mangrove species richness, adult and seedling density, adult LBA, canopy cover, Shannon-Weiner Diversity, Evenness and crab hole counts were determined using one- and two-way analysis of variance (ANOVA). Data were tested for homogeneity of variance and normality, and significance levels were increased ($P < 0.01$, 99% confidence intervals) where data did not meet that criteria (O'Neill, 2000, Underwood, 1997).

Similarities in mangrove community assemblages among areas and survey years were also determined using multivariate Principle Coordinates Ordination (PCO). Due to the amount of data points (as a result of the number of transects, quadrats and surveys), average area data was calculated to better graphically represent clusters of similar and dissimilar groups.

Sample points that plot in proximity to one another display similar community composition. The further the sample points are away from each other, the greater the difference in their communities. Prior to analysis, data were dispersion weight-corrected; standardised to maintain equal weight among common and rare species; and compiled in Bray-Curtis similarity matrices. Analysis of Similarity (ANOSIM) was also used to statistically determine dissimilarities in community structure among the mangrove areas over time (Clarke and Gorley, 2006).

PERMANOVA was used to determine significant differences in macroinvertebrate community assemblages, however, as noted above, caution is advised as very low statistical power was used.

2.3 Mangrove Mapping

Geoeye™ (0.5 m pixel) natural colour satellite images, captured in 2010, 2013, and 2018, were provided to Vision Environment by Coffey to analyse and determine mangrove community composition and density.

Image processing and classification was carried out using ESRI® ArcGIS Pro™ 2019 Geographical Information System (GIS) software. Arbitrary areas of interest for mangrove community areas, intertidal wetlands and mud flats were created using natural breaks between the mangrove, water and terrestrial communities in order to subset the imagery. Non-marine wetland areas (terrestrial ecosystems, man-made structures, water bodies and bare ground) were visually identified and excluded from the subsets. Broad mangrove community classes were visually identified from the satellite imagery.

The satellite images were then segmented by grouping pixels that had homogeneous spectral similarities. This process aided in identifying general mangrove community clusters, rather than isolating specific trees, in order to identify dominant communities. Mangrove communities were categorised into segments using the ArcGIS Pro module Segmentation (ESRI® ArcGIS Pro™ 2019). Segment training areas were then applied to each segment using the ArcGIS Pro module Segment Training Manager (IDRISI®-Selva™ 2012), derived from mangrove transect information. Training areas were converted into classification signatures (specific mangrove classes) and used as part of an object-based supervised classification process. Support Vector Machine Learning Classification was used as a decision rule (ESRI® ArcGIS Pro™ 2019), based on the probability that a specific pixel value range belongs to a particular mangrove class, was used for the supervised classification.

Final classification of mangrove, saltmarsh and mudflat classes were created using the ArcGIS Pro module Classify (ESRI® ArcGIS Pro™ 2019). The classifications were then manually rationalised into broad mangrove community classes. Major classes included: *Ceriops* sp. dominated communities; *Avicenna* sp. communities; *Rhizophora* sp./*Bruguiera* sp. dominated communities; saltmarsh, saltpan and mudflats; grasslands and developed areas. Classes were further visually assessed against the groundtruthed transect data. Mangrove community areas were calculated using these data (pixel number per class by pixel size). The study area outlines, and mangrove community classifications were reproduced as high-quality maps using ESRI® ArcMap™ 10.1 geographical information system (GIS) software.

The four main mangrove vegetation classes (Figure 3) consisted of:

- *Rhizophora/Bruguiera* forest communities, which included over 50% composition *Rhizophora stylosa*, *R. apiculata*, *Bruguiera gymnorhiza* and *B. parviflora* species;
- *Ceriops tagal* shrub dominated communities (>50%);
- *Avicennia marina* communities; and
- Grasslands.

Unclassified pixels, representing salt flats, salt marsh, mud flats, shadows, bare ground, sand dunes and water were mapped but not used in any of the main analyses.

Change in vegetation analysis was done using image differencing, in order to identify upper and lower limits to normal variation beyond which is considered natural change. Change analysis was performed by isolating only vegetated areas and differentiating between vegetation classes among monitoring years. A raster mathematical equation was used using the ESRI® ArcGIS Pro™ 2019 image calculator and Reclassify module, whereby a mathematical expression was performed on classified Geoeye™ satellite images captured in 2010, 2013 and 2018. A threshold of mean $\pm$ 3 standard deviations was used to obtain a 99% confidence limit in significant change from classified imagery captured in 2011, 2013 and 2018. Positive vegetation gain and negative vegetation loss was then mapped, and areas reported for different year combinations (2010 to 2013, 2013 to 2018, and 2010 to 2018).



Figure 3. Examples of mangrove communities in Caution Bay, including *Rhizophora/Bruguiera* forests (upper left), *Ceriops shrublands* (upper right), and *Avicennia* forest (lower).

3 Results and Discussion

3.1 Mangrove Communities

Approximately 394 ha of mangrove habitat within the study area, incorporating the leased area of the PNG LNG Plant, was investigated, which included the LNG footprint. The most encountered species within the transects, particularly at the seaward edge, were the Red Stilted Mangrove (*R. stylosa*) and the Orange Mangrove (*B. gymnorhiza*). The Grey Mangrove (*A. marina*) was typically observed towards the mid and back of the stand, and often occurred as an emergent within the *Rhizophora/Bruguiera* forest component. The Yellow Mangrove (*C. tagal*) was commonly recorded at the landward edge of the mangrove stand. The above-mentioned mangrove species are typically common and encountered in neighboring countries within the tropical Asia-Pacific region, including Malaysia, Indonesia and Australia (Paijmans and Rollet, 1976-1977, Pernetta and Hill, 1981).

Other species that were observed but not recorded in plots or transects included the Myrtle Mangrove (*Osbornia octodonta*.), the Milky Mangrove (*Excoecaria agallocha*), the River Mangrove (*Aegiceras corniculatum*) and the Cannonball Mangrove (*Xylocarpus granatum*). An isolated patch of the Black Mangrove (*Lumnitzera racemosa*) was observed towards the

south of the LNG Plant jetty. Saltmarsh species (Figure 4) encountered included saltbush (*Enchylaena* sp.), bead weed (*Sarcocornia quinqueflora*) and saltcouch (*Sporobolus* sp).

Local people have been recorded in the past as harvesting mangroves for firewood, building material and tools, food and fishing activities (Liebezeit and Rau, 2006, Shearman, 2010). Some evidence of prior and recent harvesting was observed particularly along Transect 7 in Area 2, during each of the 2011, 2014 and 2019 surveys (Figure 5).



Figure 4. Bead weed saltmarsh (*Sarcocornia* sp.) observed at Transect 12.



Figure 5. Historic and recent harvesting activity within the mangrove habitat in Transect 7.

During the 2019 survey, 2,003 mangrove plants were recorded (33% adult mangroves and 67% seedlings). Between one to three species of mangrove were recorded in each quadrat. Note that mangrove parameters can be highly variable both within and between areas, and within and between surveys. As such, only statistically significant variation provides a clear indication of spatial and temporal changes and can be considered valid.

3.1.1 Mangroves in 2019

No significant statistical difference ($P > 0.05$) was evident for mangrove species richness between the areas, with mean species per quadrat ranging from 1.2 species in Area 5 to 1.9 species in Area 3 (Figure 6, Table A1 in Appendix).

No significant spatial variation ($P > 0.05$) between areas was evident for adult plant density due to the amount of intra-area variation. Mean adult density per quadrat ranged from 8.6 adults/quadrat in Area 4 to 28.7 adults/quadrat in Area 6 (Figure 6, Table A1 in Appendix). No significant spatial differences ($P > 0.05$) between the areas were evident for seedling density, with mean density per quadrat ranging from nine seedlings/quadrat to 68 seedlings/quadrat (Figure 6, Table A1 in Appendix). LBA also did not vary significantly ($P > 0.05$) across the surveyed areas, ranging from 15 m²/ha at Area 4 to 49 m²/ha at Area 5 (Figure 7, Table A1 in Appendix).

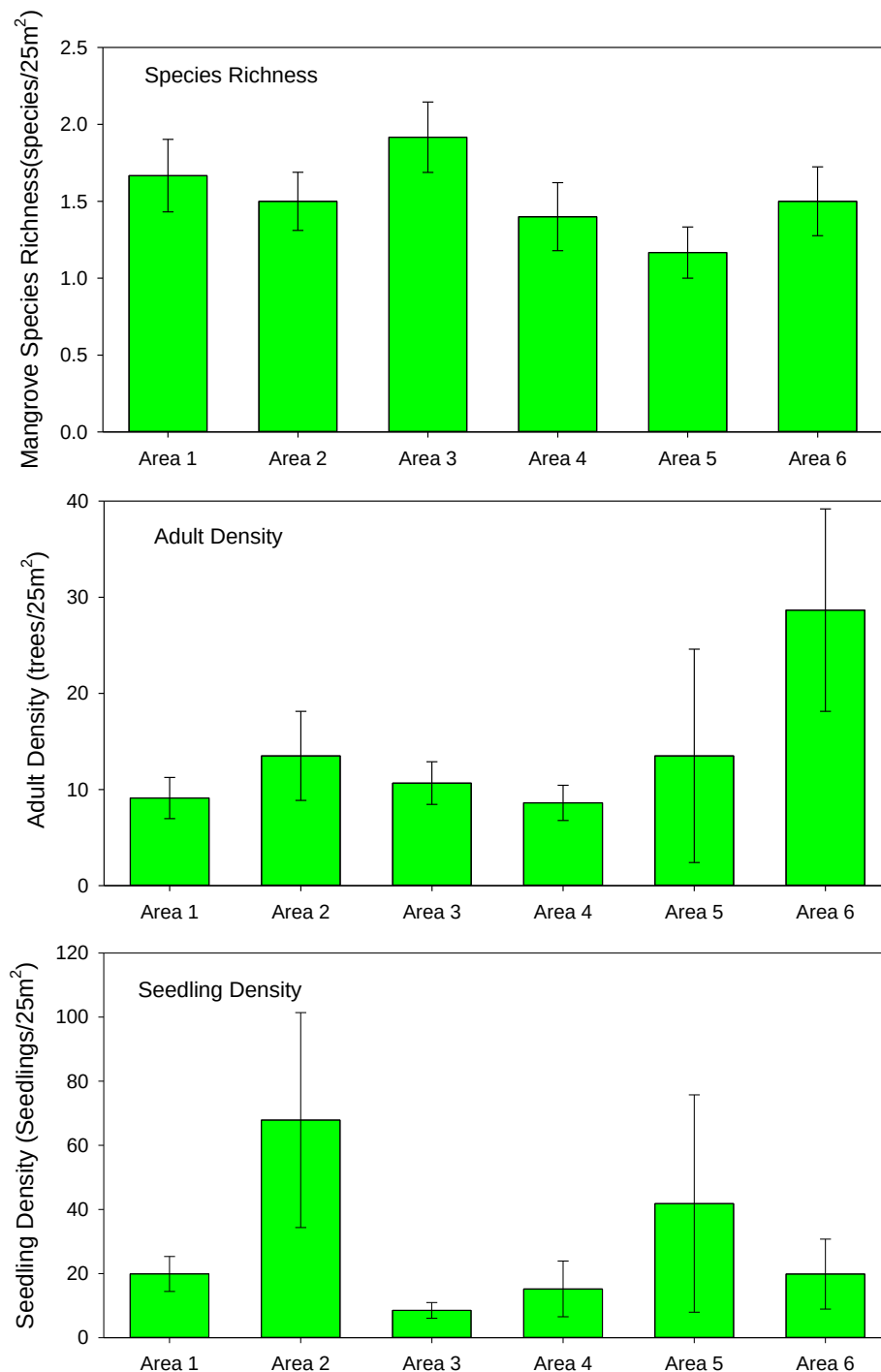


Figure 6. Mean mangrove species richness, and adult and seedling density across areas. Values are means $\pm$ SE.

Canopy cover was also consistent across the areas, ranging from 60% at Area 3 to 89% at Areas 2 and 4 (Figure 7, Table A1 in Appendix). Significantly ($P < 0.05$) higher crabhole densities were evident in Area 4 (27 holes/0.25m²) and Area 2 (23 holes/0.25m²), than in Area 5 (16 holes/0.25m², Figure 7).

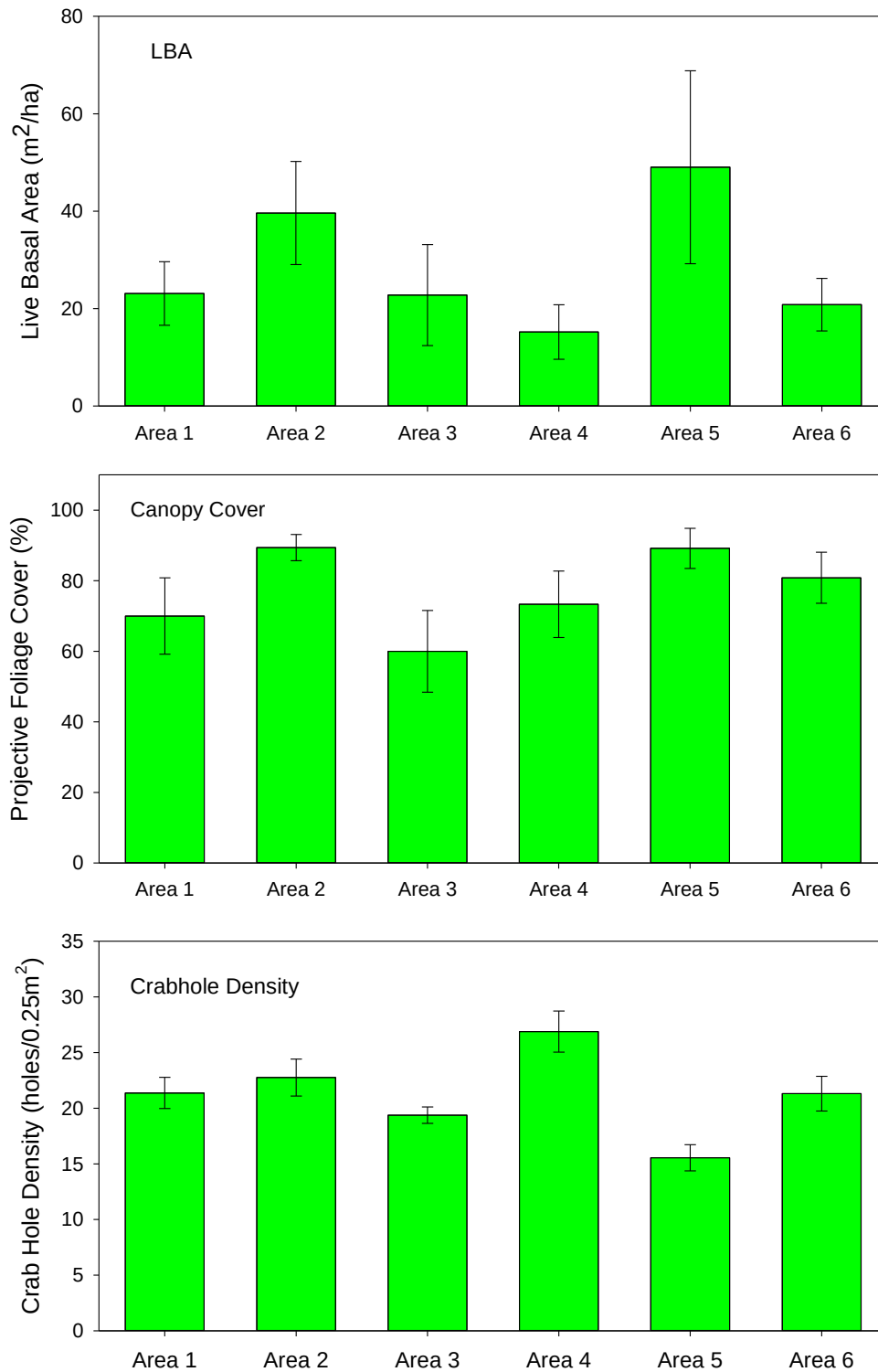


Figure 7. Mean Live Basal Area (LBA), canopy cover and crabhole density across areas. Values are means $\pm$ SE.

The following crab species were observed during the survey: Mud Crab (*Scylla serrata*), Orange Clawed Fiddler Crab (*Uca coarctata*, Figure 8), Marsh Crab (*Sesarma* sp.), Tuxedo Crab (*Australopax tridentate*), Lemon-Yellow Clawed Fiddler Crab (*Uca Perplexa*, Figure 8) and Shore Crab (*Hemigrapsus* sp.). Although not much information or literature is available on the commonality of non-commercial crab species in PNG, the above-mentioned species are commonly found throughout the Asia-Pacific region.



Figure 8. Orange Clawed Fiddler Crab and Lemon-Yellow Clawed Fiddler Crab observed during the 2019 surveys.

Observations regarding leaf defoliation, discoloration, herbivory and dieback were made at each quadrat (Table 3). Moderate to severe mangrove dieback was observed in several transects in Area 3 and Area 6 (Figure 9), with slight to moderate leaf defoliation and/or discoloration recorded in Areas 2, 3, 4 and 6.

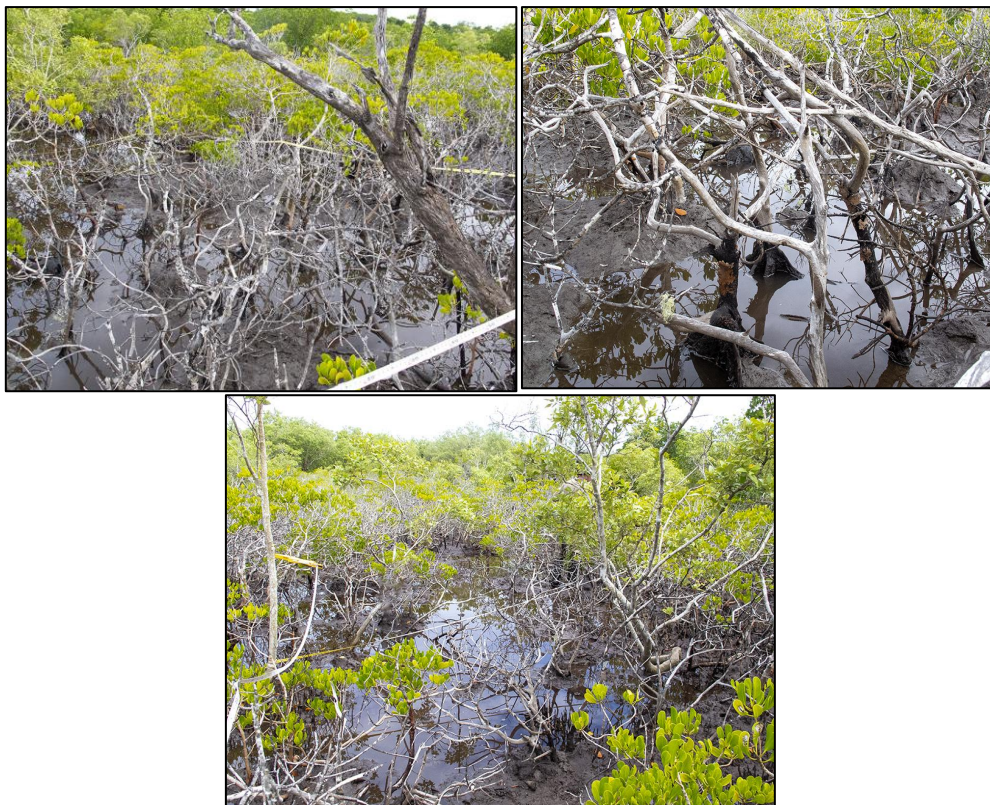


Figure 9. Evidence of mangrove dieback around Area 6, with ponding of stagnant water.

Table 3. Summary of observations for each monitoring quadrat in the 2019 survey.
Light and dark grey shading denote moderate and severe mangrove attributes.

Location	Site	Leaf Defoliation	Leaf discolouration	Herbivory	Mangrove dieback
Area 1	T5 – 0m	No	No	No	No
	T5 – 50m	No	No	No	No
	T5 – 100m	No	No	No	No
	T5- 150m	No	No	No	No
	T5 – 200m	No	No	No	No
	T6 – 0m	No	No	No	No
	T6 – 50m	No	No	No	No
	T6 – 100m	No	No	No	No
Area 2	T4 – 0m	No	No	No	No
	T4 50m	No	No	No	No
	T4 – 100m	No	No	No	No
	T7 – 0m	Slight	No	Moderate	No
	T7 – 50m	Slight	No	No	No
	T7 – 100m	Slight	No	No	No
	T7 – 150m	Slight	No	Moderate	No
	T7 – 200m	No	No	No	No
Area 3	T8 – 0m	Slight	Slight	No	No
	T8 – 50m	Moderate	Slight	No	Severe
	T8 – 100m	No	No	No	No
	T9 – 0m	Slight	Slight	No	Moderate
	T9 – 50m	Moderate	Slight	No	Moderate
	T9 – 100m	Slight	No	No	No
	T10 – 0m	No	No	No	No
	T10 – 50m	No	No	No	No
	T10 – 100m	No	No	No	No
	T11 – 0m	Slight	Slight	No	No
	T11 – 50m	No	No	No	No
	T11 – 100m	No	No	No	No
Area 4	T1 – 0m	Slight	Slight	No	No
	T1 – 50m	Slight	Slight	No	No
	T1 – 100m	Slight	Moderate	Moderate	Slight
	T2 – 0m	Slight	Slight	No	No
	T2 – 50m	No	No	No	No
	T2 – 100m	No	No	No	No
	T3B – 0m	Slight	No	No	No
	T3B – 50m	No	No	No	No
	T3B – 100m	No	No	No	No
Area 5	T12 – 0m	No	No	No	No
	T12 – 50m	No	No	No	No
	T12 – 100m	No	No	No	No
	T13 – 0m	No	No	No	No
	T13 – 50m	No	No	No	No
	T13 – 100m	No	No	No	No
Area 6	T14 – 0m	Slight	Slight	No	No
	T14 – 50m	Moderate	Slight	No	Moderate
	T14 – 100m	Moderate	Slight	No	Moderate
	T15 – 0m	Slight	Slight	No	Slight
	T15 – 50m	Slight	Moderate	No	Severe
	T15 – 100m	Slight	Slight	No	No

Dieback in Areas 3 and 6 appeared to be restricted to *Ceriops* sp. These species favor the landward edge of the mangrove habitat due to their low tolerance for tidal inundation. Areas of water pooling were recorded where the dieback occurred, suggesting that continual saturation of the sediment may have resulted in root rot and eventual plant death. Note that no investigations were performed to determine possible causation of the dieback.

Multivariate analysis (Figure 10) indicated that in 2019, a small but significant dissimilarity (difference) in mangrove community composition among mangrove areas was observed (ANOSIM; $P < 0.05$; R Statistic 0.1). Pairwise area comparisons indicated that the largest differences in community composition were evident between Area 6 and Areas 1, 2 and 5. This is likely due to the higher proportion of *A. marina* in Area 6 in comparison with Areas 1, 2 and 5.

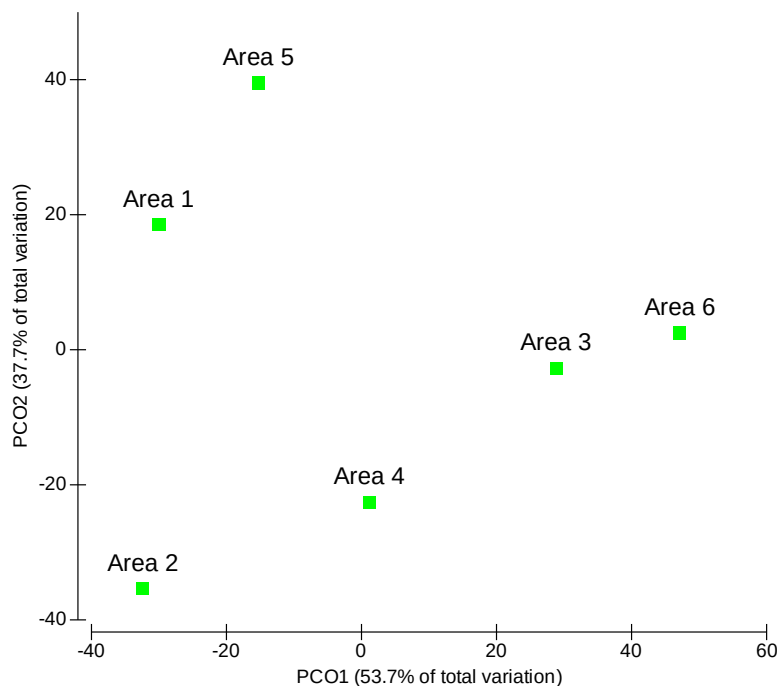


Figure 10. Principle Coordinates Ordination (PCO) of mangrove communities across areas. Samples were averaged by plot/transect. Data were standardised and weight dispersion corrected.

3.1.2 Mangrove Temporal Variation

No significant spatial (between areas) or temporal (between survey years) variation was evident for mangrove species richness (number of species present), with average species richness per area ranging from 1 species in Area 2 in 2014 to 1.9 species in Area 3 in 2019 (Figure 11, Table A1 to A3 in Appendix). Note that Areas 5 and 6 were not included in the temporal analysis as these areas were first monitored in 2019.

No significant temporal variation was evident for adult mangrove density, with similar adult plant numbers in 2011 (5 to 18 adults/25 m²), 2014 (4 to 21 adults/25 m²) and 2019 (9 to 29 adults/25 m²). No significant spatial variation was evident between the monitoring areas due to the large differences in adult densities across quadrats, within each area (Figure 11, Tables A1 to A3 in Appendix A).

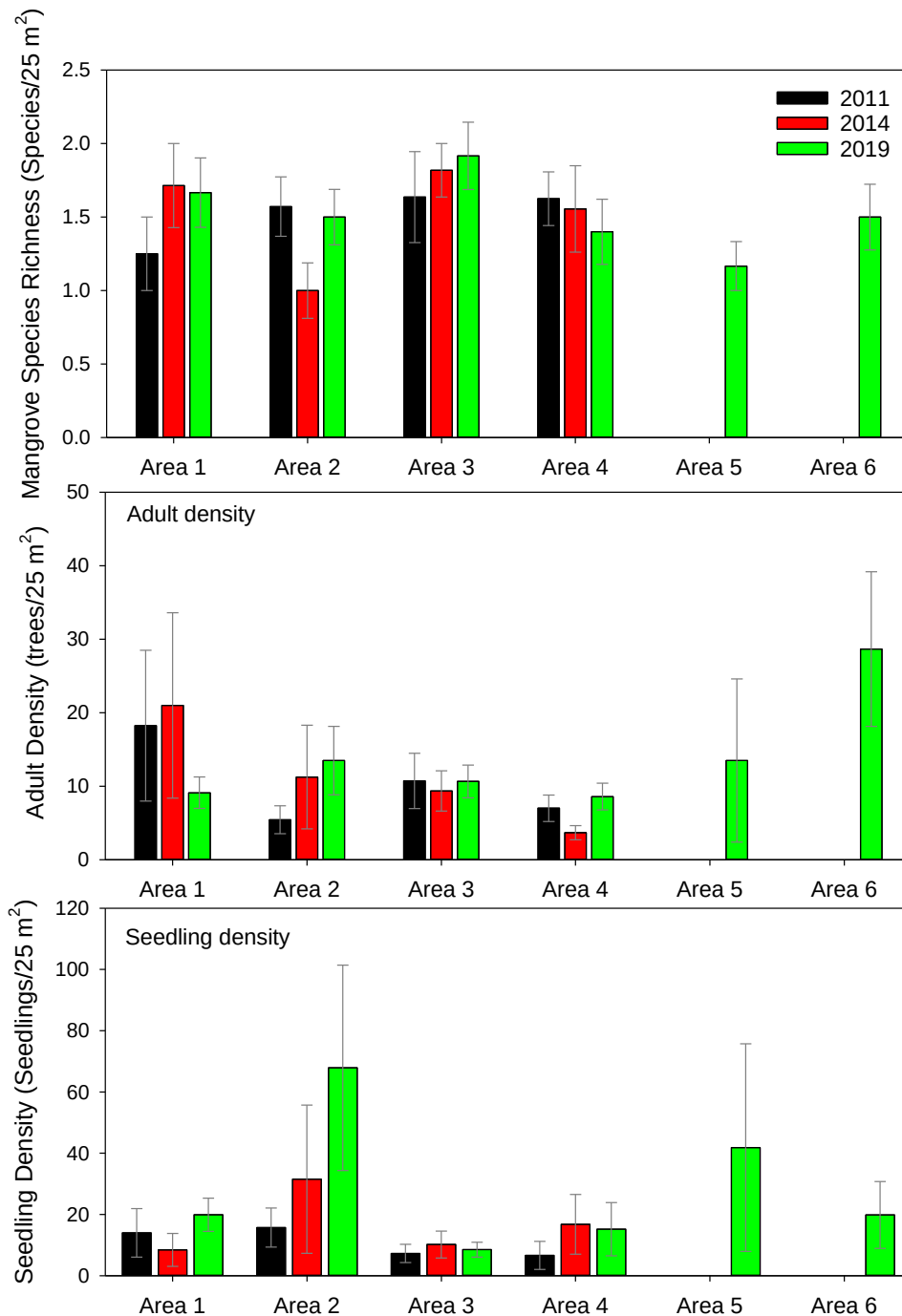


Figure 11. Mean mangrove species richness, and adult and seedling density across areas of interest and survey years.
Values are means $\pm$ SE.

Seedling density also did not exhibit significant temporal variation, with overall similar seedling numbers in 2011 (7 to 16 seedlings/25 m²), 2014 (8 to 32 seedlings/25 m²) and 2019 (9 to 68 seedlings/25 m²). However spatial variation was evident with significantly ($P < 0.05$) higher seedling density consistently observed at Area 2 throughout all three surveys (Figure 11, Tables A1 to A3 in Appendix A). As there was no statistical interaction effect, meaning that the observed difference in seedling densities for Area 2 did not differ over different times, this suggests during each survey, seedling densities have remained consistently higher at Area 2

compared to the other areas. This could be due to a number of reasons, including the age of the mangrove stand where the transects lie, distance from neighboring reproductive adults, competition for light through the canopy cover, root structure complexity not permitting the transfer of new propagules to certain areas, predation, sediment condition affecting propagule establishment, tidal regimes allowing greater recharge of new propagules to the same area each year, as well as a number of other unknown factors (McKee, 1995, McKee *et al.*, 2007, Minchinton, 2001).

No significant spatial or temporal variation was evident for Shannon-Weiner Diversity or evenness, indicating that mangrove communities remained overall similar across the areas and stable across the years (Figure 12, Tables A1 to A3 in Appendix A).

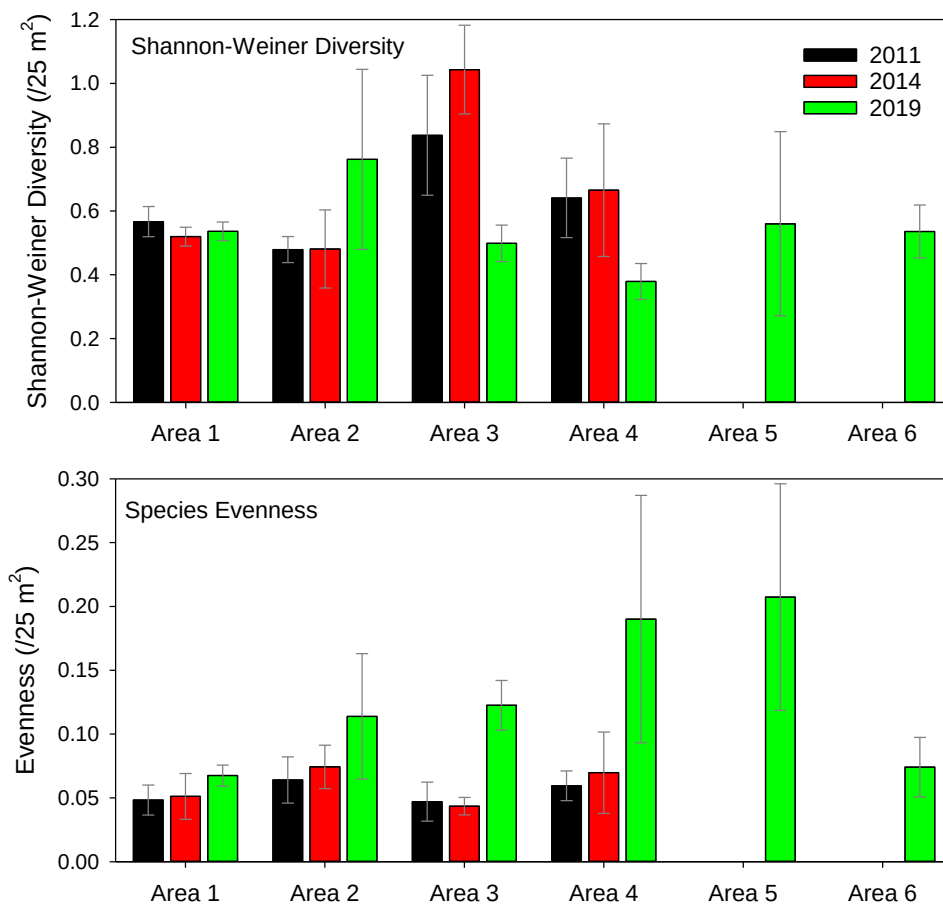


Figure 12. Mean mangrove Shannon-Weiner Diversity and evenness across areas of interest and survey years.

Values are means $\pm$ SE.

No significant spatial or temporal variation was evident for mangrove Live Basal Area (LBA). LBA remained reasonably consistent across the surveys in 2011 (11 to 27 m²/ha), 2014 (13 to 27 m²/ha) and 2019 (15 to 49 m²/ha). Similarly, canopy cover remained consistent across the areas and surveys, ranging from 59% cover in Area 4 in 2011 to 89 % cover in Areas 2 and 5 in 2019 (Figure 13, Tables A1 to A3 in Appendix A).

While no significant spatial variation in crabhole densities was evident across the areas, significant ($P < 0.05$) temporal variation was recorded with significantly lower crabhole

densities in 2011 (5.4 to 9.4 holes/0.25m²), intermediate densities in 2014 (13.0 to 16.5 holes/0.25m²) and significantly higher densities in 2019 (15.6 to 26.9 holes/0.25m²). As this temporal fluctuation was evident across all areas both adjacent and further afield from the LNG Plant, this suggests natural temporal variation across the region as opposed to local anthropogenic influences.

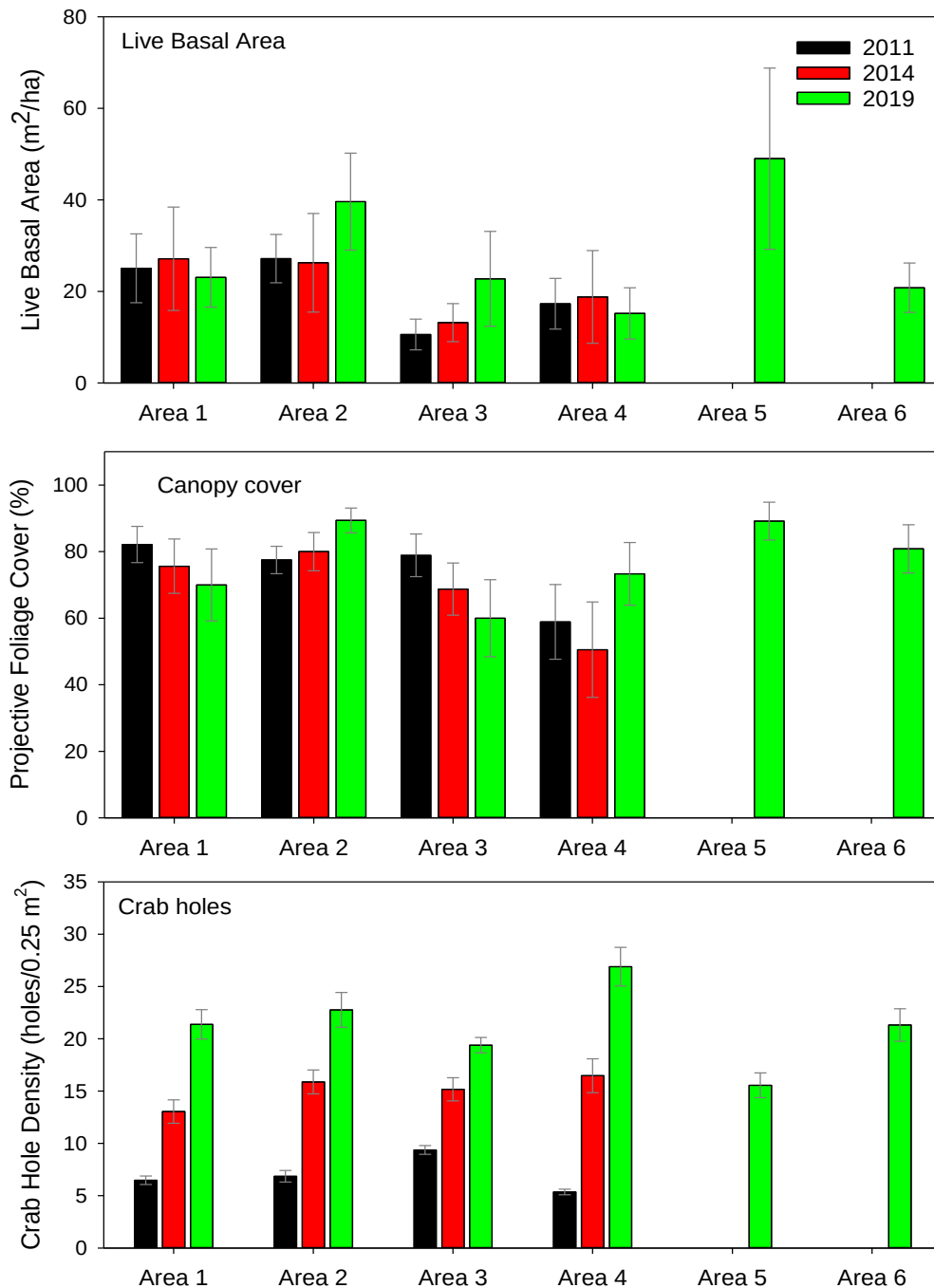


Figure 13. Mean mangrove LBA, canopy cover and crabhole density across areas of interest and surveys.

Values are means ± SE.

Multivariate analyses indicated that there were no significant dissimilarities (differences) in mangrove community composition either spatially across mangrove areas (ANOSIM; $P > 0.01$; R Statistic -0.02), or between the three surveys ($P > 0.01$; R Statistic 0.04), indicating no discernible impact from the construction and operation of the LNG Plant on the monitored mangrove habitats (Figure 14).

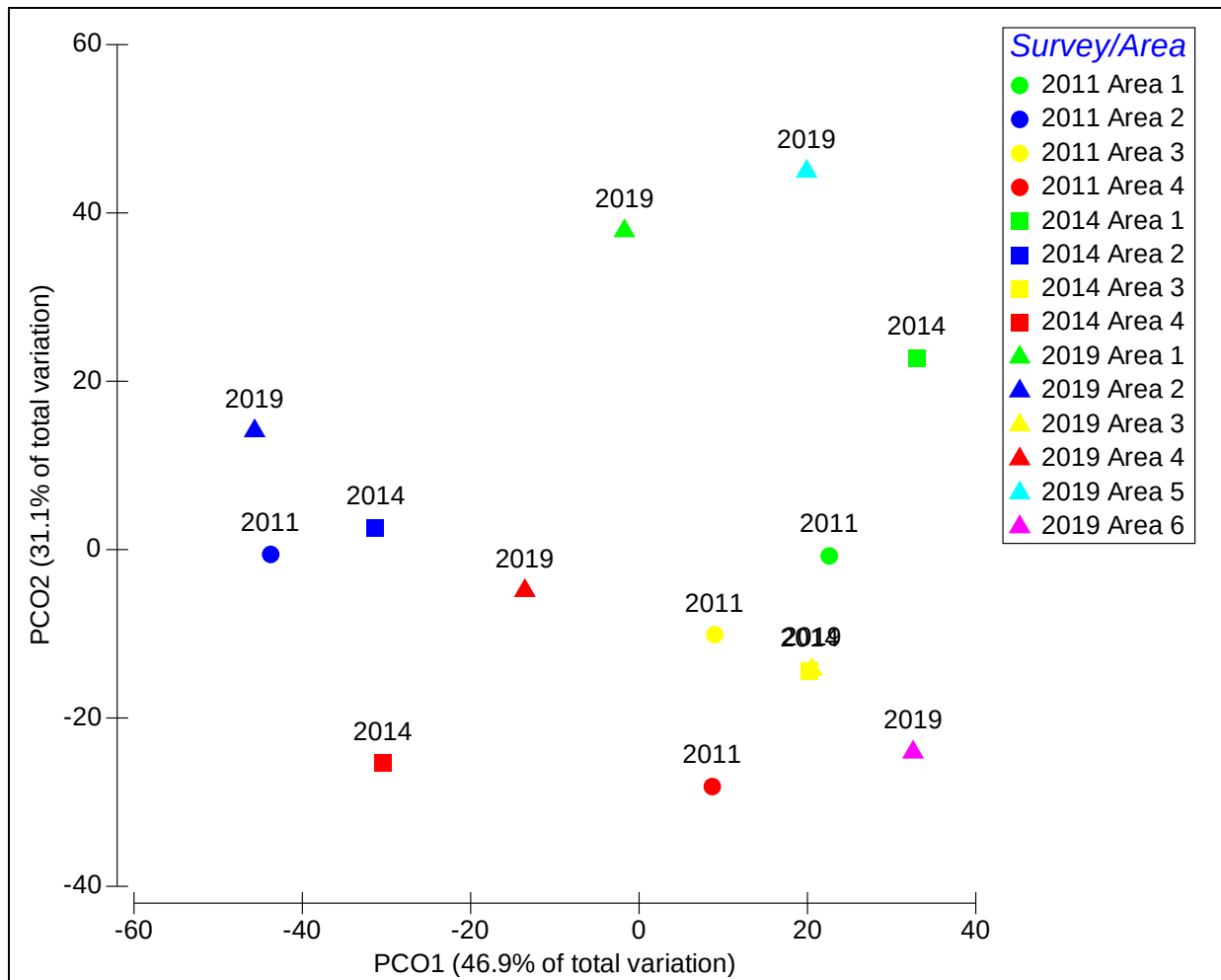


Figure 14. Principle Coordinates Ordination (PCO) of mangrove communities across areas and surveys.

Samples were averaged by plot/transect. Data were standardised and weight dispersion corrected. Circles denote 2011, squares denote 2014 and triangles denote 2019 monitoring campaign, different colours denote the different Areas investigated.

3.2 Mangrove mapping

3.2.1 Mangrove mapping in 2019

Approximately 394 ha of mangrove forests were mapped in 2019 encompassing the six areas of interest, using 2018 GeoEye 50cm pixel imagery. In contrast, approximately 283 ha of forest was mapped in 2014 which encompassed the original four areas of interest. Classified areas in the 2018 imagery were also compared with the images from 2011 and 2013, in order to document any changes which may have occurred.

Based on the 2018 imagery and supported by the 2019 groundtruthing, the dominant mangrove community was dense *Rhizophora/Bruguiera*, making up 49% of the total area, followed by *A. marina* (8.6%), and *C. tagal* shrubs (7.6%). Mudflats and saltpans made up approximately 32.5% of the total area, covering 124 ha (Table 4). Mangrove habitats covered approximately 247 ha, with *Rhizophora/Bruguiera* forest covering 75% of this area (Table 5, Figure 10).

Table 4. Total mapped area classification in 2010, 2013 and 2018 using GeoEye imagery

Class	2011		2013		2018	
	ha	%	ha	%	ha	%
Water	6.2	1.6	8.7	2.2	12.6	3.2
Developed	0.0	0.0	5.1	1.3	8.5	2.2
<i>Ceriops</i> sp.	12.3	3.1	48.3	12.3	28.9	7.3
<i>Avicennia</i> sp.	15.7	4.0	54.9	13.9	32.9	8.3
<i>Rhizophora/Bruguiera</i> sp.	230	58.3	130.7	33.2	185.0	46.9
Mudflats – Saltpans	128	32.5	143.3	36.4	124.1	31.5
Grasslands	2.2	0.5	3.2	0.8	2.2	0.6
Total area (ha)	394.4	100	394.2	100	394.2	100

Table 5. Total mapped mangrove area classifications in 2010, 2013 and 2018 using GeoEye imagery.

Mangrove Class	2011		2013		2018	
	ha	%	ha	%	ha	%
<i>Ceriops</i> sp.	12.3	4.8	48.3	20.6	28.9	11.7
<i>Avicennia</i> sp.	15.7	6.1	54.9	23.5	32.9	13.4
<i>Rhizophora/Bruguiera</i> sp.	230.0	89.1	130.7	55.9	185.0	74.9
Total mangrove area (ha)	258		233.9		246.8	

In 2019, mangrove clearing from construction of the LNG Plant, LNG Plant jetty and pipeline landfalls was still evident (Figures 15 and 16). Seedlings were observed to have emerged at areas that had previously been cleared.

3.2.2 Temporal vegetation classification

Temporal comparisons conducted from 2010 to 2018 indicated that there were some changes in mangrove community composition over the survey years, although the total mapped mangrove area has remained consistent over the survey years. While *Rhizophora/Bruguiera* forest was consistently the dominant mangrove habitat, cover of this habitat decreased from 89% to 56% from 2011 to 2013, prior to increasing again to 75% in 2018. This result was most likely an artefact in the classification of one mangrove community to another based on spectral differences/similarities, most likely due to sensor and/or image capture differences from year to year. An overall increase in *C. tagal* and *A. marina* dominated habitats was evident from 2011 to 2018, increasing from 5 to 6% in 2011 to 12 to 13 % in 2018 (Table 5, Figures 17-19).

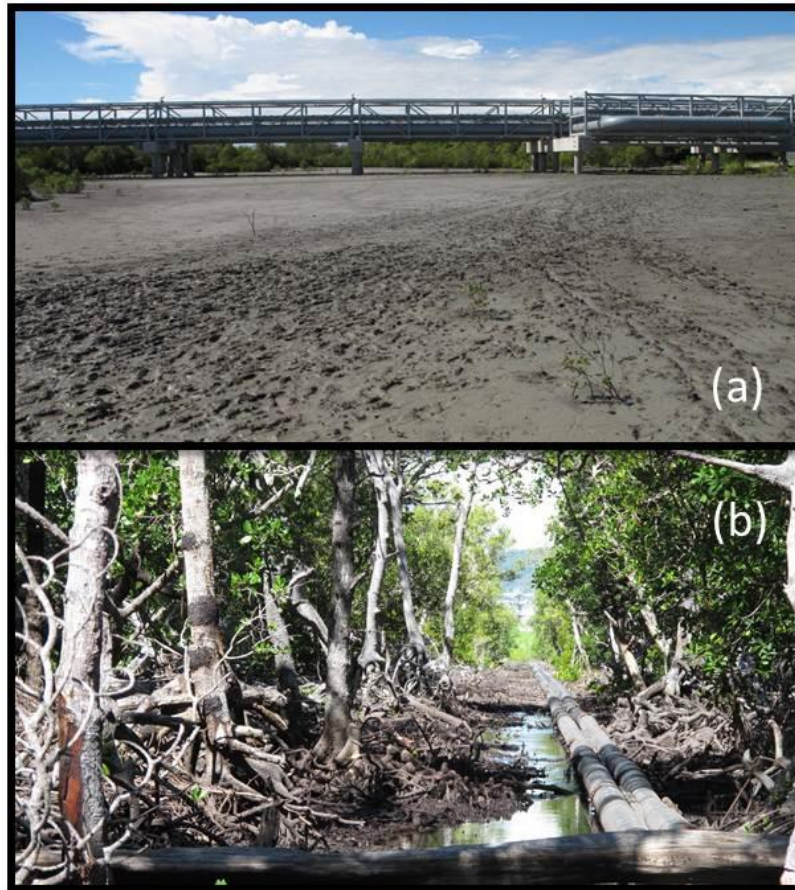


Figure 15. Mangrove clearing (adjacent to T4) for the installation of the PNG LNG Project infrastructure, including (a) the jetty and (b) seawater intake lines in 2014.



Figure 16. Clearing footprint of mangrove forests for the pipeline laydown areas in Area 2.

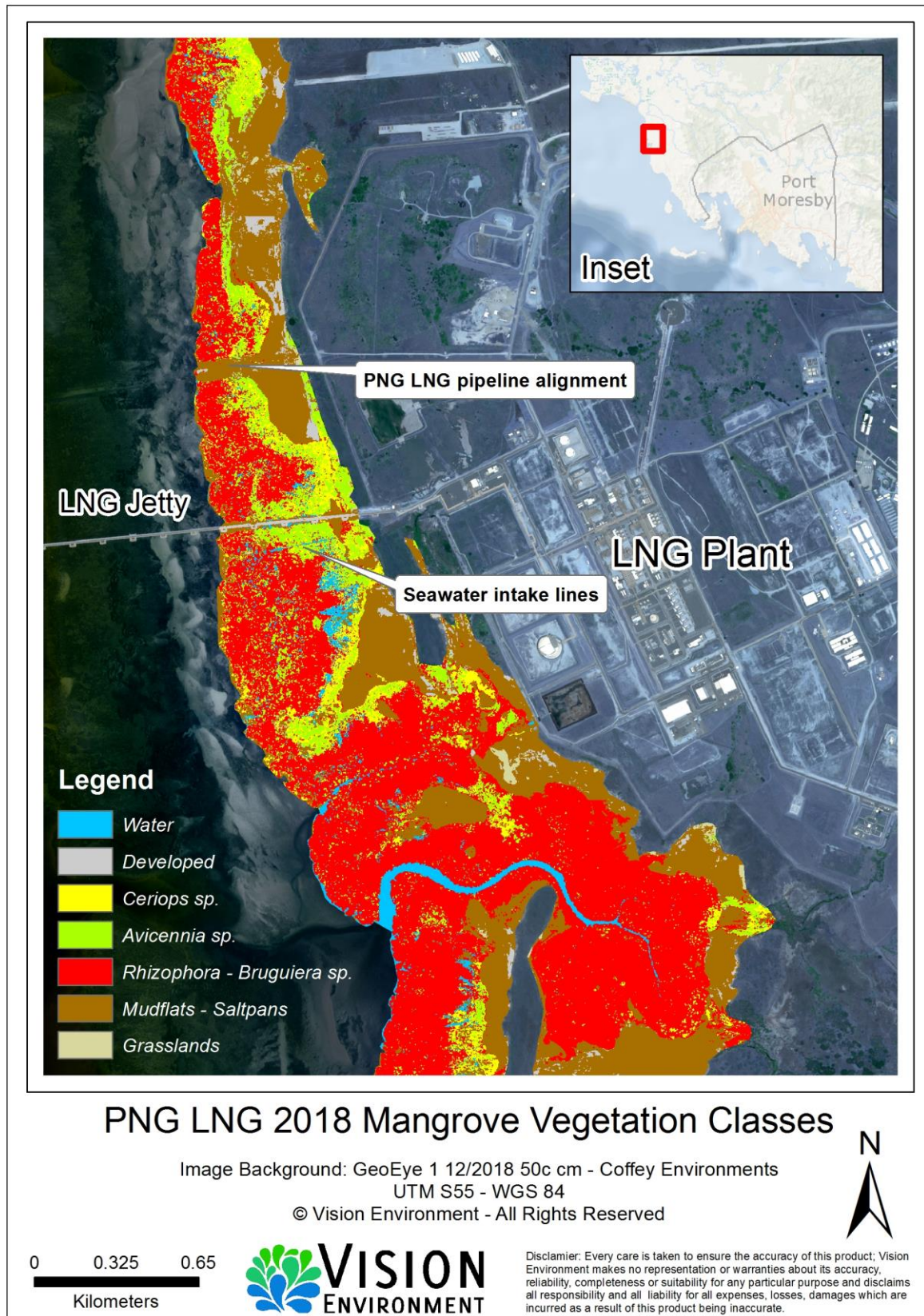


Figure 17. Map overview of classified mangrove areas near the LNG Plant in 2018, Caution Bay. Map projection WGS84 – UTM Zone 55S.

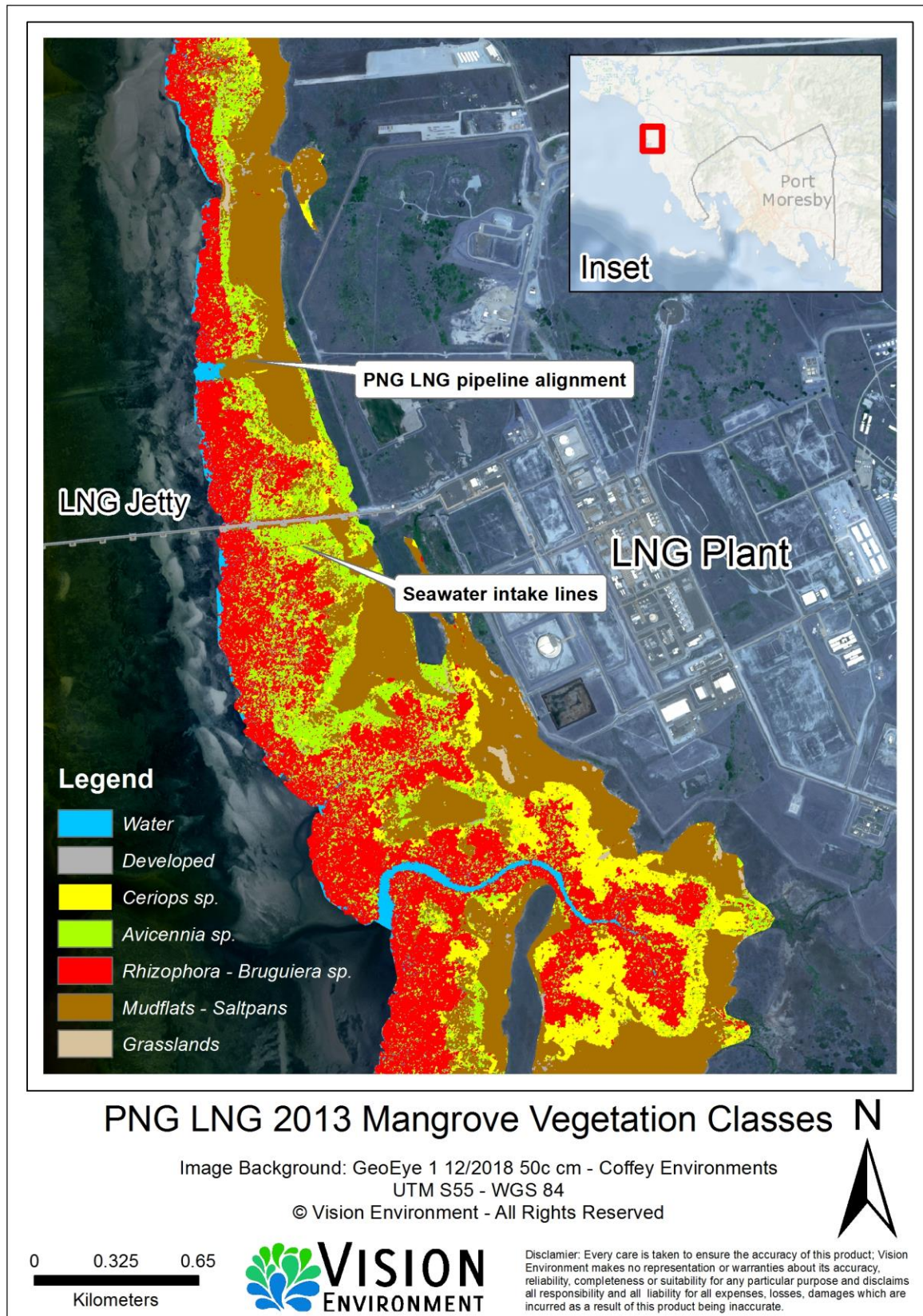


Figure 18. Map overview of classified mangrove areas near the LNG Plant in 2013, Caution Bay. Map projection WGS84 – UTM Zone 55S.

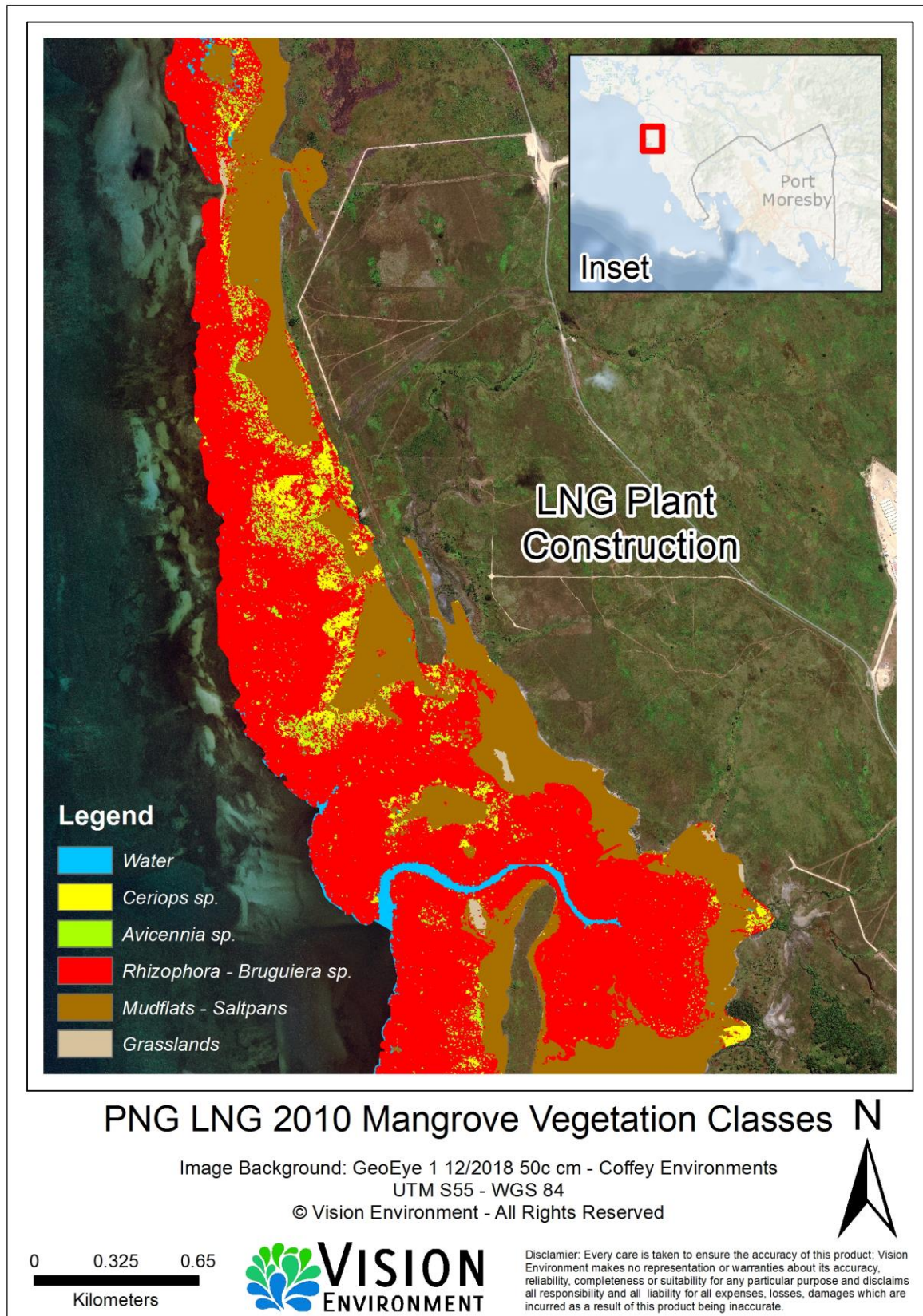


Figure 19. Map overview of classified mangrove areas near the proposed LNG Plant in 2010, Caution Bay.

Map projection WGS84 – UTM Zone 55S.

Between the survey years, there was minor fluctuation in the proportions of species coverage (Table 5), as well as classified general areas (Table 4). This is likely to have been as a result of small temporal variations in species coverage, as well as minor mapping and classification inaccuracies, including the angle and time at which each GeoEye image was collected, geo-rectification variations, presence of shadows in some images, and resolution inconsistencies. Across the three satellite images, the largest mapped areas were *Rhizophora/Bruguiera* sp. (33 to 58% of the area), and mudflats/salt pans (32 to 36% of the area).

3.2.3 Vegetation change over time

Changes in vegetation between 2010 and 2013 were evident (Figure 20), with approximately 9.3% vegetation loss calculated. The construction of the LNG Plant jetty and the desalination pipelines in Area 2 during this period resulted in the removal of predominantly *Rhizophora/Bruguiera* forest. Clearing of mangroves for pipeline placement was also undertaken in Area 1. These factors, in addition to the potential minor analysis errors listed above, resulted in the vegetation changes during this period.

Changes in vegetation cover were also evident from 2013 to 2018 imagery (Figure 21), with an approximately 5% vegetation increase predominantly recorded at the landward edge of the mangrove area. This suggests recolonization of *Avicennia* sp. and *Ceriops* sp within this area. Some areas of vegetation loss were also observed in areas away from the LNG Plant. This was observed during groundtruthing with moderate to severe dieback noted within Areas 3 and 6. Again, small inconsistencies between the maps may be attributed to minor changes in sensor types, and capture angles of the imagery.

When comparing vegetation change between 2010 (pre-LNG Plant construction) and 2018 (post- LNG Plant construction/operational phase), a residual vegetation loss of 4.3% overall was recorded (Figure 22).

3.2.4 Mapped dieback areas

During the 2019 survey, areas of dieback, dominated by *Ceriops* sp., were observed to be continually wet (Figure 34, and Section 3.1.1), possibly indicating continual saturation of the sediment which may have resulted in some root rot. Other potential causes of the mangrove dieback from 2013 to 2018 (Figure 24) may be due to altered water flow resulting in sediment erosion or deposition, sea level rise, or changes in water or sediment quality potentially increasing the availability of nutrients or contaminants (Duke *et al.*, 2003a, Duke *et al.*, 2003b, Duke *et al.*, 2017).

While the dieback was recorded, no further investigations were performed to determine possible causes. Clearing of the mangroves for the LNG Plant jetty and pipeline landfall may have resulted in changes in water flow/tidal regime in mangrove habitats located on the landward side, possibly causing erosion and localised pooling and ponding (Figure 23). It is well known that mangrove roots provide natural barriers and sediment retention. Many studies have shown that removal of mangroves can increase the likelihood of erosion, allowing greater volumes of tidal waters to persist further up a mangrove stand to areas where mangrove species with low tolerances to frequent tidal inundation occurs. This can change the mangrove community structure over time (Blasco *et al.*, 1996, Semeniuk, 1980). A change in the water flow may also have been responsible for the recolonisation of *A. marina*. and *C. tagal* between 2013 to 2018, although this has not been verified.

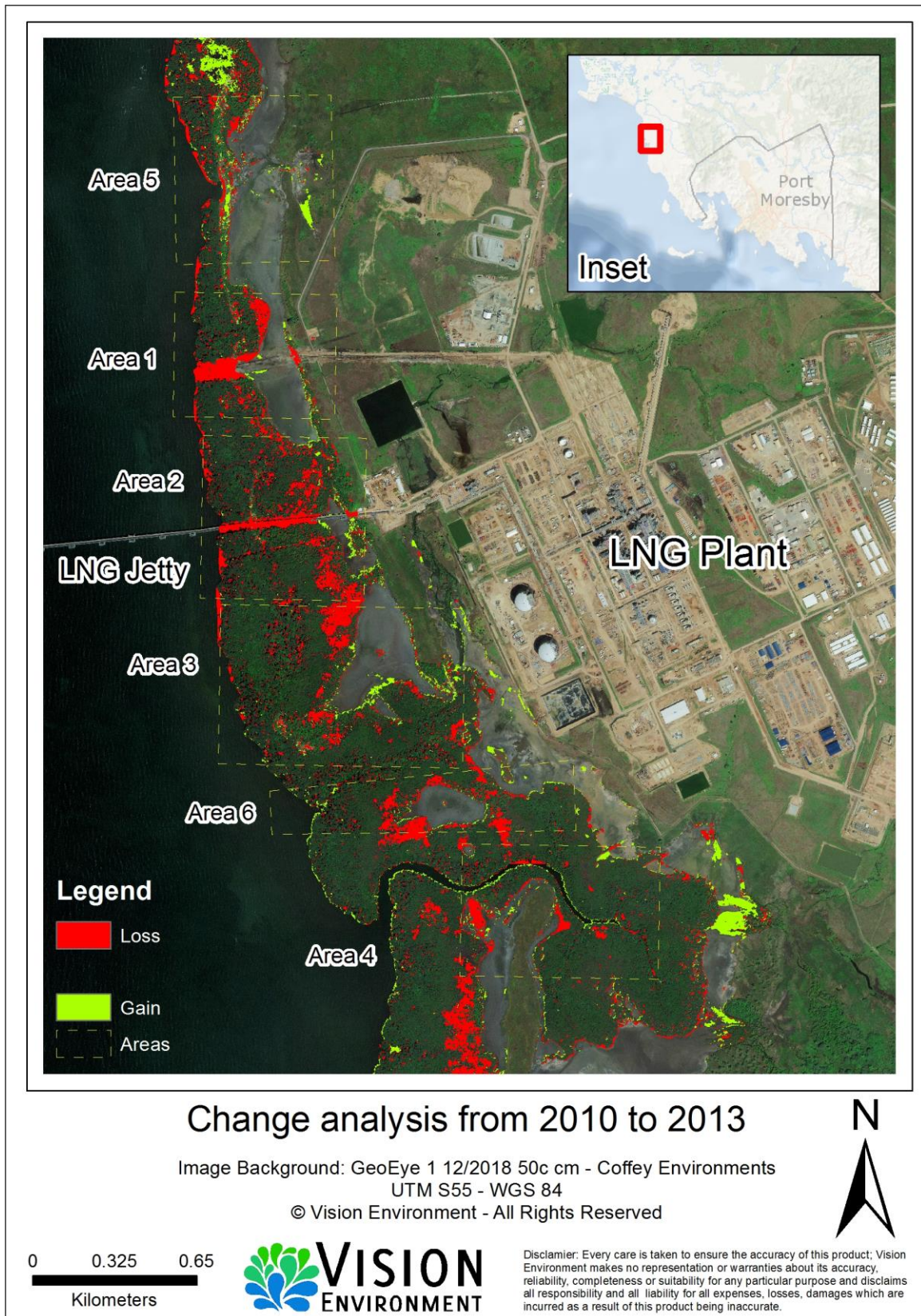


Figure 20. Vegetation change analysis from 2010 to 2013, with green pixels demonstrating vegetation gain and red pixels showing vegetation loss.
Map projection WGS84 – UTM Zone 55S.

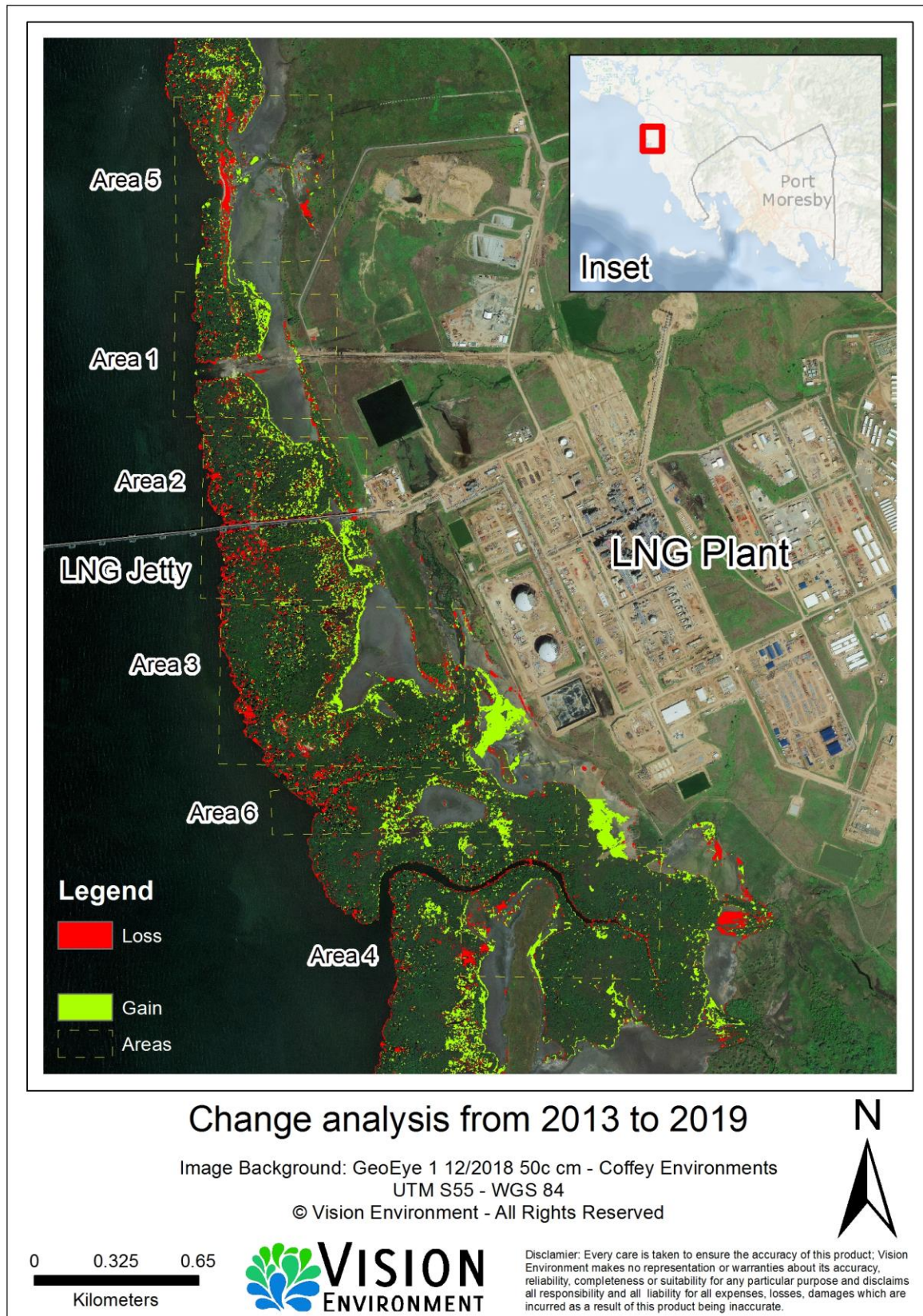


Figure 21. Vegetation change analysis from 2013 to 2019, with green pixels demonstrating vegetation gain and red pixels showing vegetation loss.
Map projection WGS84 – UTM Zone 55S.

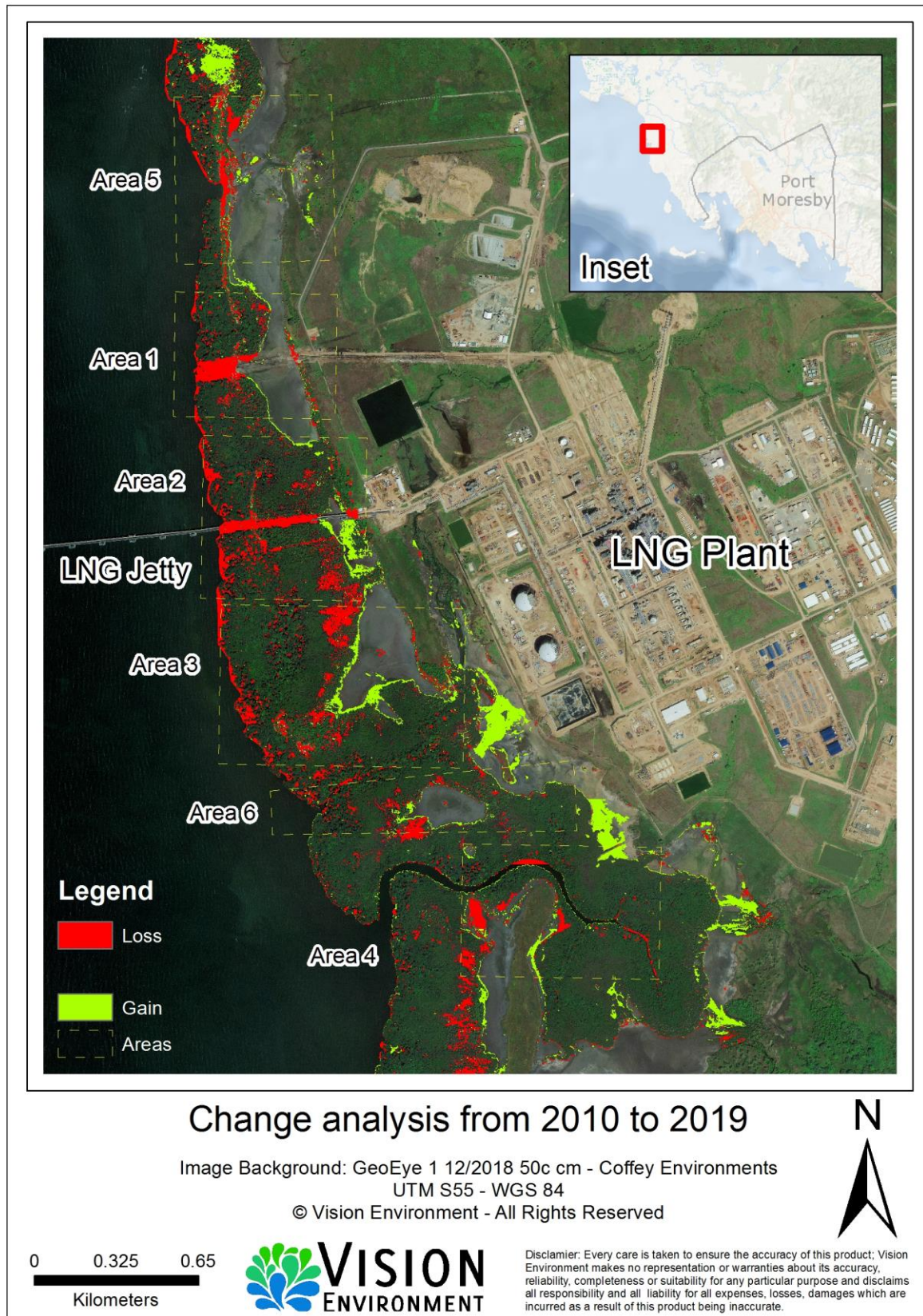


Figure 22. Vegetation change analysis from 2010 to 2019, with green pixels demonstrating vegetation gain and red pixels showing vegetation loss.
Map projection WGS84 – UTM Zone 55S.

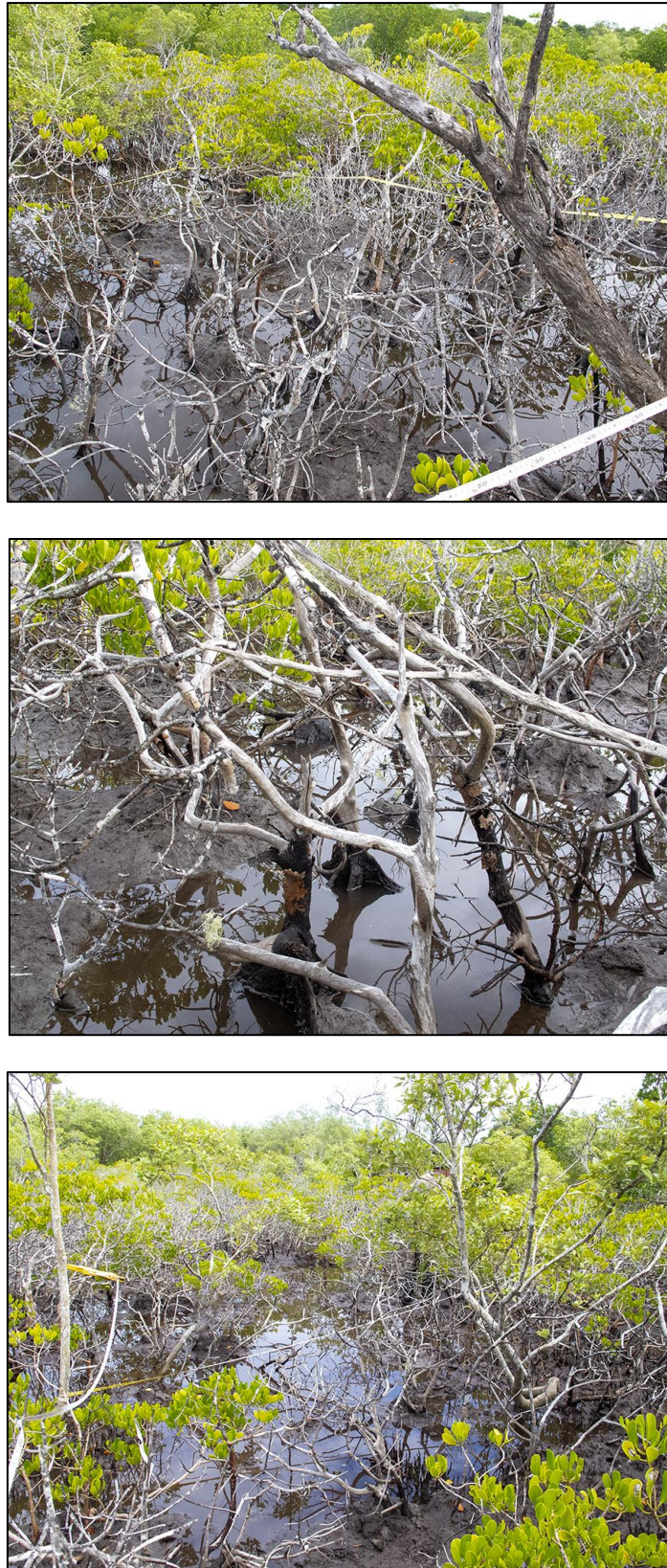


Figure 23. Evidence of significant mangrove dieback in Transect 15 at Area 6 in 2019 and pooling and ponding of flow; *Note, photos were taken during the low tide.*

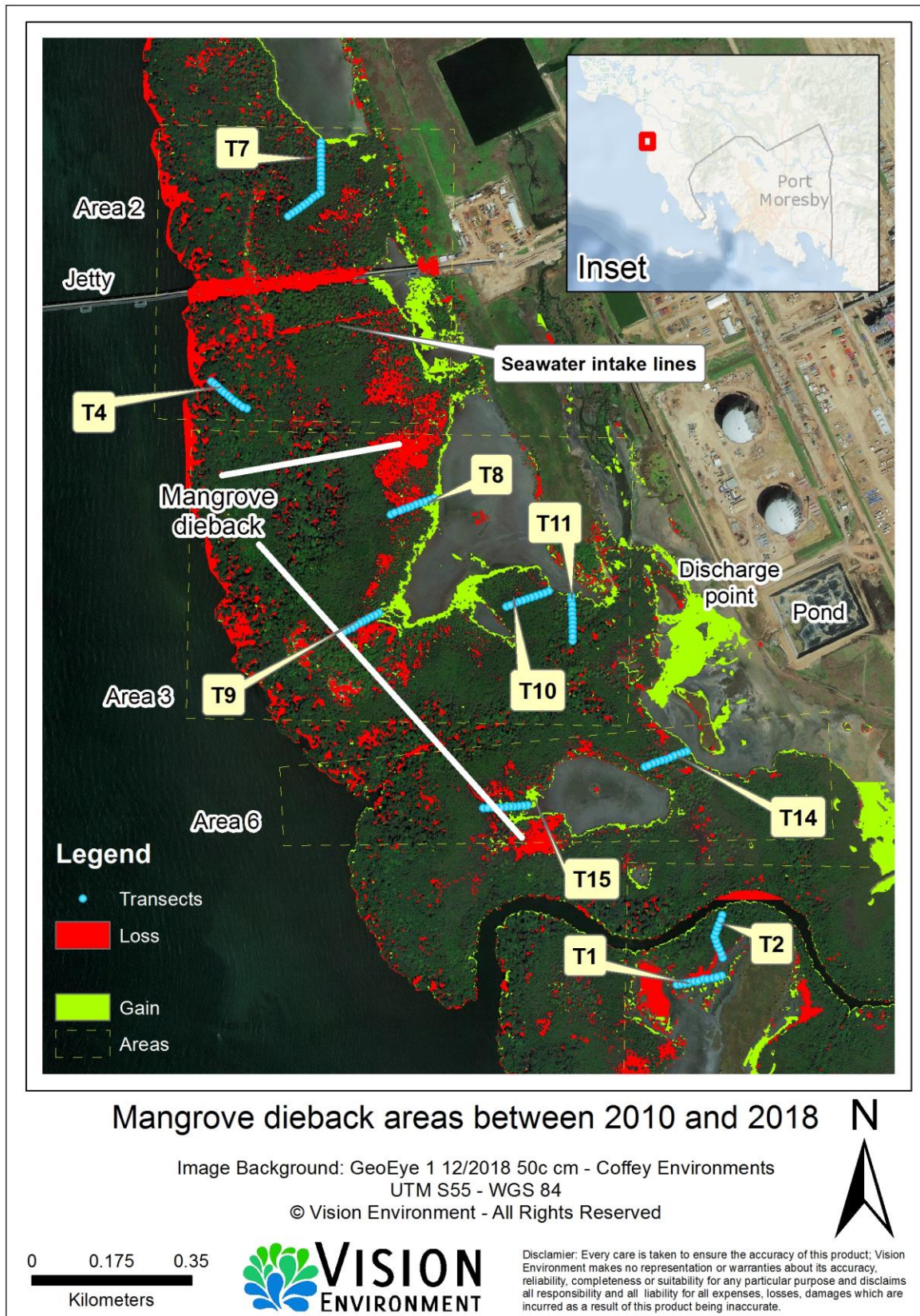


Figure 24. Mangrove dieback areas within Areas 2, 3 and 6 from 2010 to 2018 (zoomed in from Figure 23), with green pixels demonstrating vegetation gain and red pixels showing vegetation loss. Map projection WGS84 – UTM Zone 55S.

3.3 Macroinvertebrates

During the 2019 survey, a total of 22 macroinvertebrate individuals were collected from 9 taxa from all transects (See Table A4 in Appendix). The Fiddler Crab, *Uca* sp. (27%), was the most common taxa encountered across all transects, followed by the gastropods, *Alvania* sp. (18%), and Cerithidae (14%) (Table 6).

Table 6. Percent (%) occurrence of macroinvertebrate taxa across transects and areas.

Phylum	Class/Order	Family	Morpho-species	% Occurrence
Crustacea	Brachyura	Ocypodidae	<i>Uca</i> sp.	27
Mollusca	Gastropoda	Rissoidae	<i>Alvania</i> sp.	18
Mollusca	Gastropoda	Cerithidae	Cerithidae 1	14
Crustacea	Caridea	Alpheidae	<i>Alpheus</i> sp.	9.1
Mollusca	Gastropoda	Ellobiidae	<i>Cassidula</i> sp.	9.1
Mollusca	Gastropoda	Acteonidae	<i>Pupa</i> sp.	9.1
Chordata	Actinopterygii	Gobiidae	Gobiidae 1	4.5
Crustacea	Brachyura	Mictyridae	<i>Mictyris</i> sp.	4.5
Annelida	Sipuncula	Sipuncula	Sipuncula 1	4.5

No macroinvertebrate organisms were recorded in the two grab samples collected from Area 6 (Table 7, Figure 25). As such, calculated macroinvertebrate indices for this area were also zero. No organisms were also recorded in the single samples from Transect 5 (Area 1), Transects 8, 10 and 11 (Area 3) and Transect 2 (Area 4).

Only one organism each was encountered at Areas 1 and 3, resulting in low species richness (1) and zero diversity values. A total of nine organism from four different taxa were recorded from the two samples collected in Area 2. As such, highest species richness (9) and diversity (1.3) were recorded at this Area. Eight organisms from three taxa were collected from Area 4, leading to the next highest diversity value (1.1). Three organisms from two taxa were encountered at Area 5.

Table 7. Macroinvertebrate abundance, species richness, diversity and species evenness per area.
N = 1

Area	Number of Transects/Samples	Total Organism Abundance	Species Richness	Shannon-Weiner Diversity
Area 1	2	1	1	0
Area 2	2	9	4	1.3
Area 3	4	1	1	0
Area 4	3	8	3	1.1
Area 5	2	3	2	0.6
Area 6	2	0	0	0

Low macroinvertebrate organism return is typically found when sampling in mangrove forests (Rumisha *et al.*, 2015). The low number of macroinvertebrate organisms per sample indicates a more intensive sampling effort (e.g. more samples) is required to characterise the macroinvertebrate communities in the mangrove habitats adjacent to the LNG Plant. VE recommend the analysis of a minimum three replicate samples per transect (and therefore six

to twelve samples per area) for macroinvertebrate analysis during future monitoring occasions to ensure sufficient statistical power, or sensitivity, is gained.

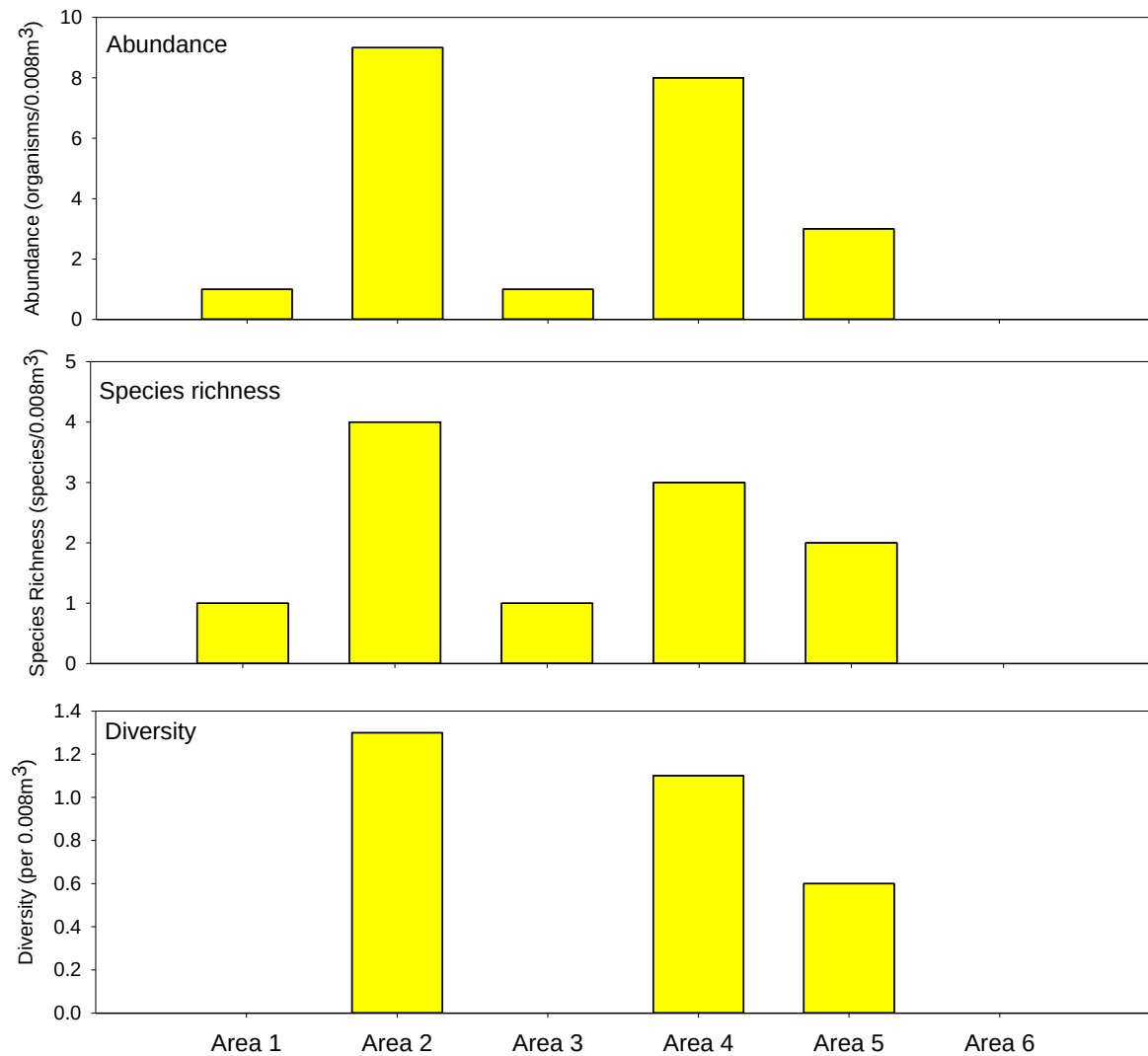


Figure 25. Macroinvertebrate abundance, species richness, diversity and species evenness per area.
 $N = 1$

4 SUMMARY

Mangrove monitoring was carried out near the LNG Plant in May 2019, in a similar manner to surveys undertaken in 2011 and 2014. An additional four transects were established in Areas 5 and 6 in 2019, resulting in 15 monitoring transects over six areas. Dominant mangrove communities in 2019 were *Rhizophora/Brugeria* forest, with a smaller proportion of *A. marina* dominated forest and *C. tagal* shrubland, similar to what was recorded in 2011 and 2014. One benthic macroinvertebrate sample was also collected from the landward edge of each transect in 2019.

Approximately 65% of the 382-ha mapped area in 2019 was found to be mangrove habitat, with mudflats and salt pans comprising almost 33% of the total area. Both the mangrove survey and the habitat mapping indicated that the dominant mangrove community was *Rhizophora/Brugeria* forest, with a smaller proportion of *A. marina* dominated forest and *C. tagal* shrubland recorded.

Some localised mangrove dieback was recorded during the 2019 survey in Areas 3 and 6, with some leaf defoliation and discoloration recorded in Areas 2, 3, 4 and 6. Changes in the water flow or tidal regime due to construction activities associated with the LNG Plant and infrastructure may have occurred, causing dieback of some mangroves and colonisation of new mangrove areas, however further investigation is required to determine the causal link, including a detailed field assessment of the newly identified dieback areas, as well as possible changes in hydrology. The majority of the other transects hosted healthy mangrove communities typical of the Australasian/south east Asian bioregion.

No significant spatial or temporal variation in mangrove parameters was evident, indicating stable mangrove populations. Crabhole density varied across the three surveys. As the fluctuation in crabhole densities was consistent across all areas both adjacent and further afield from the LNG Plant, this indicated natural influences as opposed to local anthropogenic effects. Significant spatial variation in mangrove parameters was evident only for seedling density, with Area 2 consistently exhibiting significantly higher seedling numbers in each survey year than other monitored areas.

Mapping of the mangrove area was carried out in 2011, 2014 and 2019, utilising Geoeye images from 2010, 2013 and 2018, respectively. During the construction phase of the LNG Plant and associated infrastructure (2010 to 2013), a loss of approximately 9.3% of generally seaward located mangroves was recorded. An increase in mangrove area in the landward zones was recorded between 2013 and 2018, resulting in an overall loss of 4.3 % of mangrove vegetation between 2010 and 2018.

Nine taxa of macroinvertebrate organisms were recorded in 2019 from the fifteen samples collected across the six areas, including crustaceans, molluscs, chordates and annelids. No organisms were encountered in seven of the samples, which is typically found during monitoring of mangrove habitats. Macroinvertebrate abundance, species richness and diversity varied across the mangrove habitat, but could not be statistically analysed due to insufficient statistical power. VE recommend increased sampling effort (minimum of three samples per transect to be collected) in future monitoring surveys in order to characterise the macroinvertebrate communities. The mangrove habitats encountered within the LNG Plant area are similar to others previously reported in Papua New Guinea, as well as neighboring countries like Australia, Indonesia and Malaysia.

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6 APPENDIX

Table A1. Mangrove stand parameters recorded in May 2019

Values are means $\pm$ SE.* Denotes calculations were based on adult trees only.

Location	Species Richness (species/25 m ²)	Total density (plants/25 m ²)	Adult density (adult plants/25 m ²)	Seedling density (seedlings/25 m ²)	*Stand Live Basal Area (m ² /ha)	Canopy cover (%)	Crab hole Density (holes/0.25 m ²)
Area 1	1.7 $\pm$ 0.2	29.0 $\pm$ 3.9	9.1 $\pm$ 2.2	19.9 $\pm$ 5.4	23.1 $\pm$ 6.5	70 $\pm$ 11	21.4 $\pm$ 1.4
Area 2	1.5 $\pm$ 0.2	81.4 $\pm$ 33.8	13.5 $\pm$ 4.6	67.9 $\pm$ 33.5	39.6 $\pm$ 10.6	89 $\pm$ 4	22.8 $\pm$ 1.7
Area 3	1.9 $\pm$ 0.2	19.2 $\pm$ 4.2	10.7 $\pm$ 2.2	8.5 $\pm$ 2.4	22.8 $\pm$ 10.4	60 $\pm$ 12	19.4 $\pm$ 0.7
Area 4	1.4 $\pm$ 0.2	23.8 $\pm$ 8.4	8.6 $\pm$ 1.8	15.2 $\pm$ 8.7	15.2 $\pm$ 5.6	73 $\pm$ 9	26.9 $\pm$ 1.8
Area 5	1.2 $\pm$ 0.2	55.3 $\pm$ 33.7	13.5 $\pm$ 11.1	41.8 $\pm$ 33.9	49.0 $\pm$ 19.8	89 $\pm$ 6	15.6 $\pm$ 1.2
Area 6	1.5 $\pm$ 0.2	48.5 $\pm$ 18.3	28.7 $\pm$ 10.5	19.8 $\pm$ 10.9	20.8 $\pm$ 5.4	81 $\pm$ 7	21.3 $\pm$ 1.6

Table A2 Mangrove stand parameters recorded in 2011, 2014 and 2019

Values are means $\pm$ SE.

Location	Total density (plants/25 m ²)			Adult density (adult plants/25 m ²)			Seedling density (seedlings/25 m ²)		
	2011	2014	2019	2011	2014	2019	2011	2014	2019
Area 1	32.3 $\pm$ 10.5	29.4 $\pm$ 12.3	29.0 $\pm$ 3.9	18.3 $\pm$ 10.3	21.0 $\pm$ 12.6	9.1 $\pm$ 2.2	14.0 $\pm$ 7.9	8.4 $\pm$ 5.4	19.9 $\pm$ 5.4
Area 2	21.1 $\pm$ 6.4	42.8 $\pm$ 25.3	81.4 $\pm$ 33.8	5.4 $\pm$ 1.9	11.3 $\pm$ 7.1	13.5 $\pm$ 4.6	15.7 $\pm$ 6.4	31.5 $\pm$ 24.2	67.9 $\pm$ 33.5
Area 3	18.0 $\pm$ 4.7	19.5 $\pm$ 4.1	19.2 $\pm$ 4.2	10.7 $\pm$ 3.8	9.4 $\pm$ 2.7	10.7 $\pm$ 2.2	7.3 $\pm$ 3.0	10.2 $\pm$ 4.4	8.5 $\pm$ 2.4
Area 4	13.6 $\pm$ 4.3	20.4 $\pm$ 9.7	23.8 $\pm$ 8.4	7.0 $\pm$ 1.8	3.7 $\pm$ 1.0	8.6 $\pm$ 1.8	6.6 $\pm$ 4.6	16.8 $\pm$ 9.8	15.2 $\pm$ 8.7
Area 5	-	-	55.3 $\pm$ 33.7	-	-	13.5 $\pm$ 11.1	-	-	41.8 $\pm$ 33.9
Area 6	-	-	48.5 $\pm$ 18.3	-	-	28.7 $\pm$ 10.5	-	-	19.8 $\pm$ 10.9

Table A3. Mangrove stand parameters recorded in 2011, 2014 and 2019Values are means $\pm$ SE. * Denotes calculations were based on adult trees only.

Location	Species richness (species/25 m ²)			*Stand Live Basal Area (m ² /ha)			Canopy cover (%)			Crab hole density (holes/0.25 m ²)		
	2011	2014	2019	2011	2011	2011	2011	2014	2019	2011	2014	2019
Area 1	1.3 $\pm$ 0.3	1.7 $\pm$ 0.3	1.7 $\pm$ 0.2	6.5 $\pm$ 0.4	6.5 $\pm$ 0.4	6.5 $\pm$ 0.4	82 $\pm$ 5	76 $\pm$ 8	70 $\pm$ 11	6.5 $\pm$ 0.4	13.0 $\pm$ 1.1	21.4 $\pm$ 1.4
Area 2	1.6 $\pm$ 0.2	1.0 $\pm$ 0.2	1.5 $\pm$ 0.2	6.9 $\pm$ 0.6	6.9 $\pm$ 0.6	6.9 $\pm$ 0.6	78 $\pm$ 4	80 $\pm$ 6	89 $\pm$ 4	6.9 $\pm$ 0.6	15.9 $\pm$ 1.1	22.8 $\pm$ 1.7
Area 3	1.6 $\pm$ 0.3	1.8 $\pm$ 0.2	1.9 $\pm$ 0.2	9.4 $\pm$ 0.4	9.4 $\pm$ 0.4	9.4 $\pm$ 0.4	79 $\pm$ 6	69 $\pm$ 8	60 $\pm$ 12	9.4 $\pm$ 0.4	15.2 $\pm$ 1.1	19.4 $\pm$ 0.7
Area 4	1.6 $\pm$ 0.2	1.6 $\pm$ 0.3	1.4 $\pm$ 0.2	5.4 $\pm$ 0.3	5.4 $\pm$ 0.3	5.4 $\pm$ 0.3	59 $\pm$ 11	51 $\pm$ 14	73 $\pm$ 9	5.4 $\pm$ 0.3	16.5 $\pm$ 1.6	26.9 $\pm$ 1.8
Area 5	-	-	1.2 $\pm$ 0.2	-	-	-	-	-	89 $\pm$ 6	-	-	15.6 $\pm$ 1.2
Area 6	-	-	1.5 $\pm$ 0.2	-	-	-	-	-	81 $\pm$ 7	-	-	21.3 $\pm$ 1.6

Table A4. Macroinvertebrates identified from samples collected in May 2019

Phylum	Class/Order	Family	Morpho-species	Area 1		Area 2		Area 3				Area 4			Area 5		Area 6	
				T5	T6	T4	T7	T8	T9	T10	T11	T1	T2	T3B	T12	T13	T14	T15
Crustacea	Caridea	Alpheidae	<i>Alpheus</i> sp.1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Mollusca	Gastropoda	Rissoidae	<i>Alvania</i> sp.1	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0
Mollusca	Gastropoda	Ellobiidae	<i>Cassidula</i> sp.1	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Mollusca	Gastropoda	Cerithidae	Cerithidae 1	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0
Chordata	Actinopterygii	Gobiidae	Gobiidae 1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Brachyura	Mictyridae	<i>Mictyris</i> sp.1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Mollusca	Gastropoda	Acteonidae	<i>Pupa</i> sp.1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
Annelida	Sipuncula	Sipuncula	Sipuncula 1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Crustacea	Brachyura	Ocypodidae	<i>Uca</i> sp.1	0	0	0	2	0	1	0	0	3	0	0	0	0	0	0

APPENDIX D: MANGROVE DIEBACK STUDY

2023

PAPUA LNG PROJECT - DOWNSTREAM: ASSESSMENT OF MANGROVE DIEBACK

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CITATION

This report should be cited as:

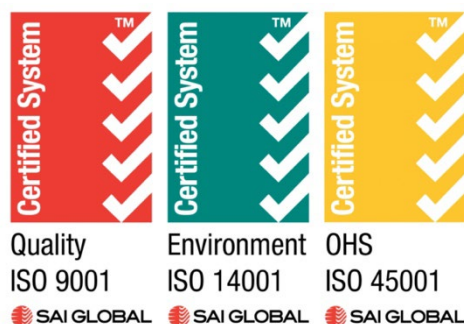
Vision Environment (2023). *Papua LNG Project – Downstream: Assessment of Mangrove Dieback in 2023*. Vision Environment ANZ, A Trinity Consultants Australia Company, Gladstone Australia.

DOCUMENT CONTROL

Document draft	Originated by	Edit and review	Date
Interim Draft issued to Coffey Environments	RA	FM	18/10/2022
Draft 2 issued to Coffey Environments	RA	FM	08/11/2022
Draft 3 issued to Coffey Environments	RA	FM	07/12/2022
Draft 4 issued to Coffey Environments	RA	FM	09/01/2023
Draft 5 issued to Coffey Environments	RA	FM	02/03/2023
Draft 6 issued to Coffey Environments	RA	FM	29/03/2023
Final issued to client	RA	FM	24/05/2023

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FILE REFERENCE

17052023 FINAL PNG_LNG_Mangrove_Report_2023_Dieback_Report_VE

EXECUTIVE SUMMARY

A survey of the mangrove communities within the lease area of the Papua New Guinea (PNG) Liquefied Natural Gas (LNG) Plant was undertaken in August 2022, following on from surveys undertaken in 2011, 2014 and 2019. The LNG Plant lies within the coastal fringes of Caution Bay, approximately 20 km north-west of Port Moresby, PNG.

The 2022 survey focussed on areas of mangrove dieback identified during the 2019 survey, examining three previously established transects and four newly established transects. Mangrove biodiversity parameters were re-examined, including species richness, adult and seedling densities, live basal areas, canopy cover and crab hole counts. Change analysis, previously conducted in the 2019 study was used to show areas of mangrove dieback or loss, and mangrove forest gain. Water quality, including temperature, salinity, pH, dissolved oxygen and turbidity, in pools and ponds was also monitored at 25 sites adjacent to the dieback areas. High resolution water quality maps were produced using a surface interpolation model.

Several mangrove dieback areas were identified adjacent to the mixing pond and retention pond, as well as to the south of the LNG Plant Jetty and PNG LNG pipeline scars. The mangrove species observed to be the most affected was the yellow mangrove, *Ceriops tagal*, which inhabits the landward edge of the mangrove habitat.

Approximately 50% of adult trees were dead along the transects, with highest dieback observed between 30 to 50 m from the landward edge of the habitat in low lying areas. In areas where statistics were able to be performed, it was found that there was no significant temporal or spatial variation in mangrove parameters between 2019 and 2022, nor across the transects. This indicates that mangrove dieback had occurred prior to 2019 and recovery was not yet evident, indicating the stressor is still present.

Pooling and ponding of water around the dieback areas was evident. However, water quality characteristics indicated that the water was not stagnant, and observations of continually flowing water suggested the input of discharge waters from the retention and/or mixing ponds, or groundwater intrusion. Up to 100 mm of elevation difference was observed between dieback areas and adjacent healthy mangrove areas hosting the same mangrove species.

While several factors were considered, including herbivory, plant disease, drought and contamination, it was hypothesised that pooling of discharge waters from the retention and mixing ponds, flowing into low lying areas, is resulting in plant stress and eventually death, with *C. tagal* known to be intolerant of frequent/continual inundation.

This hypothesis was tested in February 2023 via a preliminary water tracer survey. Limited tracer releases due to weather constraints, indicated that water from the mixing pond travelled to several dieback areas. This suggests that the continual discharge of these waters is leading to pooling of water in low lying areas and may be responsible for mangrove dieback. Further tracer studies are recommended to provide additional information to support this hypothesis.

The 2022 change analysis also indicated that mangrove areas increased within the pond discharge areas from 2010 to 2022, primarily attributable to an increase in *A. marina* density, a species suited to frequent tidal inundation. This was most likely due to the construction of the retention and mixing ponds and resultant increase in water discharge or flow, thus indicating that changes in hydrodynamic flows can have both positive and negative impacts.



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ACRONYMS

ANOVA	Analysis of Variance
APHA	American Public Health Association
DEEDI	Department of Employment, Economic Development and Innovation
DEM	Digital Elevation Models
DES	Department of Environment and Science
DO	Dissolved oxygen
EMPNGA	ExxonMobil PNG Antelope Limited
GPS	Global Positioning System
LBA	Live Basal Area
LiDAR	Light Detection and Ranging
LNG	Liquefied Natural Gas
PFC	Projective Foliage Cover
PNG	Papua New Guinea
SE	Standard Error
SEM	Surface Elevation Models
WQ	Water Quality

1. INTRODUCTION

Mangroves are communities of halophytic (salt-tolerant) trees that exist in intertidal zones, often fringing estuarine creeks and river banks (Blasco et al. 1998). Mangrove forests are highly productive, play an important role in nutrient cycling and act as nursery areas for a diverse array of organisms, providing food for a number of juvenile fish and crustacean species (Jones et al. 2000, Laegdsgaard and Johnson 2001).

Mangrove biodiversity is influenced by tidal exposure and inundation. Some species of mangroves live on the upper reaches of creeks and rivers, and prefer different water quality attributes to those that inhabit the lower reaches (Ridd et al. 1990, Lovelock 1993). Mangrove biodiversity is also influenced by geographical location, with highest biodiversity found in warmer parts of the world (Duke 1992, Duke et al. 1998a, Duke et al. 1998b, Government of Papua New Guinea 2015). There are over 30 species of mangroves found in PNG (Paijmans and Rollet 1977, Robertson et al. 1991, Raga 2006, Shearman 2010), with an estimated 592,900 ha of mangroves distributed along the coastline (Robertson et al. 1991, Joyce 2005, Faunce and Serafy 2006). Table 1 lists some of the more common mangrove species found in PNG.

Table 1. Common mangrove species found in PNG (Ellison 1997, 2009).

Species name	Common name
<i>Acanthus ilicifolius</i>	Holly mangrove
<i>Acrostichum speciosum</i>	Mangrove fern
<i>Aegialitis annulata</i>	Club mangrove
<i>Aegiceras corniculatum</i>	River mangrove
<i>Avicennia marina</i>	Grey mangrove
<i>Bruguiera gymnorhiza</i>	Large-leafed orange mangrove
<i>Bruguiera parviflora</i>	Small-leafed orange mangrove
<i>Ceriops tagal</i>	Yellow mangrove
<i>Crinum pedunculatum</i>	Mangrove lily
<i>Cynometra iripa</i>	Wrinkle pod mangrove
<i>Excoecaria agallocha</i>	Milky mangrove
<i>Heritiera littoralis</i>	Looking-glass mangrove
<i>Hibiscus tiliaceus</i>	Native hibiscus
<i>Lumnitzera racemosa</i>	Black mangrove
<i>Osbornia octodonta</i>	Myrtle mangrove
<i>Sonneratia alba</i>	Mangrove apple
<i>Rhizophora apiculata</i>	Tall-stilted mangrove
<i>Rhizophora stylosa</i>	Red mangrove
<i>Xylocarpus granatum</i>	Cannonball mangrove
<i>Xylocarpus mekongensis</i>	Cedar mangrove

The proposed Papua LNG Project is a development project for the Papua LNG co-venture participants: TotalEnergies EP PNG Limited (an affiliate of TotalEnergies SA), ExxonMobil PNG Antelope Limited and ExxonMobil PNG Elk Limited (affiliates of Exxon Mobil Corporation (ExxonMobil)) and Pac LNG Assets Limited, Pac LNG International Limited, Pac LNG Investments Limited, Pac LNG Overseas Limited and Pac LNG Holdings Limited (affiliates of Santos Limited).

The existing PNG LNG Project commercialises gas reserves in the Hela, Western and Southern Highlands provinces of PNG. The gas is transported to the LNG Plant via the PNG LNG pipeline where it is liquefied and exported by ship to international gas markets. The LNG Plant is currently operated by ExxonMobil PNG Limited, an affiliate of Exxon Mobil Corporation.

New LNG processing trains are proposed, which will expand the capacity of the LNG Plant by an additional 4 million tonnes per annum stream day capacity. Gas for the Project will be supplied from the Elk and Antelope reservoirs in Gulf Province.

ExxonMobil PNG Antelope Limited (EMPNGA) is the ExxonMobil affiliate responsible for the construction of the Project. Niugini LNG Operating Company Limited is the ExxonMobil affiliate responsible for operation once the Project has been constructed and commissioned.

Mangrove communities exist in the intertidal area between the onshore facilities, including the LNG Plant, and facilities in the marine environment, including the gas pipeline and LNG Plant Jetty. A baseline assessment of the mangrove communities was undertaken to inform the Project environmental impact statement in 2011, with subsequent monitoring undertaken during construction and operation of the project (Alquezar and Boyd 2011, Vision Environment 2014, 2019). Expansion activities are planned at the site, including construction of new offshore pipelines and associated landfalls, and extension of the LNG Plant Jetty.

During the 2019 baseline investigation, dieback was observed at several transects within two areas (Vision Environment 2019). A survey of the mangrove communities within the lease area of the LNG Plant was undertaken during August 2022, to determine the extent and possible causes of the dieback (Figure 1). Further investigations into dieback causes were undertaken in February 2023.

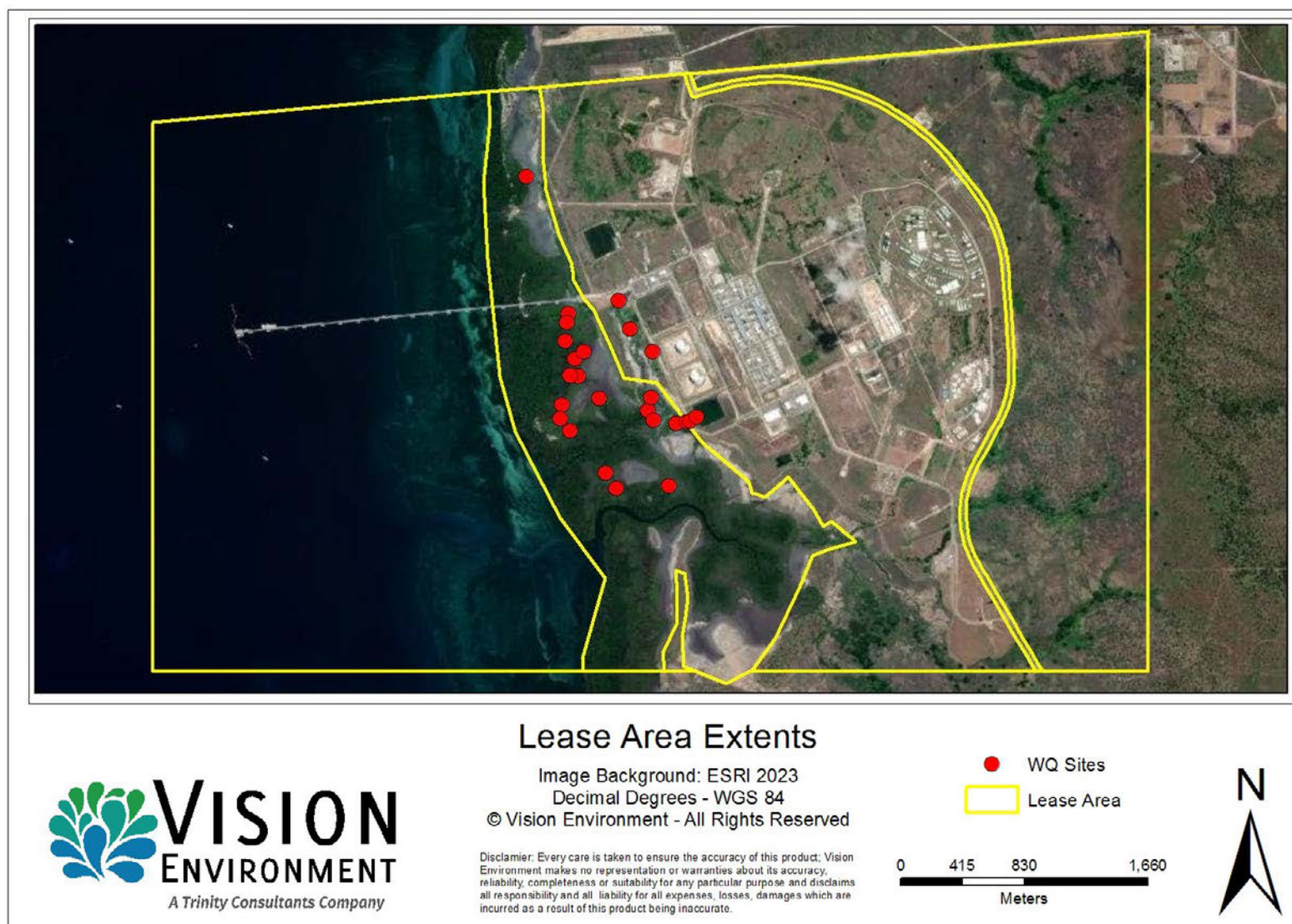


Figure 1. Map showing water quality sites (in red) within lease area

2. METHODOLOGY

The initial survey in 2022 focussed on areas of mangrove dieback identified during the 2019 monitoring, examining three previously established transects and four newly established transects. Mangrove tree dieback was defined as trees with complete loss of foliage, desiccated trunks, stems and roots, and colour change from grey/brown to a white/bleached colour.

The primary study area included the mangrove habitat adjacent to the facilities surveyed previously in 2011, 2014 and 2019 (Alquezar and Boyd 2011, Vision Environment 2014, 2019) (Figure 1). Sampling methodologies were similar to previous surveys, and were adopted from standard protocols derived from worldwide authorities, including Australian and New Zealand Standards, the American Public Health Association (APHA) Standard Methods for the Examination of Water and Wastewater (APHA 2017), the Queensland (Australia) Department of Environment and Science (DES) Monitoring and Sampling Manual (DES 2018), and the Queensland Department of Employment, Economic Development and Innovation (DEEDI) Data collection protocol for mapping and monitoring mangrove communities in Queensland (DEEDI 2011). Strict quality assurance and quality control measures were in place for all work undertaken.

2.1 Mangrove Measurements

Three previously established transects (T8, T9, and T15) were surveyed and four new transects (TA, TB, TC, and TD) were established based on possible dieback areas identified via satellite imagery (Figure 2). Transects were between 70 and 100 m in length. Other transects with no dieback surveyed in 2019, were not assessed in the current survey.

Three 25 m² quadrats were established within each transect, at the start, end and midway points. Quadrat boundaries were marked using a tape measure and all trees (> 1 m height) and seedlings (< 1 m height) were identified and counted to determine mangrove species richness, density and diversity indices. Canopy cover was determined within each quadrat using vegetation Projective Foliage Cover (PFC) estimates. A total of 20 readings were taken at randomised locations within each quadrat using a PFC tube. Cover was classified as open (0 to 5%), sparse (6 to 25%), moderate (26 to 50%) or dense (> 50%).

Live Basal Area (LBA) was calculated as the sum of tree girths (diameter of each tree) at breast height within each 25 m² quadrat. Values were then calculated as square meter (m²) of cross-sectional tree area per hectare. Mangrove composition and relative canopy cover was also estimated at 10 m intervals along each transect for mapping groundtruthing purposes.

Crab hole densities were determined by randomly placing ten replicate 0.25 m² quadrats on the substrate and counting crab holes. Density was calculated as the number of crab holes per unit area.

Visual estimation/observations of leaf defoliation (degree of leafless branches), discoloration (degree of leaf color change from green), and dieback (weathering of whole trees with significant loss of leaves and branches) for each quadrat were determined and a scale used to determine the severity, with no change (<5%), slight (5-25%), moderate (26-50%), and severe (>50%).

2.2 Water Quality

Localized pooling and ponding of water was observed within the dieback areas in 2019 (Vision Environment 2019). As such, the water quality of these pond/pools, and adjacent discharge

points was assessed during 2022. A total of 25 water quality (WQ) sites were established (Figure 3), with temperature, pH, dissolved oxygen, salinity and turbidity measured in triplicate using a multiparameter water quality meter (YSI ProDSS, Figure 4). Note that an isolated patch of mangrove dieback was observed to the north of the LNG Plant Jetty (WQ25; Figure 3), however no mangrove transects were established at that site.

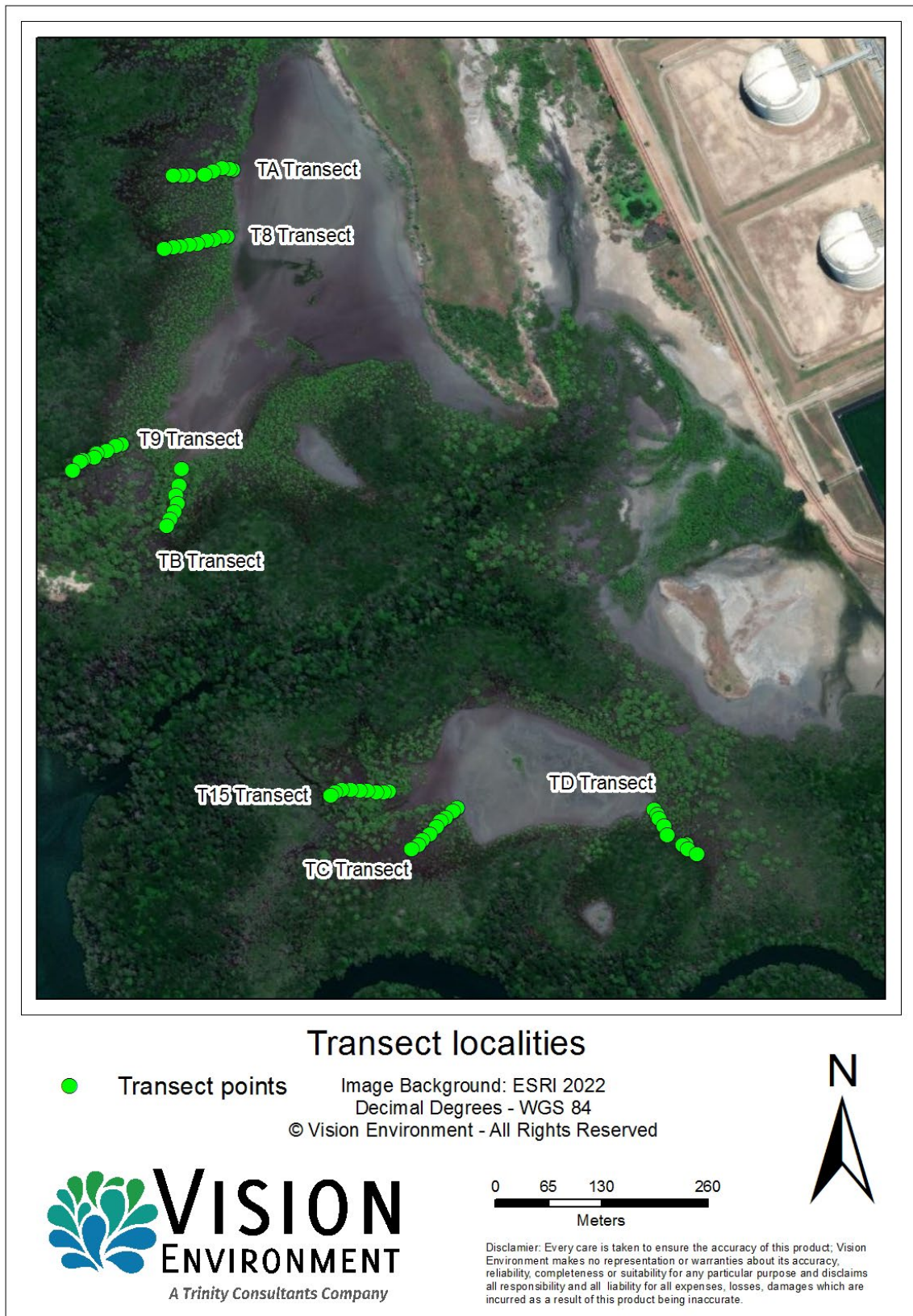


Figure 2. Location of previously (T8, T9 and T15) and newly (TA, Tb, TC and TD) established mangrove monitoring transects.

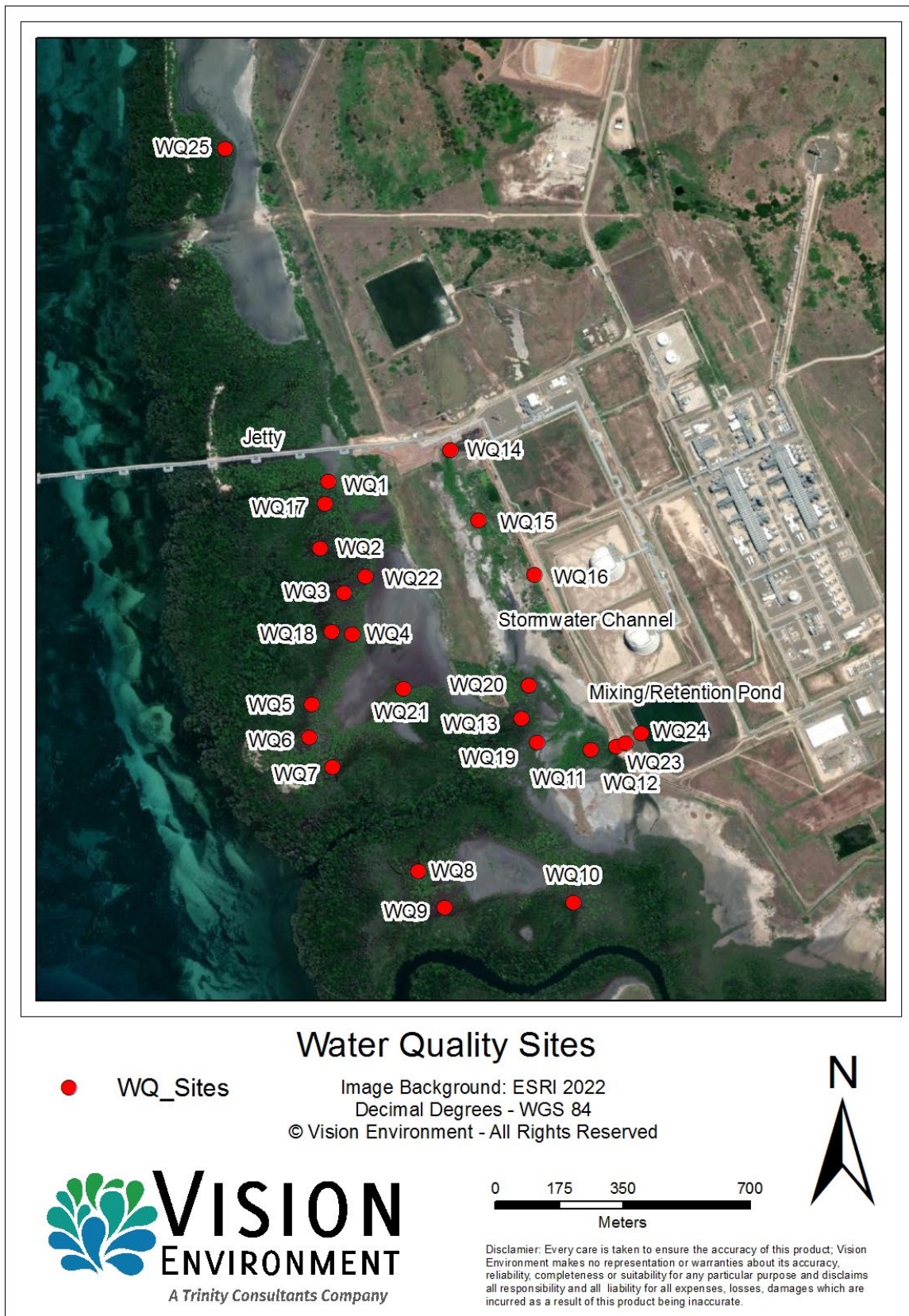


Figure 3. Location of 2022 water quality assessment sites.



Figure 4. Water quality parameters were recorded in pooled water within dieback areas using a multiparameter water quality meter.

2.3 Data Analysis

Spatial and temporal (2019 and 2022 surveys, where available) variation in mangrove species richness, adult and seedling density, adult LBA, canopy cover and crab hole density were determined using one- and two-way analysis of variance (ANOVA). Data were tested for homogeneity of variance and normality, and significance levels were increased ($P < 0.01$, 99% confidence intervals) where data did not meet that criteria (Underwood 1997, O'Neill 2000). Dead trees were only recorded during the 2022 survey, therefore only 2022 spatial variation was reported for dieback data.

2.4 Mangrove Mapping

Mean water quality results were linked to Global Positioning System (GPS) coordinates. The ArcGIS Pro Kriging module (ESRI® ArcGIS Pro™ 2019) was used to create a surface interpolation of the water quality parameters as a potential predictor of surface water pathways. Given that freshwater, saline and hypersaline areas were identified, salinity was used as a proxy to determine potential discharge flows from the retention pond, the mixing pond, and stormwater channels adjacent to the plant. High quality maps were produced based on the surface interpolation of the water quality parameters and dieback areas superimposed from ground truthing and satellite visual identification. Interpolated areas closest to the water quality sites displayed the highest accuracies. Temperature, pH, dissolved oxygen and turbidity interpolated surface maps were also produced and are presented in the Appendix.

Geoeye™ (0.5 m pixel) natural colour images, captured in 2022, were provided to Vision Environment by Tetra Tech to analyse and determine mangrove community composition and density.

Image processing and classification was carried out using ESRI® ArcGIS Pro™ 2022 Geographical Information System (GIS) software. Arbitrary areas of interest for mangrove community areas, intertidal wetlands and mud flats were created using natural breaks between the mangrove, water and terrestrial communities in order to subset the imagery. Non-marine wetland areas (terrestrial ecosystems, man-made structures, water bodies and bare ground) were visually identified and excluded from the subsets. Broad mangrove community classes were visually identified from the satellite imagery.

The satellite images were then segmented by grouping pixels that had homogeneous spectral similarities. This process aided in identifying general mangrove community clusters, rather than isolating specific trees to identify dominant communities. Mangrove communities were categorised into segments using the ArcGIS Pro module Segmentation (ESRI® ArcGIS Pro™ 2022). Segment training areas were then applied to each segment using the ArcGIS Pro module Segment Training Manager (ESRI® ArcGIS Pro™ 2022), derived from mangrove transect information. Training areas were then converted into classification signatures (specific mangrove classes) and used as part of an object based supervised classification process. Support Vector Machine Learning Classification was used as a decision rule (ESRI® ArcGIS Pro™ 2022), based on the probability that a specific pixel value range belongs to a particular mangrove class, for the supervised classification.

Final classification of mangrove, saltmarsh and mudflat classes were created using the ArcGIS Pro module Classify (ESRI® ArcGIS Pro™ 2022). The classifications were then manually rationalised into broad mangrove community classes. Classes were further visually assessed against the ground-truthed transect data. The study area outlines, and mangrove community classifications, were reproduced as high-quality maps using ESRI® ArcMap™ 10.1 geographical information system (GIS) software.

Several mangrove dieback areas were identified adjacent to the LNG Plant. As such, the four main mangrove vegetation classes (Figure 5) consisted of:

- *Rhizophora/Bruguiera* forest communities, which included over 50% composition *R. stylosa*, *R. apiculata*, *B. gymnorhiza* and *B. parviflora* species towards the seaward edge;
- *A. marina* dominated communities and emergent among other species;
- *C. tagal* dominated shrub communities, mainly within the landward edge of the forest; and
- General mangrove dieback areas (all species included).

Change in vegetation analysis from 2010 to 2022 was performed by isolating only vegetated areas and differentiating between vegetation classes among monitoring years. A raster mathematical equation using the ESRI® ArcGIS Pro™ 2022 image calculator and Reclassify module, was utilised whereby a mathematical expression was performed on classified Geoeye™ satellite images captured in 2010 and 2022. Positive vegetation gain (green pixels) and negative vegetation loss (red pixels) was then mapped, and areas reported for different year combinations. In the current study, high resolution maps of vegetation change between 2010-2022, and 2019-2022 were created and dieback areas and water quality sites were superimposed onto each map. Zoomed areas included dieback areas adjacent to the

mixing/retention ponds and the LNG Plant Jetty and PNG LNG pipeline mangrove removal scars. Although every care was taken to reduce errors in georectification, some slight georectification errors between the 2010 and 2022 maps were evident, and as a result some erroneous miss classification between the two satellite images was observed, particularly around the edges of vegetation classes for the change analyses.



Figure 5. Examples of mangrove communities in Caution Bay, including *Rhizophora/Bruguiera* forests (upper left), *Ceriops* shrublands (upper right), *Avicennia* forest (lower left), and dieback trees (lower right).

Light Detection and Ranging (LiDAR) remote sensing was used to determine surface elevation of the study area of interest. LiDAR point cloud data captured in 2022, was sourced from Tetra Tech. LiDAR data was used to create ground Digital Elevation Models (DEM) and Surface Elevation Models (SEM) within the study area using ESRI® ArcGIS Pro™ 2022 module ground and 1st return values, to determine differences in ground elevation and canopy elevation among mangrove areas. Twenty random points were used to collect ground surface height above sea level for each dieback area and ground elevation in the adjacent areas that contained healthy mangroves of the same species or mudflats.

One-way ANOVA was used to determine significant differences in height elevation of bare ground points from LiDAR data among dieback areas, adjacent mangrove areas, and mudflats. Data were tested for homogeneity of variance and normality, and significance levels were increased ($P < 0.01$, 99% confidence intervals) where data did not meet that criteria (Underwood 1997, O'Neill 2000). DEM and SEM were reproduced as high-quality maps using ESRI® ArcMap™ 10.1 software.

2.5 Tracer Study

Based on results gained from the 2022 field survey, a fluorescent water tracer study was undertaken in February 2023 to determine if water discharged from the mixing pond was reaching the dieback areas of interest.

Approximately 10 g of Rhodamine Water Tracer (WT) powder was mixed with 10 L of seawater, creating a final concentration of ~ 2 ppm over a 5 m³ volume of water at the release points. The water tracer was red in appearance and therefore easy to view among the mangrove forests and mudbanks (Figure 6).

As the dye moved downstream from the release points, water quality parameters, including Rhodamine concentrations, were used to track the tracer along its pathway (Figure 6). Additional Rhodamine WT was released further downstream when the dye became too dilute to see.

Aerial drones (DJI Inspire 2 and DJI Mini 3) were used to capture images at 60 m altitude during tracer movement. Between three to five Ground Control Points (GCP) were used for each image to aid in georectifying. GPS points were taken at the centre of each GCP and used for image rectification.

Rhodamine WT was released at two locations (Release 1 & Release 2). Other areas of interest were identified, but not investigated due to weather and time constraints.



Figure 6. Water tracer release point and plume tracking using a multiparameter water quality meter.

Each image georectified according to the GCP and segmented by grouping pixels that had homogeneous spectral similarities (Figures 7 & 8), using the ArcGIS Pro Segmentation module (ESRI® ArcGIS Pro™ 2022). Segment training areas were then applied to each segment using the ArcGIS Pro Segment Training Manager module. Training areas were then converted into classification signatures (specific classes: mud, vegetation and WT) and used as part of an object based supervised classification process. Support Vector Machine Learning Classification was used as a decision rule, based on the probability that a specific pixel value range belongs to a particular class, for the supervised classification. Final classification of mud, vegetation and WT classes were created using the ArcGIS Pro Classify module.

The WT class was then separated using the ArcGIS Pro Reclassify module and superimposed onto a mosaic of orthorectified images captured from the drones. The WT layers were visually

assessed to determine final route and destination of the discharge water from the mixing ponds and reproduced as high-quality maps using ESRI® ArcMap™ 10.1 GIS software.

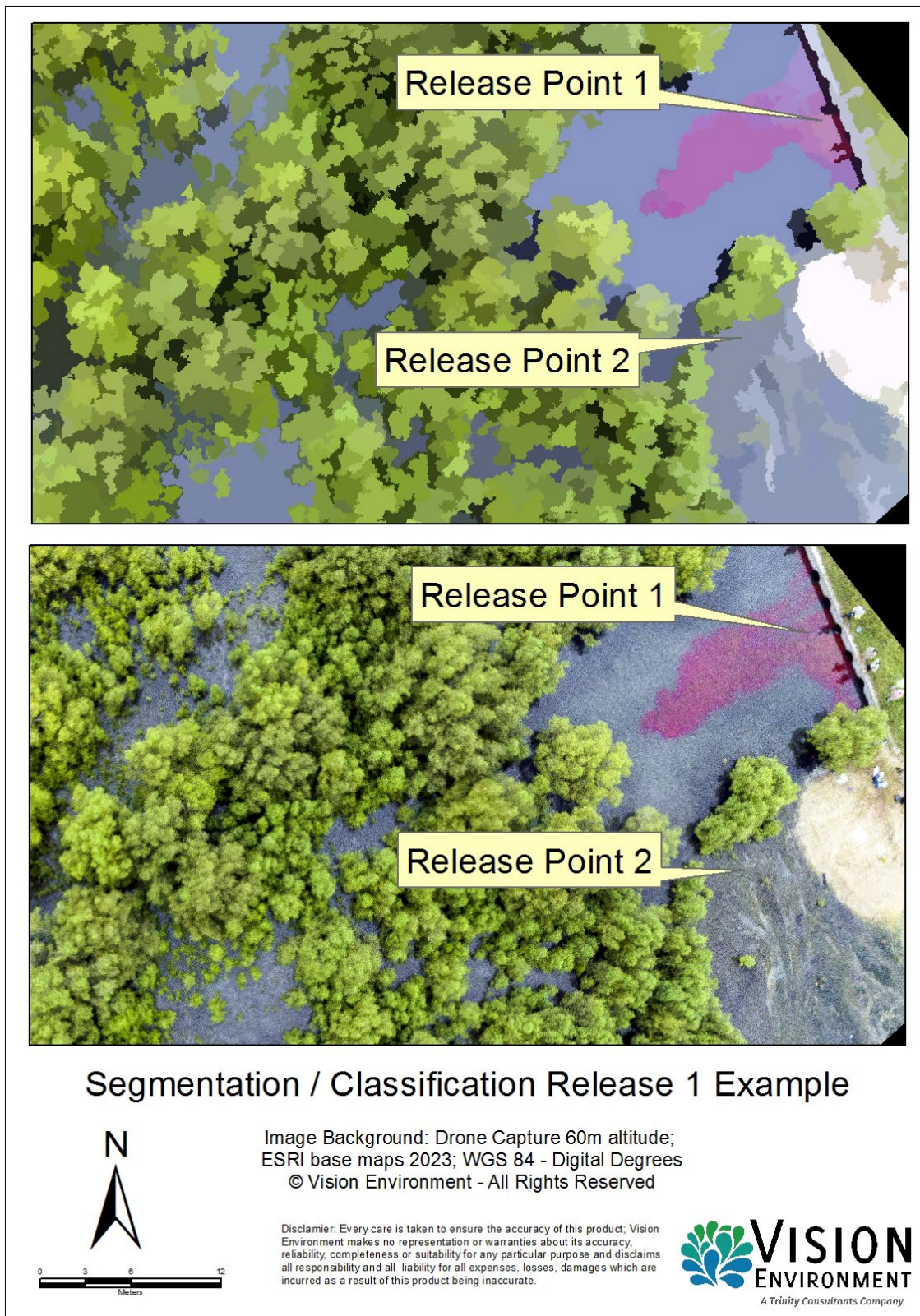


Figure 7. Example of segmentation of WT plumes from Release Point 1 from the original image.

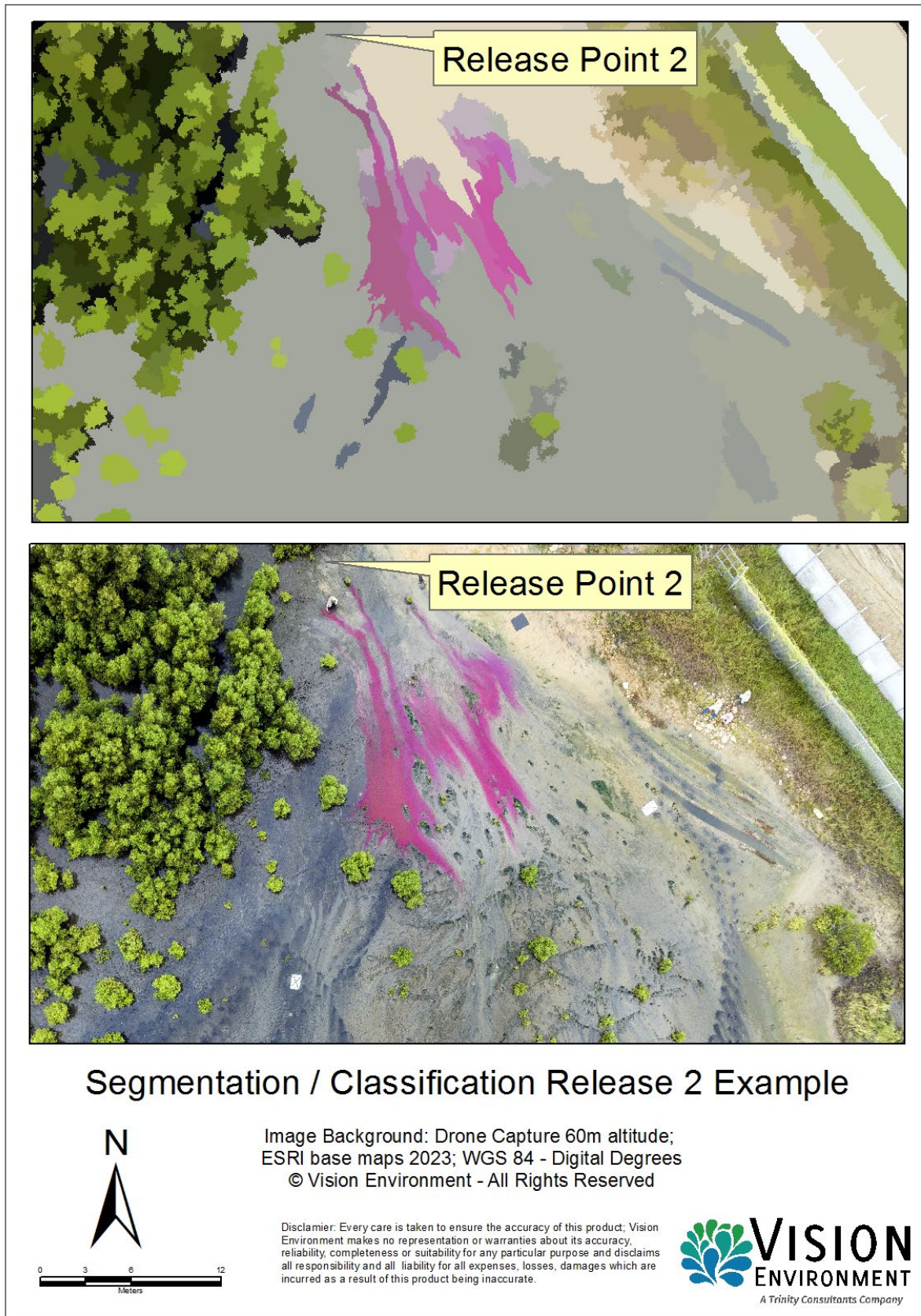


Figure 8. Example of segmentation of WT plumes from Release Point 2 from the original image.

3. RESULTS & DISCUSSION

3.1 Mangrove Communities

Approximately 167 ha of estuarine habitat (mangroves, salt marshes and salt flats) within the leased area of the LNG Plant was investigated. The most commonly encountered species, particularly at the seaward edge, were the Red Stilted Mangrove (*Rhizophora stylosa*) and the Orange Mangrove (*Brugeria gymnorhiza*). The Grey Mangrove (*Avicennia marina*) was typically observed towards the mid and back of the stand, and often occurred as an emergent within the *Rhizophora/Brugeria* forest component. The Yellow Mangrove (*Ceriops tagal*) was commonly recorded at the landward edge of the mangrove stand. The above-mentioned mangrove species are commonly recorded in PNG and neighboring countries (Paijmans and Rollet 1976-1977, Pernetta and Hill 1981).

Other species that were observed during the survey within the leased areas but not recorded in plots or transects where dieback occurred, included the Myrtle Mangrove (*Osbornia octodonta*), the Milky Mangrove (*Excoecaria agallocha*), the River Mangrove (*Aegiceras corniculatum*) and the Cannonball Mangrove (*Xylocarpus granatum*). Saltmarsh species (Figure 9) encountered included Saltbush (*Enchylaena* sp.), Bead Weed (*Sarcocornia* sp.) and Saltcouch (*Sporobolus* sp.).



Figure 9. Bead weed saltmarsh (*Sarcocornia* sp.) observed at Transect 12.

During the 2022 survey, a total of 817 mangrove plants were recorded (74% live and dead adults and 26% seedlings) across the seven transects. Of the adult mangroves encountered towards the back of the stand, where dieback was present, approximately 50% were found to be dead. *C. tagal* was the most common mangrove species encountered across the transects (live 47%, dead 37%), followed by *A. marina* (live 13%, dead < 1%), and *R. Stylosa* (live 2%, dead < 1%). Note, these percentages were calculated based on transects from dieback areas only, not total leased area. See mapping component for total areas affected.

No significant ($P > 0.05$) statistical ($P > 0.05$) spatial variation was evident for mangrove species richness across the transects, with mean species per quadrat ranging from 1.3 species in Transect TC to 2.7 species in Transect TB (Figure 10, Table A1 in Appendix).

No significant ($P > 0.05$) spatial variation was evident for adult plant density due to the amount of variation within each transect and quadrat. Mean adult density ranged from 8 adults/quadrat

in Transect TB to 24 adults/quadrat in Transect T15. Additionally, no significant ($P > 0.05$) spatial variation was evident for live or dead adults across the transects. Seedling density also remained similar across the transects, ranging from 6 seedlings/quadrat to 19 seedlings/quadrat (Figure 10, Table A1 in Appendix).

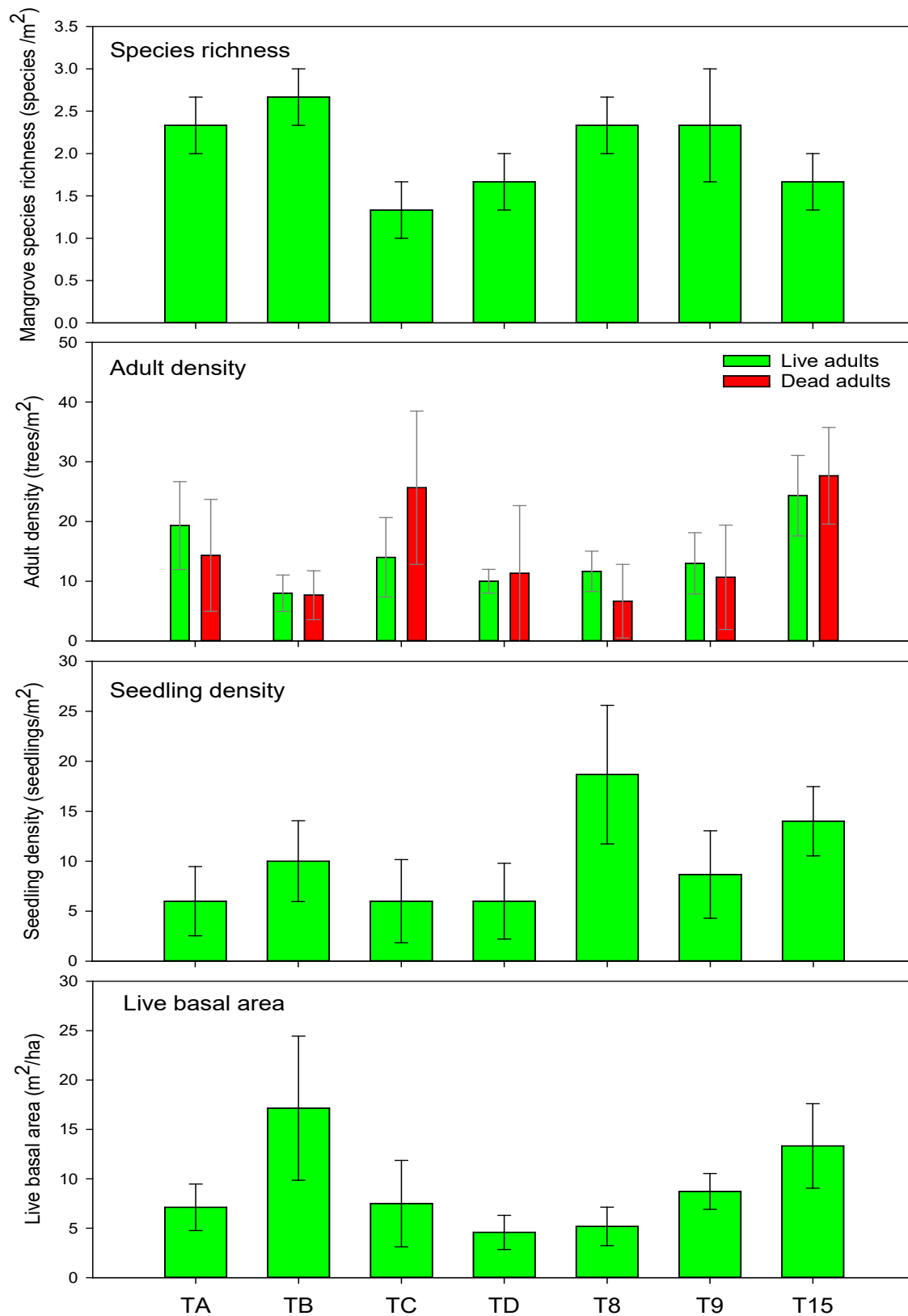


Figure 10. 2022 Mangrove species richness, adult and seedling density, and adult LBA in transects. Values are means $\pm$ SE.

Canopy cover also did not differ significantly ($P > 0.05$) across the transects, ranging from 42% at Transect TC to 72% at Transect T15 (Figure 11, Table A1 in Appendix). Similarly, crab hole densities remained similar across the transects (13 to 17 holes/0.25m², Figure 11).

The following crab species were observed during both 2019 and 2022 surveys: Mud Crab (*Scylla serrata*), Orange Clawed Fiddler Crab (*Uca coarctata*, Figure 12), Marsh Crab (*Sesarma* sp.), Tuxedo Crab (*Australopax tridentate*), Lemon-Yellow Clawed Fiddler Crab (*Uca Perplexa*, Figure 12) and Shore Crab (*Hemigrapsus* sp.). The above-mentioned species are also commonly found in tropical north Australia.

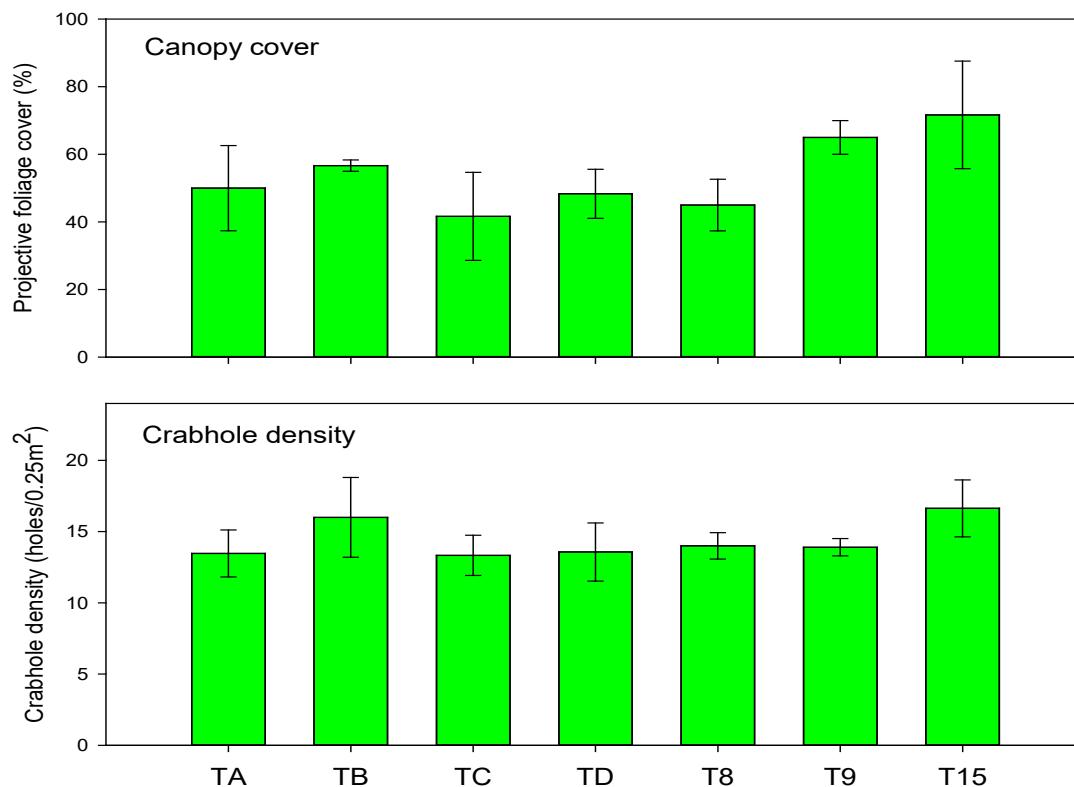


Figure 11. 2022 Canopy cover and crabhole density in transects. Values are means $\pm$ SE.



Figure 12. Orange Clawed Fiddler Crab and Lemon-Yellow Clawed Fiddler Crab observed during the 2019 and 2022 surveys.

Table 2 lists the observations of leaf defoliation, discoloration, and dieback for each quadrat. Moderate to severe mangrove dieback was observed in all transects (Figure 13), with slight to moderate leaf defoliation and/or discoloration also recorded. Generally, dieback and severe defoliation/discoloration occurred between 30 to 50 m from the landward edge of the mangrove stand with *C. tagal* most affected, and *A. marina* moderately affected. Moderate amounts of stagnant and ponding water were typically evident where dieback had occurred. No herbivory was observed adjacent to the mangrove dieback areas.

Table 2. Summary of observations for each monitoring quadrat in the 2019 and 2022 survey. *Light and dark grey shading denote moderate and severe mangrove attributes, respectively.*

Site	Leaf Defoliation		Leaf discoloration		Mangrove dieback	
	2019	2022	2019	2022	2019	2022
T8 – 0m	Slight	No	Slight	No	No	No
T8 – 50m	Moderate	Moderate	Slight	Moderate	Severe	Severe
T8 – 100m	No	Moderate	No	Moderate	No	Moderate
T9 – 0m	Slight	Slight	Slight	Slight	Moderate	Moderate
T9 – 50m	Moderate	Moderate	Slight	Moderate	Moderate	Moderate
T9 – 100m	Slight	Moderate	No	Slight	No	Moderate
T15 – 0m	Slight	Moderate	Slight	Moderate	Slight	Moderate
T15 – 50m	Slight	Severe	Moderate	Severe	Severe	Severe
T15 – 100m	Slight	Moderate	Slight	Moderate	No	Moderate
New transects	2022		2022		2022	
TA – 0m	Slight		Slight		No	
TA – 50m	Moderate		Moderate		Severe	
TA – 100m	Moderate		Slight		Moderate	
TB – 0m	No		Slight		No	
TB – 50m	Moderate		Moderate		Moderate	
TB – 100m	Moderate		Moderate		Moderate	
TC – 0m	Moderate		Moderate		Moderate	
TC – 50m	Moderate		Moderate		Severe	
TC – 100m	Moderate		Moderate		Severe	
TD – 0m	Slight		Slight		No	
TD – 50m	Slight		Slight		Slight	
TD – 100m	Moderate		Moderate		Moderate	

Ceriops sp. favor the landward edge of the mangrove habitat due to their low tolerance for tidal inundation. Areas of water pooling were recorded where the dieback occurred, however not where live mangroves existed, suggesting that continual saturation of the sediment may have resulted in root rot and eventual plant death. Other potential causes of the mangrove dieback may include altered water flow resulting from sediment erosion or deposition, sea level rise or fall, or changes in water or sediment quality potentially increasing the availability of contaminants (Duke et al. 2003a, Duke et al. 2003b, Duke et al. 2017).

Significant areas of dieback (>7,500 ha; > 2,000 km stretch of coastline), have been reported from 2015 to 2019 along the Gulf of Carpentaria in northern Australia (Harris et al. 2017, Duke

et al. 2020) and north-western Australia (Lovelock et al. 2017), linked to very strong El Niño events resulting in sea level changes and extreme drought conditions. Although some of the dieback patches adjacent to the LNG Plant appeared to occur concurrently with these extreme dieback events in northern Australia, no other extensive dieback was observed further north or south of the LNG Plant, suggesting that dieback areas were most likely not linked to the strong El Niño events as observed elsewhere.



Figure 13. Evidence of mangrove dieback around transects, with ponding and stagnant water present.

3.2 Comparison of 2019 and 2022 Mangrove Community Composition

Three transects (T8, T9 and T15) were surveyed in both 2019 and 2022, and therefore, temporal comparisons could be undertaken. No significant ($P > 0.05$) temporal differences in species richness, live adult tree density, LBA, canopy cover, seedling density or crab hole density were observed (Figure 14), indicating that mangrove communities within transect T8, T9 and T15 have not deteriorated further since 2019. Dieback did not appear to be recent within the transects, however dieback (as determined by weathering and decomposition of leaves and stems) appeared to be more recent adjacent to the newly established WQ areas, particularly around WQ13 and WQ19. No live seedlings were encountered in T8, T9 or T15 in 2019 or 2022, suggesting no new mangrove recruitment was evident within the dieback areas.

A total of 370 ha of mangrove forest was mapped in 2019, and 390 ha in 2022 (Figure 15), using 2018 GeoEye 50cm pixel imagery. Based on the 2019/2022 imagery and supported by the ground truthing, the dominant mangrove community was dense *Rhizophora/Bruguiera* forest, making up 49% and 33% of the total area respectively, followed by *Ceriops* shrubs (8 to 16%) and *Avicennia* sp. (~9%). Mudflats and saltpans made up approximately 33 to 36% of the total area, covering approximately ~130 to 140 ha (Table 3). Although dead mangroves were not quantified in 2019, approximately 23 ha (~6%) were mapped in 2022.

Table 3. Total mapped area classification in 2019, and 2022 using GeoEye imagery.

Note; Dead mangrove areas were not investigated during the 2019 mapping round. Some slight mapping errors in miss classification were also noted between 2019-2022.

Class	Area (ha)		% cover	
	2019	2022	2019	2022
<i>Ceriops</i> sp.	28.9	62.7	7.8	16.1
<i>Avicennia</i> sp.	32.9	35.3	8.9	9.0
<i>Rhizophora/Bruguiera</i> sp.	185.0	129.7	49.9	33.2
Dead mangrove areas	-	23.2	-	5.9
Mudflats – Saltpans	124.1	139.5	33.5	35.7
Total	370.9	390.4	100	

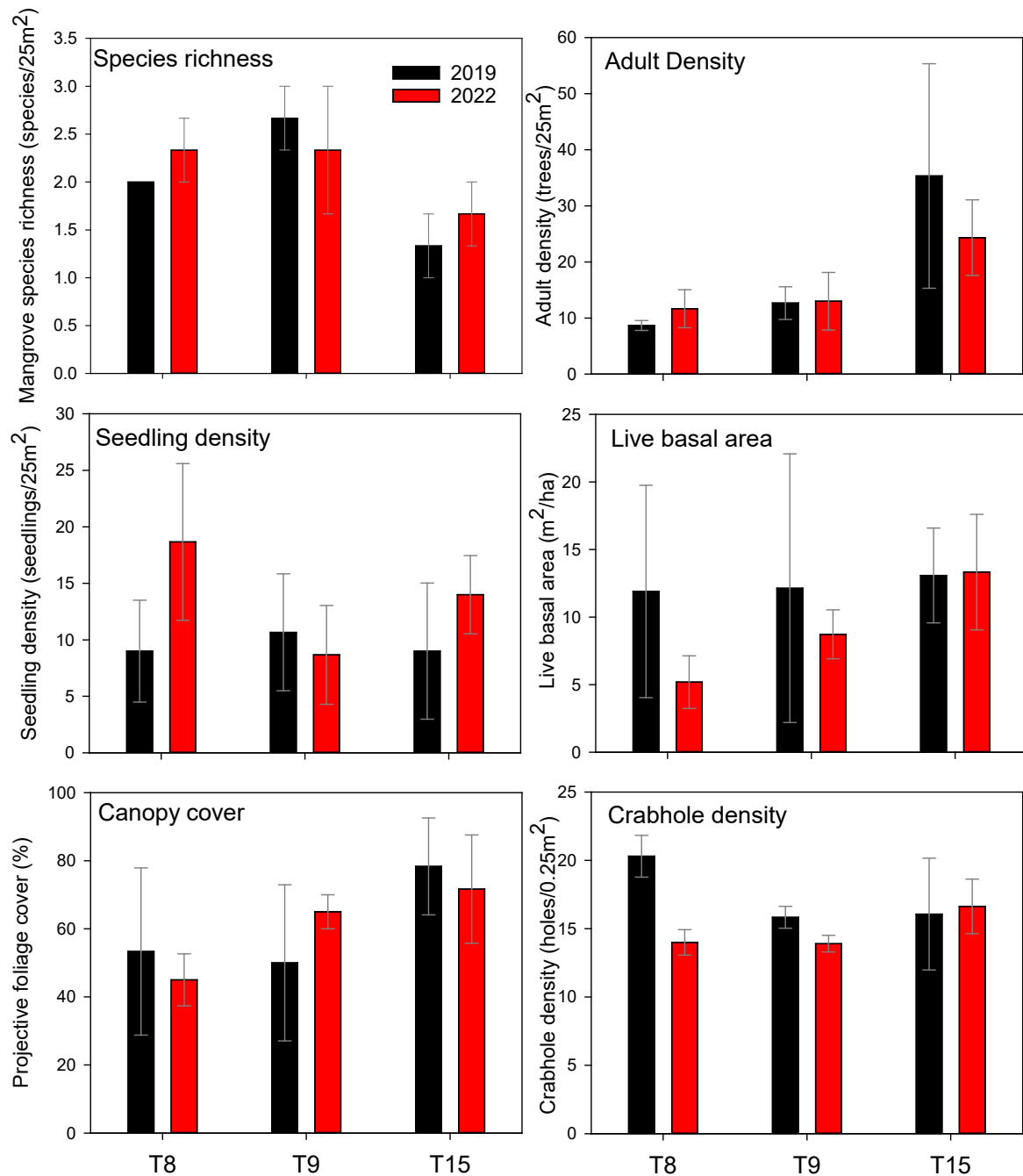


Figure 14. 2019 and 2022 mangrove species richness, adult and seedling density, LBA, canopy cover and crab hole density in transects. Values are means $\pm$ SE ($n = 3$).

The 2022 change analysis indicated that mangrove areas increased within the adjacent mixing pond discharge areas from 2010 to 2022 (Figure 16), primarily attributable to an increase in *A. marina* density, a species suited to frequent tidal inundation. This was most likely due to the construction of the retention and mixing ponds and resultant increase in water discharge or flow. However, the increase in flow from these areas is likely to have impacted mangrove forests (primarily *C. tagal*) further downstream, which prefer lower tidal inundation and frequency.

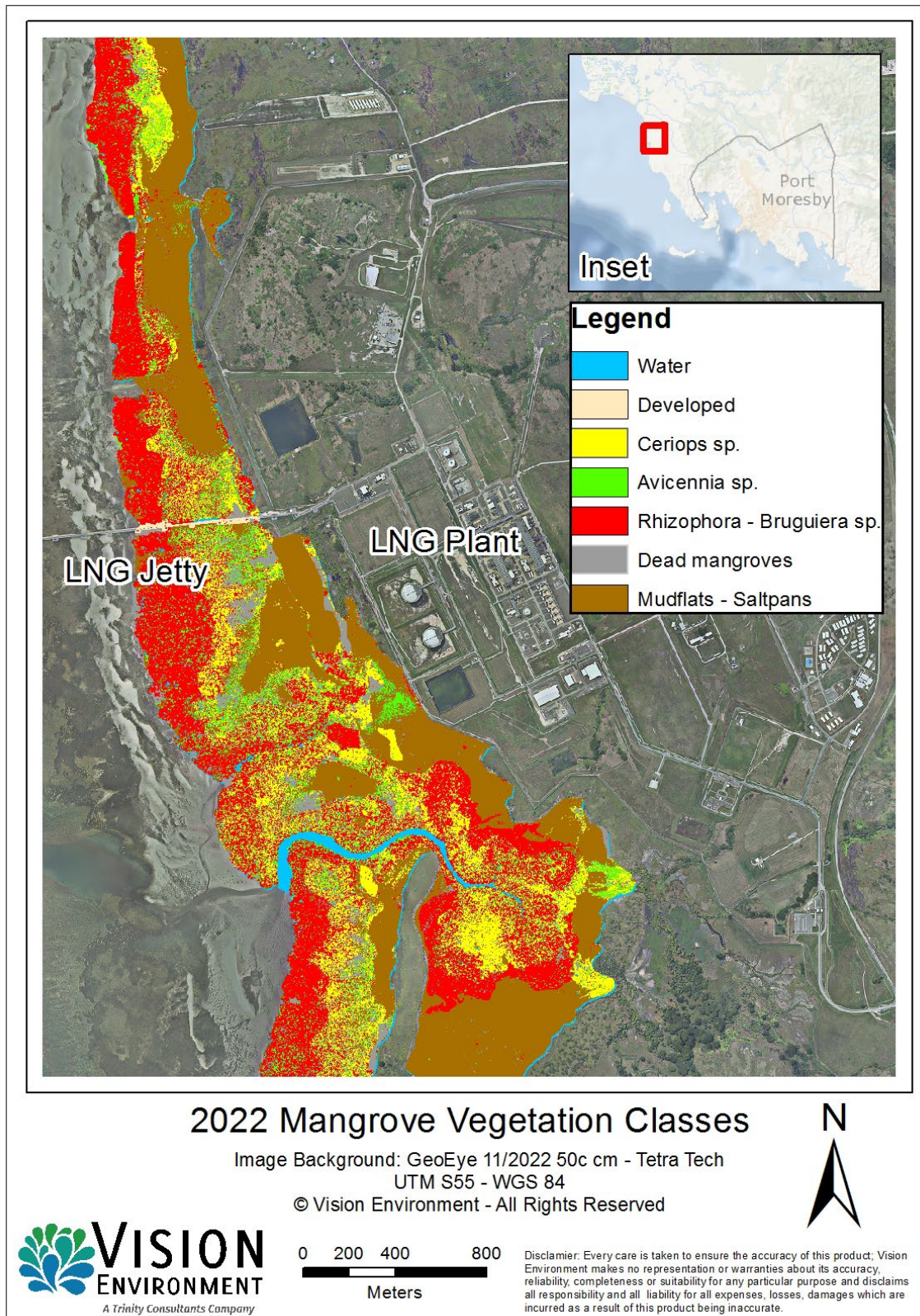


Figure 15. Map overview of classified mangrove areas near the LNG Plant in 2022, Caution Bay. Map projection WGS84 – UTM Zone 55S.

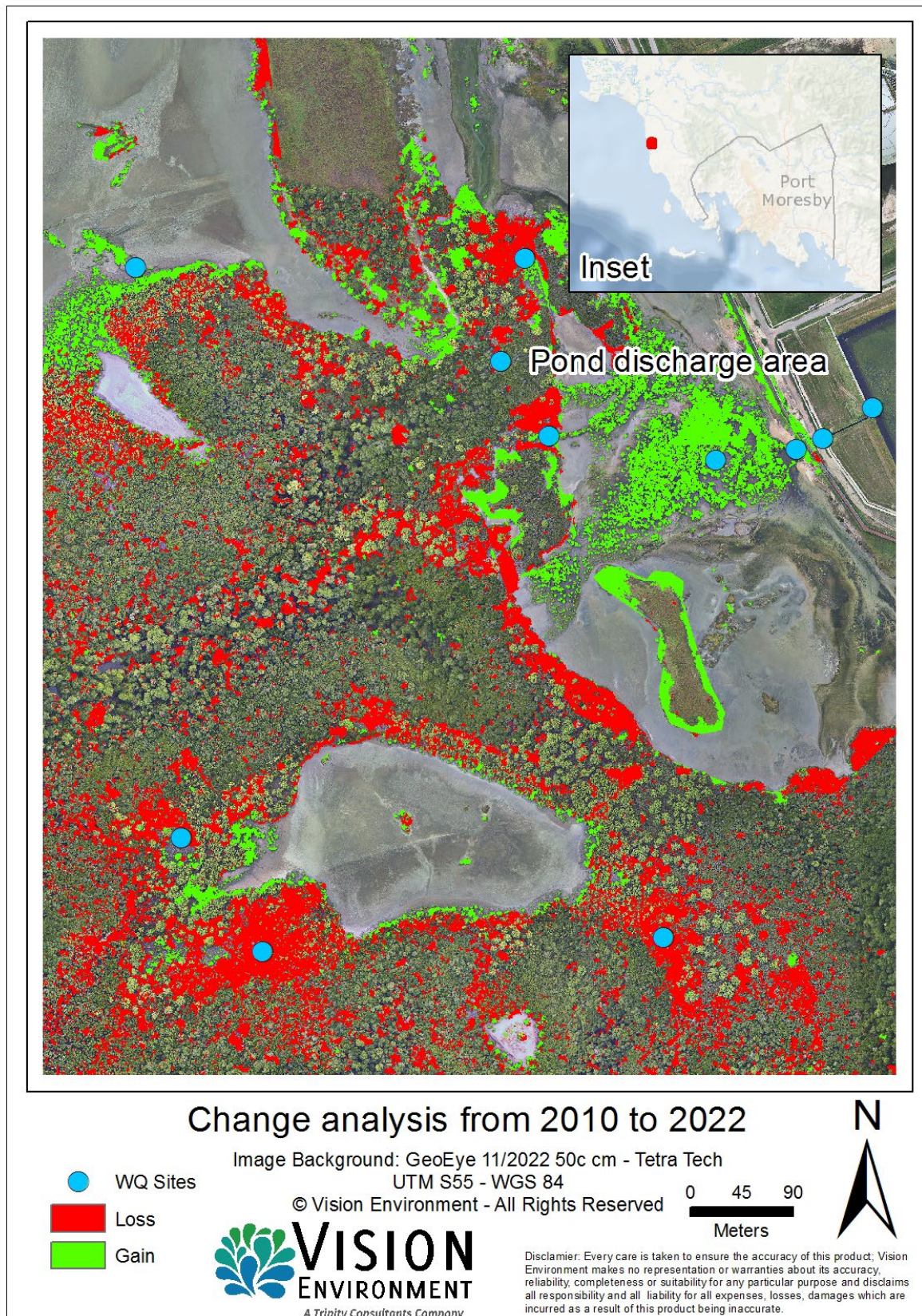


Figure 16. Change analysis from 2010 to 2022 of area adjacent to the retention and mixing pond discharges.

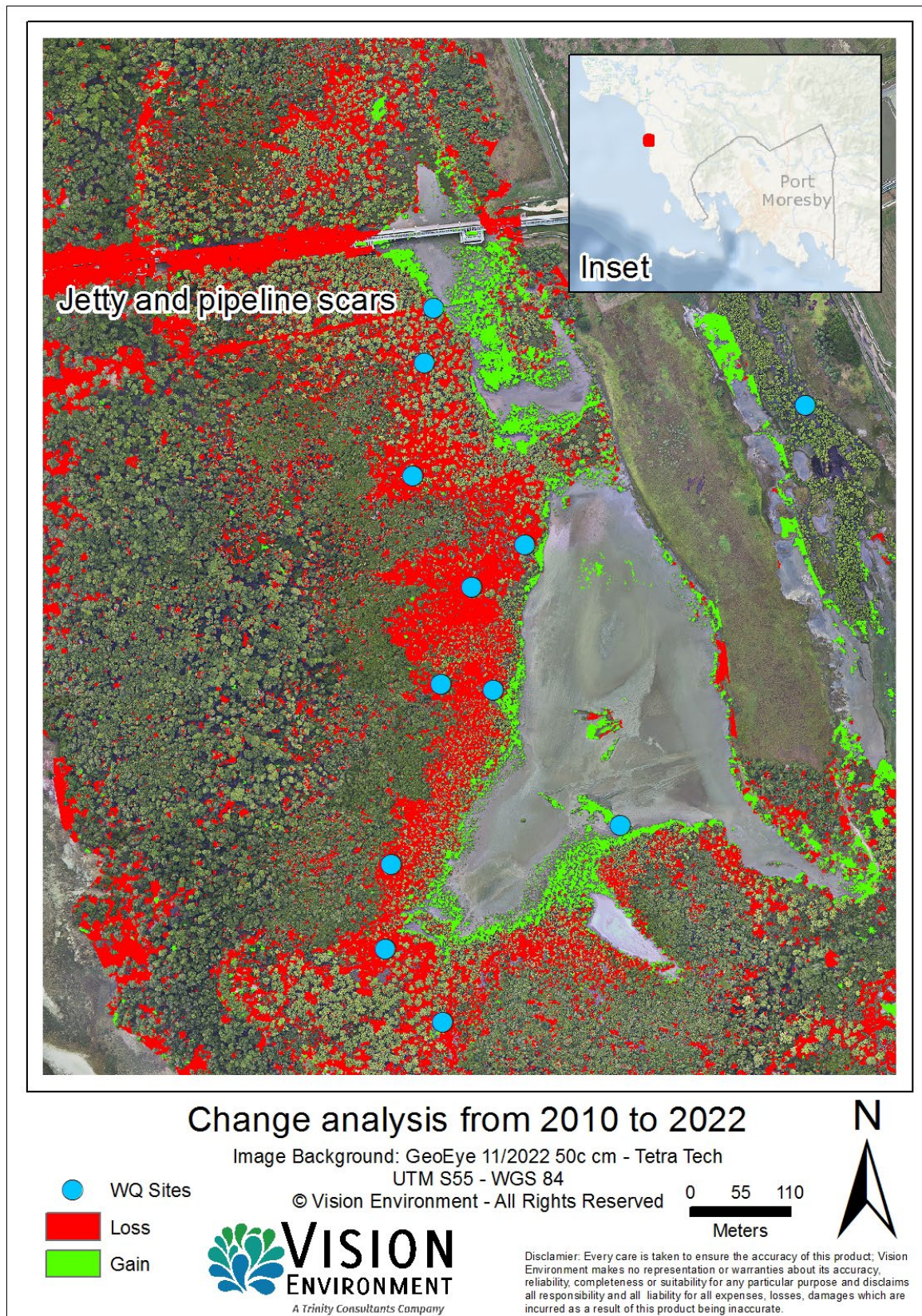


Figure 17. Change analysis from 2010 to 2022 of LNG Plant Jetty and PNG LNG pipeline mangrove removal areas.

Dieback to the south of the LNG Plant Jetty and pipeline mangrove removal scars was also observed from 2010 to 2022 (Figure 17). It is unknown if the increase in water ponding and pooling in these areas is attributable to the flow increase from the mixing/retention ponds, or attributable to a change in tidal volume and flow because of mangrove removal during the LNG Plant Jetty and PNG LNG pipeline construction, which has altered the hydrodynamics of the area, although the latter is the most likely scenario.

Of note is the gain in mangrove density (predominantly *A. marina*) observed adjacent to the dieback areas. From 2010 to 2022, 11.6% of the total leased area exhibited mangrove loss, 3.9% exhibited mangrove gain and 84.6% exhibited no net change in mangrove structure (Figures 16 & 17). Changes in coastal water flows can have both negative and positive impacts on mangrove ecosystems.

3.3 Water Quality

Water quality results were generally within normal ranges typically encountered within tropical mangrove ecosystems (Figures 18 to 20, Table A2 and Figures A1 to A3 in Appendix). Fresh to brackish water (salinity of 1.3 ppt) was recorded in a creek parallel to the plant (WQ16), most likely from storm water runoff. Site WQ8, close to mangrove dieback areas, also exhibited brackish water (salinity of 12.7 ppt), suggesting possible freshwater intrusion from the LNG Plant or groundwater sources.



Figure 18. Site WQ16 containing freshwater, most likely attributable to storm water runoff.

Most other areas of dieback exhibited similar salinity ranges (50 to 60 ppt) as the retention and mixing ponds. This level of salinity was within typical ranges of mangrove habitat at the time of sampling, and therefore it is unknown whether discharge from the ponds is contributing to mangrove dieback from water quality analysis alone.

Some areas of the mangrove habitat may exhibit low drainage ability, and therefore may be more susceptible to flooding (Duke et al. 2003a, Duke et al. 2010, Lagomasino et al. 2021). Flatter mangrove areas have the ability to drain excess water during storm conditions, king

tides or runoff from further upstream of the mangrove stands (Lagomasino et al. 2021). Sinking centers have been observed in parts of northern Australia (Duke et al. 2003a, Duke et al. 2010), with major mangrove dieback occurring from the formation of anoxic pools of water as sediment subsided in tidal wetlands. Similar conditions were observed along the dieback areas adjacent to the LNG Plant during the low tide (Figure 19). However, stagnant water pools typically display low dissolved oxygen and high salinity, which was not observed in these pools, suggesting potential frequent recharge of seawater from an alternate source.



Figure 19. Site WQ8 with brackish water and associated mangrove dieback. Image shows evidence of sink centres.

3.4 Substrate Elevation

The 2022 LiDAR information indicated that there were statistically significant ($P < 0.01$) differences in elevation between mudflat areas, dieback areas and adjacent healthy mangrove areas. The dieback areas exhibited a mean ground elevation of 0.87 ± 0.01 m. Areas directly adjacent to dieback areas, hosting the same mangrove species, exhibited a mean elevation of 0.98 ± 0.01 m. Mudflat areas were exhibited a mean elevation of 1.1 ± 0.02 m. A depth difference of 100 mm was present in all dieback areas compared to their adjacent healthy mangrove communities, suggesting some form of sinking or erosion within dieback areas.

Given that only ~100 mm exists between live healthy mangrove areas and mudflats, this depth difference may be crucial in sustaining healthy mangrove communities with optimum tidal inundation/frequency. Any subtle changes in sediment depth may be significantly altering mangrove communities. Figures 21 and 22 show digital/surface elevation models of bare ground and canopy cover, respectively.

Another likely scenario is that the constant water discharge from the retention and mixing ponds into the low drainage areas of the mangrove habitats does not permit sufficient drying time for the mangroves, resulting in plant stress and ultimately death.

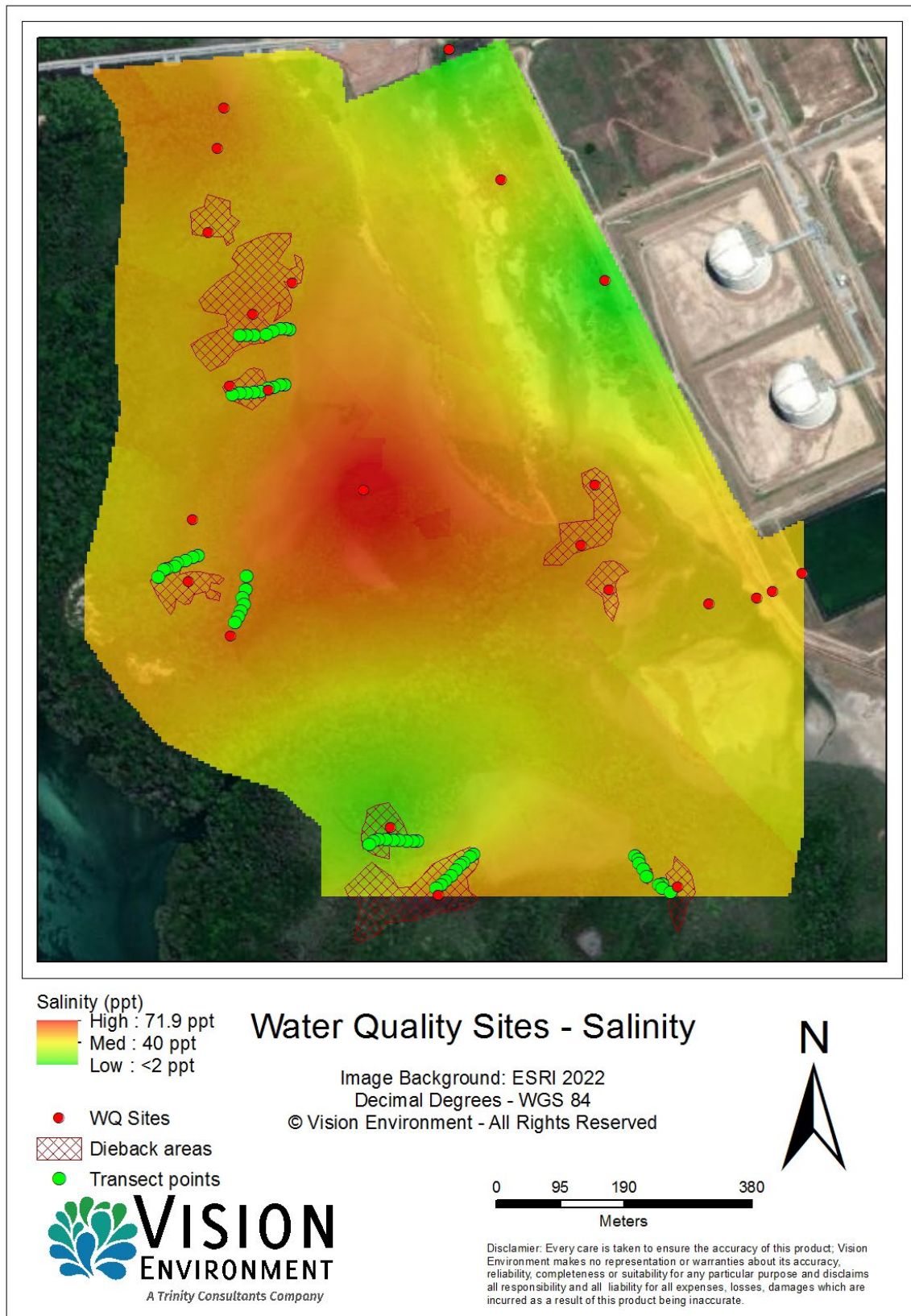


Figure 20. Surface interpolation of water salinity gradients across the 25 water quality monitoring sites in 2022.

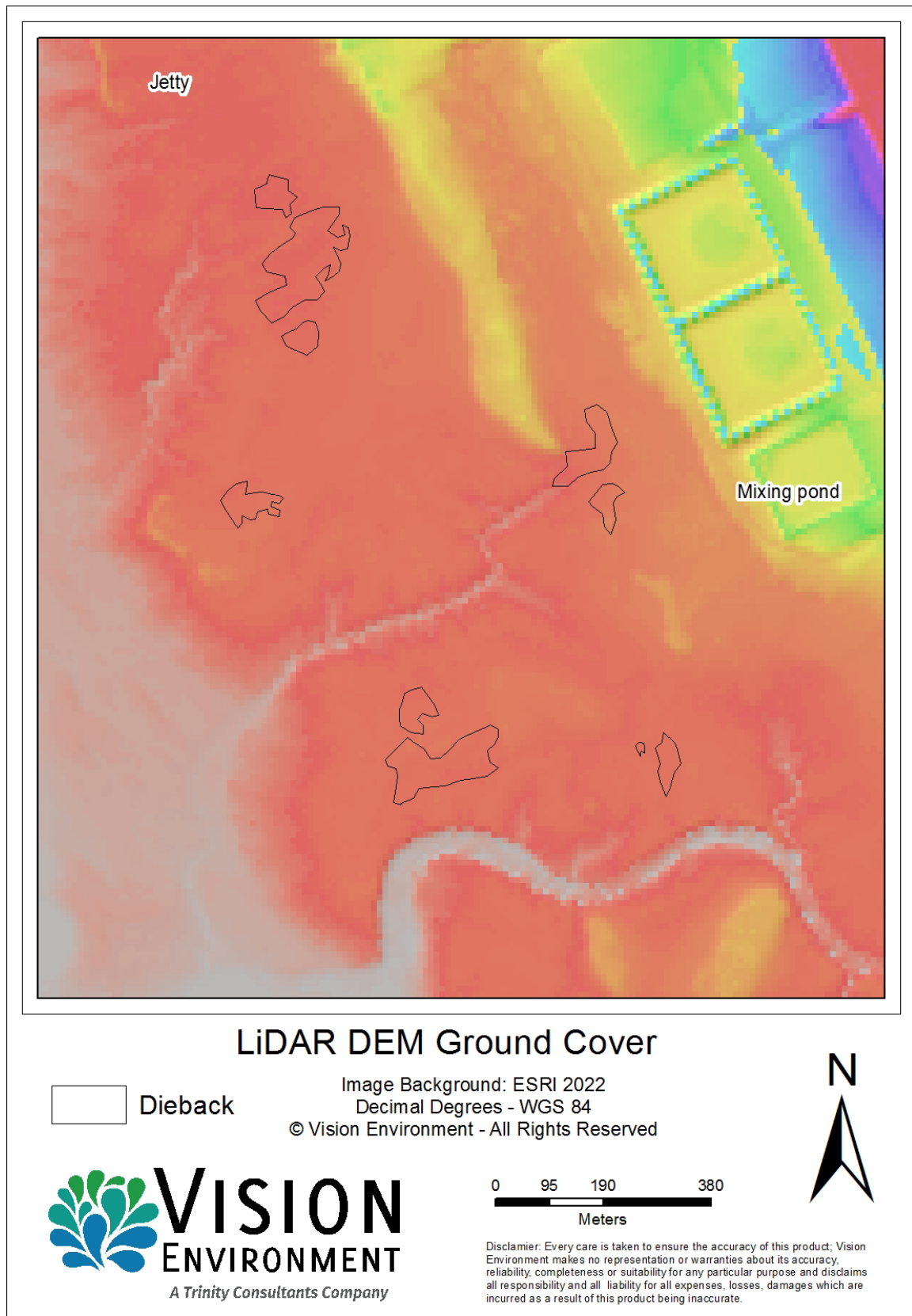


Figure 21. Ground Digital Elevation Model (DEM) of LiDAR data collected in 2022. Data source point cloud sourced by Tetra Tech. Colours represent elevation (m) from water level, excluding vegetation.

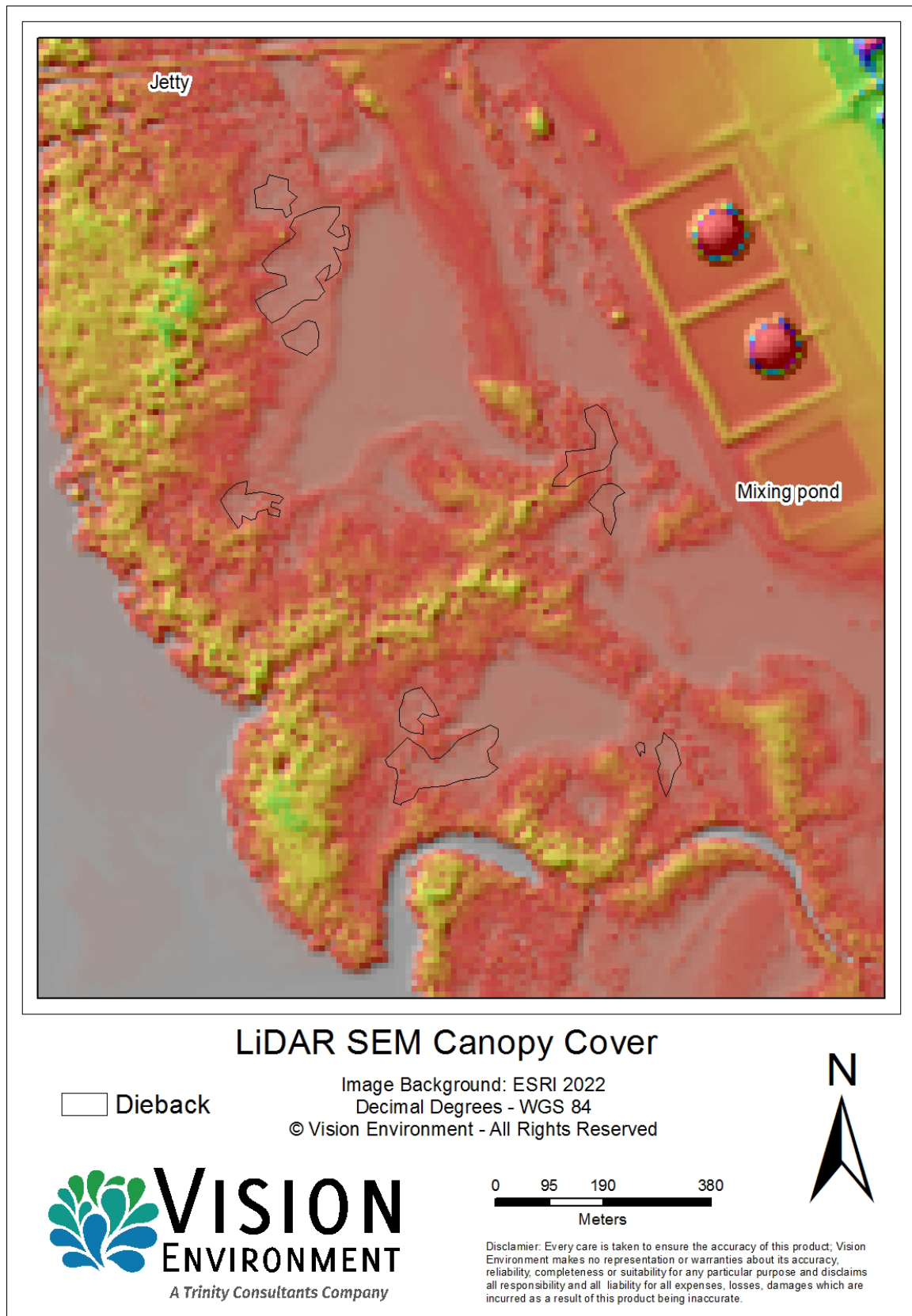


Figure 22. Canopy Surface Elevation Model (SEM) of LiDAR data collected in 2022.
Data source point cloud sourced by Tetra Tech. Colours represent elevation (m) from water level.



Figure 23. Downstream flow of water at site WQ19 during the flooding tide.

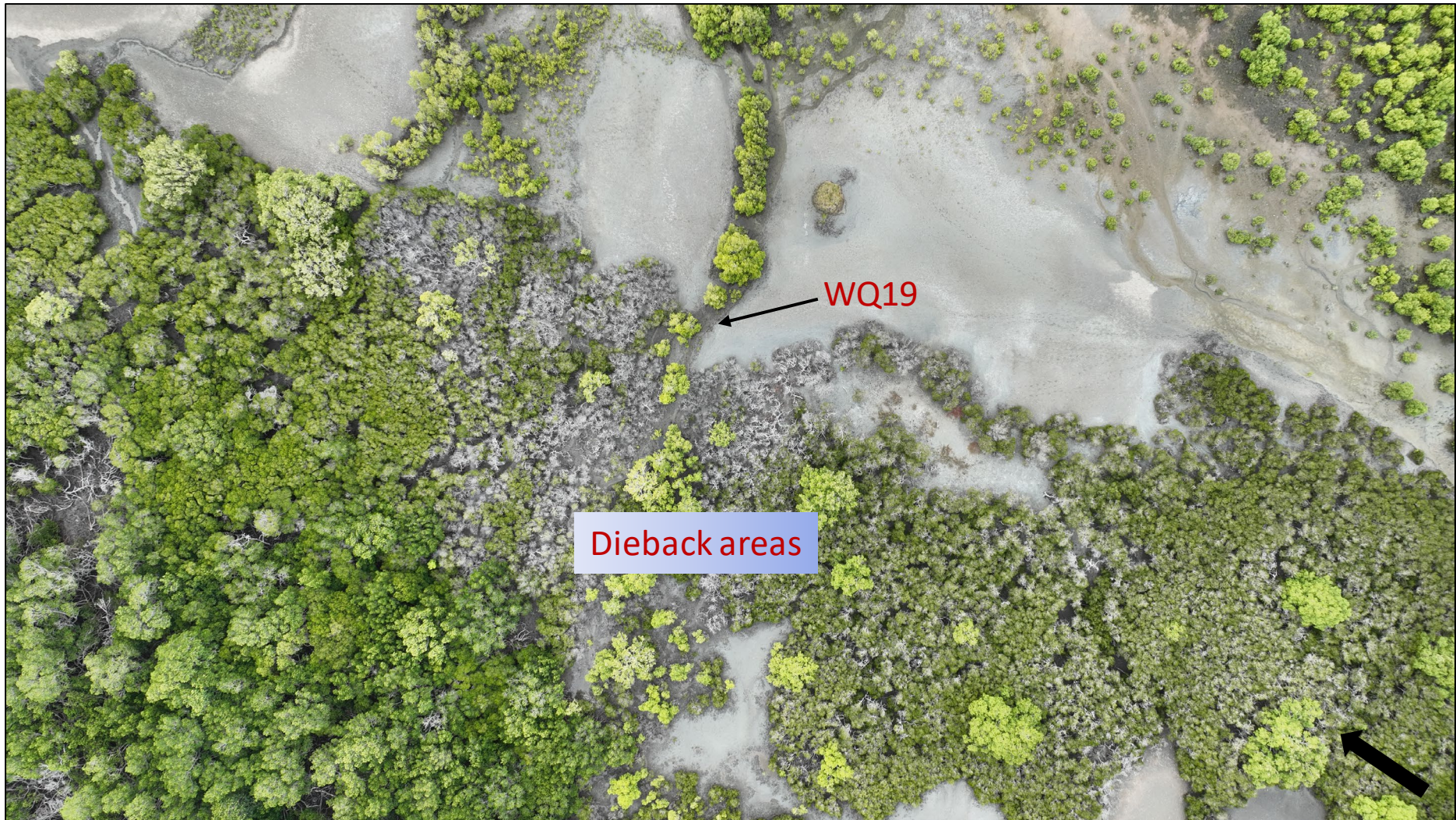


Figure 24. Aerial drone image of site WQ19 where continuous downstream water discharge was observed adjacent to new dieback areas. Black arrow denotes North direction.

Water was observed to be running downstream into the adjacent dieback areas close to WQ13 and WQ19 during the flooding (incoming) tide (Figures 23 and 24), which suggests that the ponded water was most likely from the discharge as opposed to tidal water.

3.5 Water Tracer Assessment

Concentrations over 1 ppm of Rhodamine were observed directly after the release of the WT dye at Release Point 1, was directly adjacent to the mixing pond discharge culverts (Figure 25). Ten minutes after release, most of the WT tracked towards a westerly direction along the dense *A. marina* forest (Figure 26). However, some of the dye did make its way towards the northern and southern creek arms of the primary pool of water, directly adjacent to the mixing pond culverts.



Figure 25. Rhodamine WT travelling to a dieback area from Release Point I (Mixing ponds).

A second release point (Release Point 2) was established south of the main pool area (Figure 27), and was tracked towards another patch of dieback, heading towards WQ10. Due to time and weather constraints, no further release points were established, however water discharge was observed to be making its way towards the northern creek arms of the main pool of water directly adjacent to the mixing pond culverts. This water discharge appeared to be tracking towards the dieback areas closest to WQ13 & WQ19.

Both WT releases were tracked directly into two different dieback regions (Figures 26 and 27), which further supports the evidence that continual discharge water from the mixing pond is potentially impacting downstream mangrove habitats.

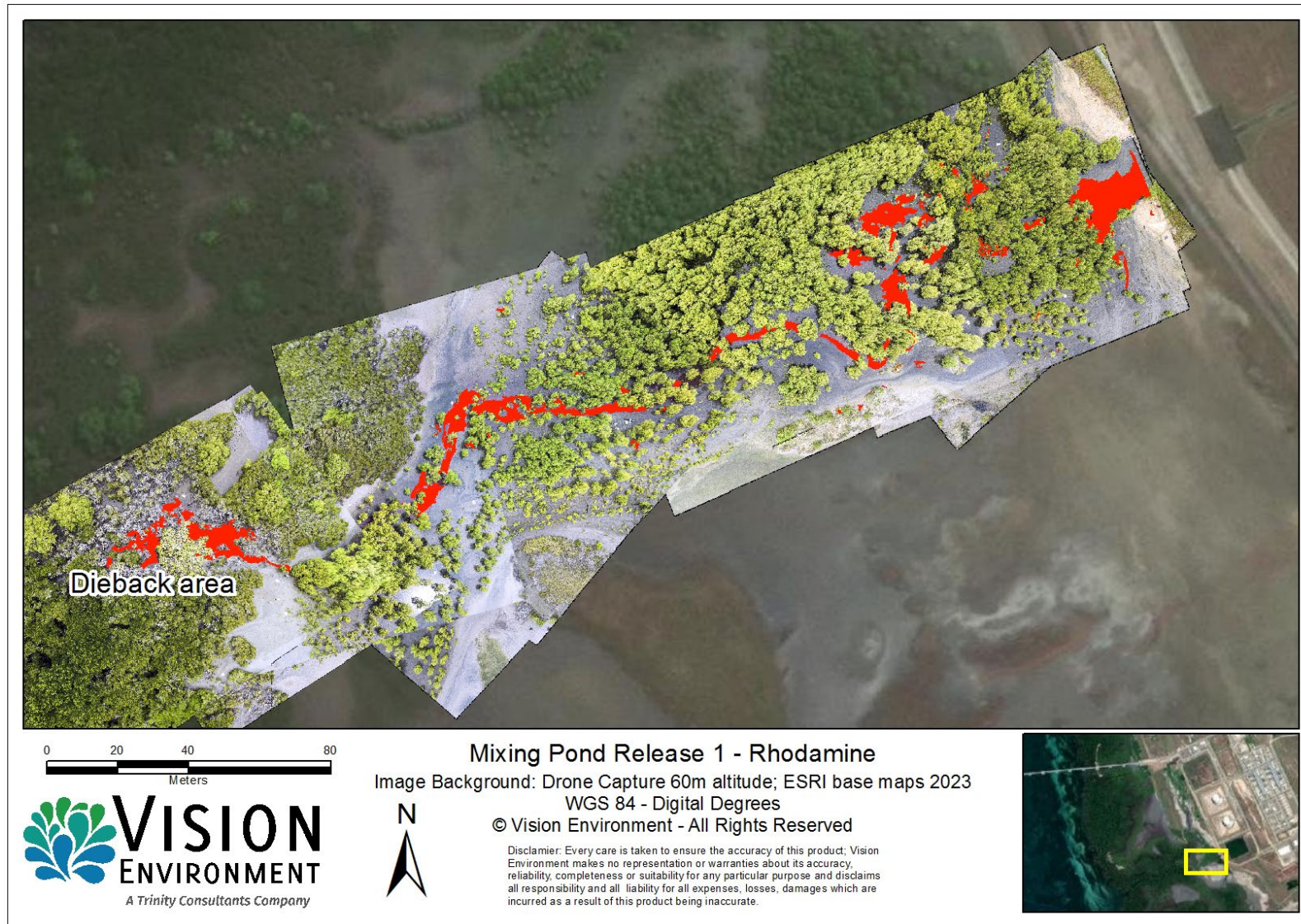


Figure 26. WT travelling from Release Point 1 towards dieback area near WQ19.

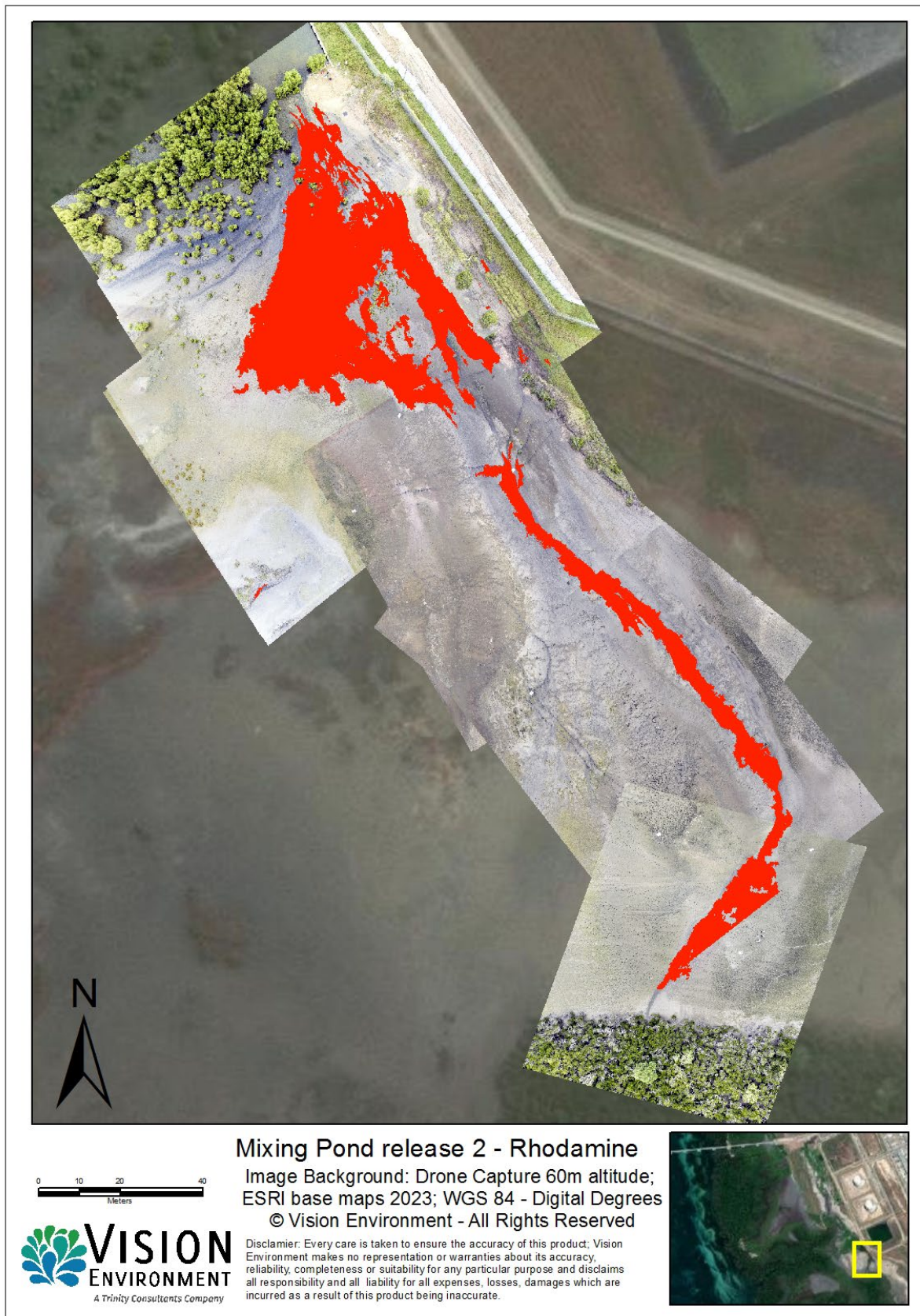


Figure 27. WT traveling from Release Point 2 towards dieback area near WQ10

Further WT surveys would be required in order to determine potential causes of the dieback areas south of the Jetty. It is suggested that Rhodamine WT be released towards the end of the pipeline mangrove scar to see if water from the flooding tide is travelling in a southerly direction along the dieback areas.

No leaf disease or fungus, or herbivorous attack of the mangroves adjacent to the dieback areas were observed, and as such is unlikely to be the cause of mangrove dieback. While not tested during the 2022/2023 surveys, water and sediment chemistry and/or contamination is not thought to be causing the mangrove dieback, based on previous contaminant investigations (raw data provided by the Project). Additionally, mangrove dieback would be more consistent and extensive, as opposed to patchy, if contamination was the issue.

4. CONCLUSIONS AND RECOMMENDATIONS

All seven transects monitored in 2022 exhibited some form of dieback, primarily towards the landward edge of the mangrove habitat. The yellow mangrove, *C. tagal*, appeared most affected by the dieback, followed by the grey mangrove, *A. marina*. Notable pooling and ponding of water were encountered around the dieback areas with sediment sinking also observed.

The investigation of water quality in ponded areas adjacent to the dieback areas suggested the introduction of freshwater in some areas, indicating possible freshwater intrusion via groundwater or surface water. Constant downstream water flow was also observed in some areas, even during tidal flooding, suggesting the water most likely came from mixing/retention pond discharges.

It is hypothesised that mangrove dieback in certain areas is likely due to the pooling of water contributed by the retention and mixing ponds, in low lying sediment areas, leading to mangrove root rot and ultimately plant death. In mangroves areas adjacent to the LNG Plant Jetty and PNG LNG pipeline area, changes in tidal flow may have caused the areas of dieback.

The results from the water tracer study indicated that discharge water from the retention and mixing ponds is pooling in the low-lying dieback areas, potentially resulting in mangrove dieback. Further tracer studies are recommended south of the LNG Plant Jetty to determine if changes in hydrology may be responsible for dieback areas south of the Jetty.

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6. APPENDIX

Table A1. Mangrove stand parameters recorded in August 2022

*Values are means $\pm$ SE (n = 3). * Denotes calculations were based on adult trees only.*

Transect	Species Richness (species/25 m ²)	Dead Adult Density (trees/25 m ²)	Live Adult Density (Trees/25 m ²)	Seedling Density (seedlings/25 m ²)	*Stand Live Basal Area (m ² /ha)	Canopy cover (%)	Crab hole Density (holes/0.25 m ²)
TA	2.3 $\pm$ 0.3	14 $\pm$ 9	19 $\pm$ 7	6.0 $\pm$ 3.5	7.1 $\pm$ 2.4	50 $\pm$ 13	14 $\pm$ 2
TB	2.7 $\pm$ 0.3	7.7 $\pm$ 4.1	8.0 $\pm$ 3.1	10 $\pm$ 4	17 $\pm$ 7	57 $\pm$ 2	16 $\pm$ 3
TC	1.3 $\pm$ 0.3	26 $\pm$ 13	14 $\pm$ 7	6.0 $\pm$ 4.2	7.5 $\pm$ 4.4	42 $\pm$ 13	13 $\pm$ 1
TD	1.7 $\pm$ 0.3	11 $\pm$ 11	10 $\pm$ 2	6.0 $\pm$ 3.8	4.6 $\pm$ 1.7	48 $\pm$ 7	14 $\pm$ 2
T8	2.3 $\pm$ 0.3	6.7 $\pm$ 6.2	12 $\pm$ 3	19 $\pm$ 7	5.2 $\pm$ 1.9	45 $\pm$ 8	14 $\pm$ 1
T9	2.3 $\pm$ 0.7	11 $\pm$ 9	13 $\pm$ 5	8.7 $\pm$ 4.4	8.7 $\pm$ 1.8	65 $\pm$ 5	14 $\pm$ 1
T15	1.7 $\pm$ 0.3	28 $\pm$ 8	24 $\pm$ 7	14 $\pm$ 4	13 $\pm$ 4	72 $\pm$ 16	17 $\pm$ 2

Table A2. Water quality parameters recorded in August 2022
Values are means $\pm$ SE (n = 3).

Date/Time	Site	Salinity (ppt)	Conductivity (mS/cm)	Turbidity (NTU)	pH	Dissolved Oxygen (% Sat)	Temperature (°C)
23/08/2022 12:16	WQ1	53.3 $\pm$ 0.1	77.5 $\pm$ 0.2	25 $\pm$ 2	8.2 $\pm$ 0.0	305 $\pm$ 1	37.2 $\pm$ 0.2
23/08/2022 12:38	WQ2	43.0 $\pm$ 0.0	64.1 $\pm$ 0.0	47 $\pm$ 3	7.4 $\pm$ 0.0	60 $\pm$ 1	34.9 $\pm$ 0.0
23/08/2022 14:01	WQ3	51.5 $\pm$ 0.0	75.1 $\pm$ 0.0	36 $\pm$ 3	7.7 $\pm$ 0.0	130 $\pm$ 1	36.3 $\pm$ 0.0
23/08/2022 14:53	WQ4	49.0 $\pm$ 0.1	71.8 $\pm$ 0.1	40 $\pm$ 6	7.7 $\pm$ 0.0	104 $\pm$ 0	34.2 $\pm$ 0.1
24/08/2022 9:43	WQ5	46.8 $\pm$ 0.0	68.8 $\pm$ 0.0	26 $\pm$ 1	7.3 $\pm$ 0.0	25 $\pm$ 2	29.6 $\pm$ 0.0
24/08/2022 10:56	WQ7	46.0 $\pm$ 0.1	67.8 $\pm$ 0.1	34 $\pm$ 3	7.5 $\pm$ 0.0	73 $\pm$ 2	31.4 $\pm$ 0.1
24/08/2022 14:53	WQ8	54.1 $\pm$ 0.0	78.0 $\pm$ 0.1	47 $\pm$ 19	7.6 $\pm$ 0.0	91 $\pm$ 0	29.9 $\pm$ 0.0
24/08/2022 15:45	WQ9	11.4 $\pm$ 0.1	19.3 $\pm$ 0.1	24 $\pm$ 0	8.0 $\pm$ 0.0	19 $\pm$ 4	31.4 $\pm$ 0.0
25/08/2022 9:58	WQ10	51.9 $\pm$ 0.2	75.2 $\pm$ 0.2	13 $\pm$ 0	7.3 $\pm$ 0.0	83 $\pm$ 2	31.0 $\pm$ 0.0
24/08/2022 8:36	WQ11	43.1 $\pm$ 0.0	63.9 $\pm$ 0.0	34 $\pm$ 6	8.1 $\pm$ 0.0	41 $\pm$ 3	28.2 $\pm$ 0.0
23/08/2022 10:21	WQ12	43.5 $\pm$ 0.0	64.5 $\pm$ 0.0	2.7 $\pm$ 0.7	8.8 $\pm$ 0.0	107 $\pm$ 0	28.0 $\pm$ 0.0
24/08/2022 8:27	WQ12	43.6 $\pm$ 0.0	64.5 $\pm$ 0.0	4.4 $\pm$ 0.4	8.6 $\pm$ 0.0	76 $\pm$ 1	27.5 $\pm$ 0.0
24/08/2022 8:57	WQ13	50.2 $\pm$ 0.0	73.0 $\pm$ 0.0	93 $\pm$ 6	7.4 $\pm$ 0.0	42 $\pm$ 1	28.2 $\pm$ 0.0
23/08/2022 16:04	WQ14	2.5 $\pm$ 0.1	4.6 $\pm$ 0.0	55 $\pm$ 5	8.5 $\pm$ 0.0	113 $\pm$ 2	30.3 $\pm$ 0.0
23/08/2022 15:54	WQ15	43.2 $\pm$ 0.0	64.2 $\pm$ 0.0	7.2 $\pm$ 0.2	8.1 $\pm$ 0.0	171 $\pm$ 1	32.1 $\pm$ 0.0
23/08/2022 15:39	WQ16	1.3 $\pm$ 0.0	2.6 $\pm$ 0.0	4.0 $\pm$ 0.1	8.0 $\pm$ 0.0	21 $\pm$ 9	28.3 $\pm$ 0.0
23/08/2022 12:27	WQ17	51.5 $\pm$ 0.1	75.4 $\pm$ 0.1	79 $\pm$ 13	7.7 $\pm$ 0.0	79 $\pm$ 2	38.9 $\pm$ 0.1
23/08/2022 15:16	WQ18	46.2 $\pm$ 0.0	68.4 $\pm$ 0.0	47 $\pm$ 1	7.6 $\pm$ 0.0	97 $\pm$ 0	35.2 $\pm$ 0.1
24/08/2022 9:04	WQ19	49.0 $\pm$ 0.1	71.5 $\pm$ 0.1	35 $\pm$ 21	7.9 $\pm$ 0.0	153 $\pm$ 9	29.0 $\pm$ 0.0
24/08/2022 9:16	WQ20	49.1 $\pm$ 0.2	71.6 $\pm$ 0.3	12 $\pm$ 3	8.1 $\pm$ 0.0	107 $\pm$ 7	29.5 $\pm$ 0.1
24/08/2022 9:31	WQ21	72.1 $\pm$ 0.1	99.6 $\pm$ 0.1	3.6 $\pm$ 0.0	7.3 $\pm$ 0.0	16 $\pm$ 0	31.0 $\pm$ 0.0
24/08/2022 12:09	WQ22	46.5 $\pm$ 0.1	68.4 $\pm$ 0.1	85 $\pm$ 2	7.5 $\pm$ 0.0	56 $\pm$ 4	30.7 $\pm$ 0.1
23/08/2022 10:15	WQ23	43.5 $\pm$ 0.0	64.4 $\pm$ 0.0	1.6 $\pm$ 0.4	8.9 $\pm$ 0.0	145 $\pm$ 3	28.8 $\pm$ 0.0
23/08/2022 10:08	WQ24	43.0 $\pm$ 0.1	63.8 $\pm$ 0.1	1.4 $\pm$ 0.1	8.9 $\pm$ 0.0	109 $\pm$ 0	28.1 $\pm$ 0.0
25/08/2022 10:48	WQ25	50.1 $\pm$ 0.2	73.2 $\pm$ 0.2	114 $\pm$ 2	7.2 $\pm$ 0.0	30 $\pm$ 2	33.1 $\pm$ 0.0

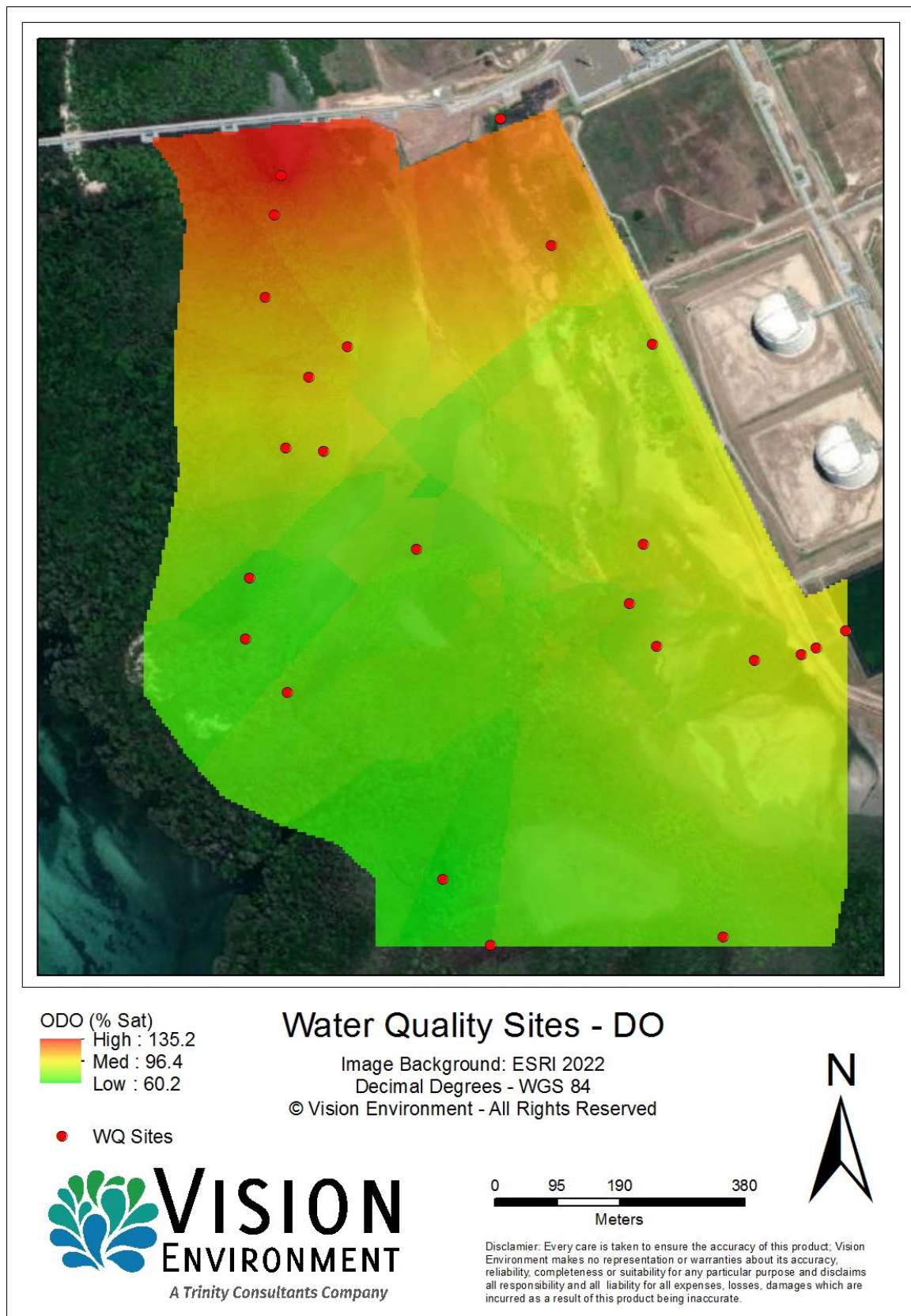


Figure A1. Surface interpolation of dissolved oxygen across water quality sites.

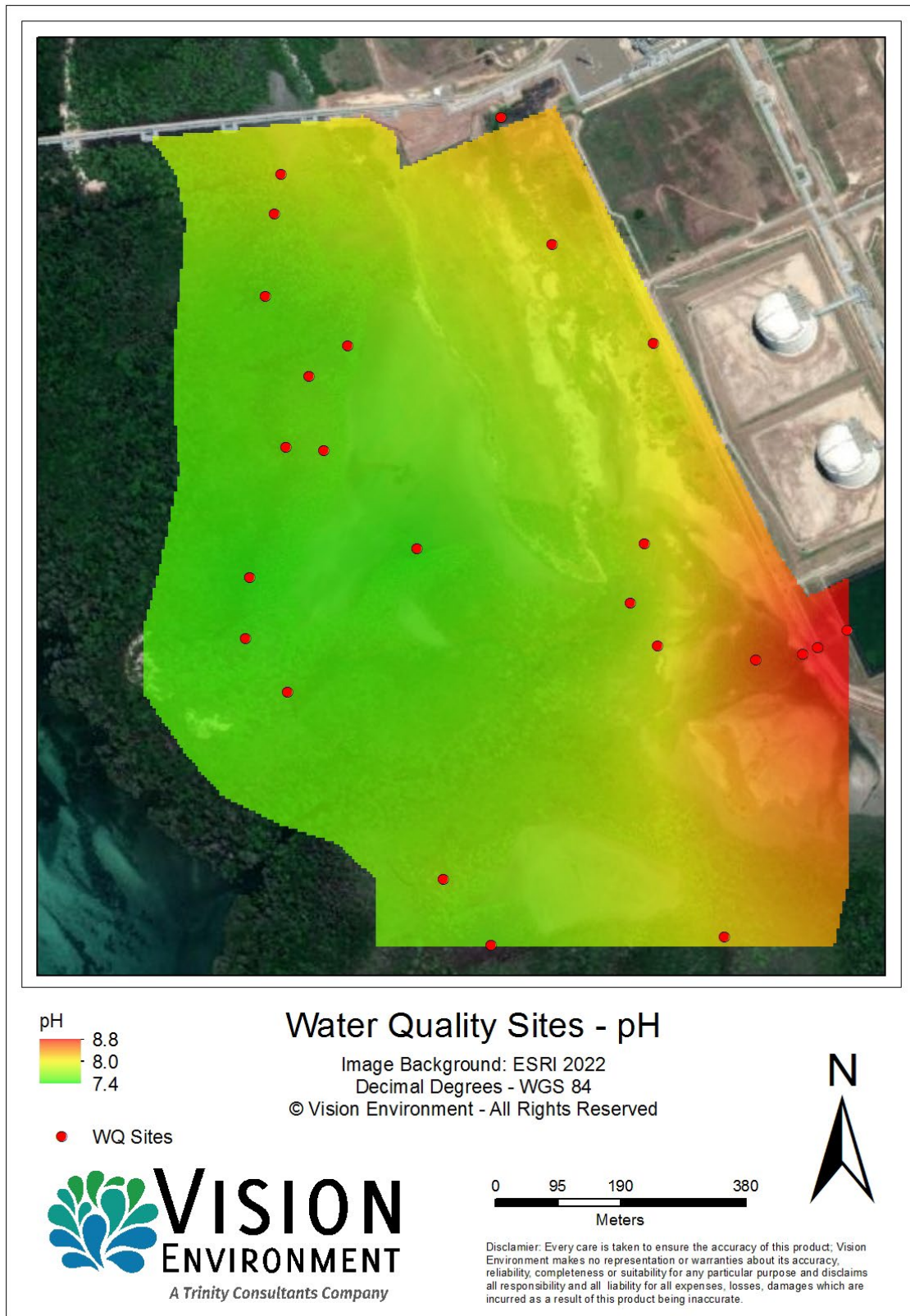


Figure A2. Surface interpolation of pH across water quality sites.

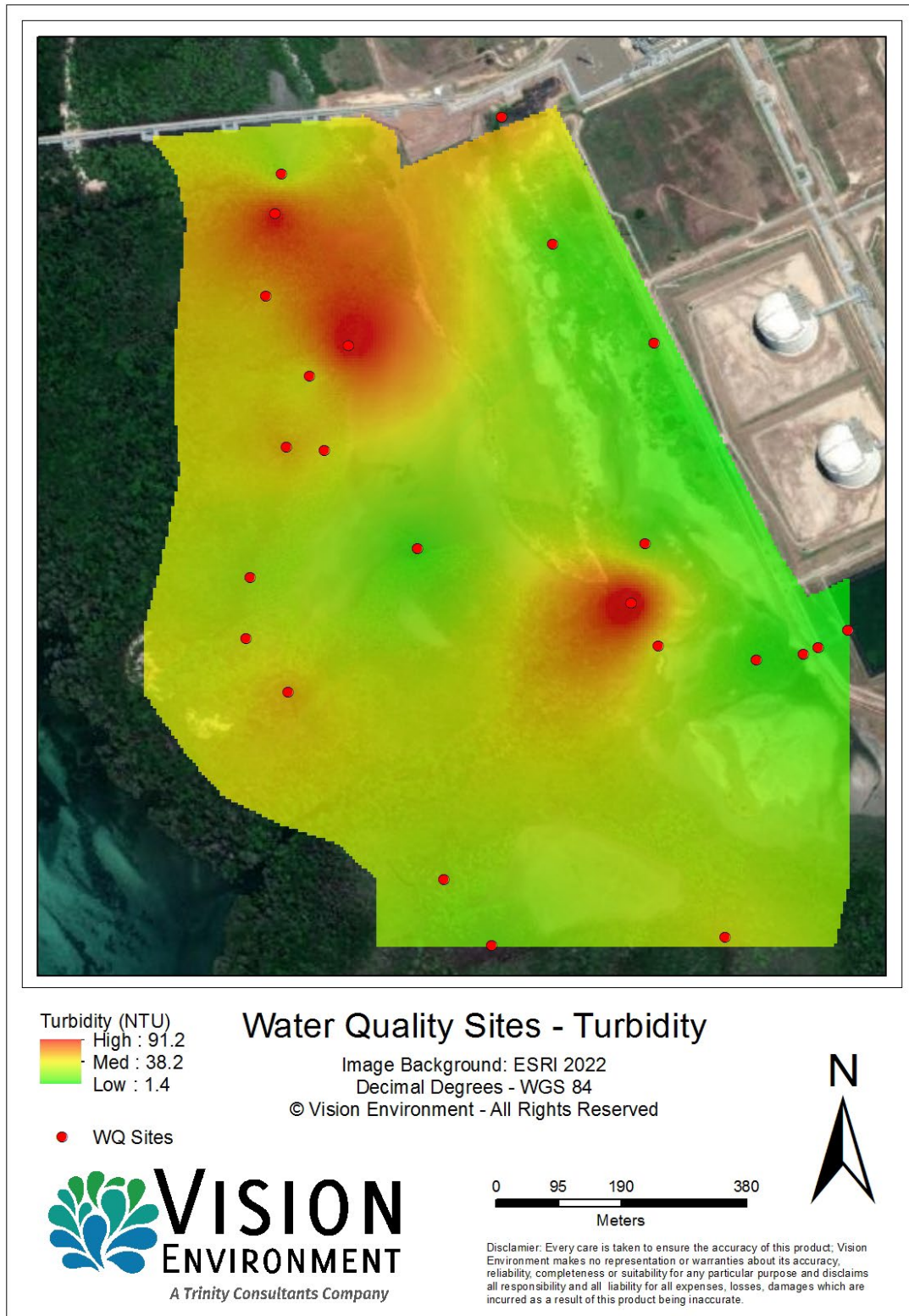


Figure A3. Surface interpolation of turbidity across water quality sites.

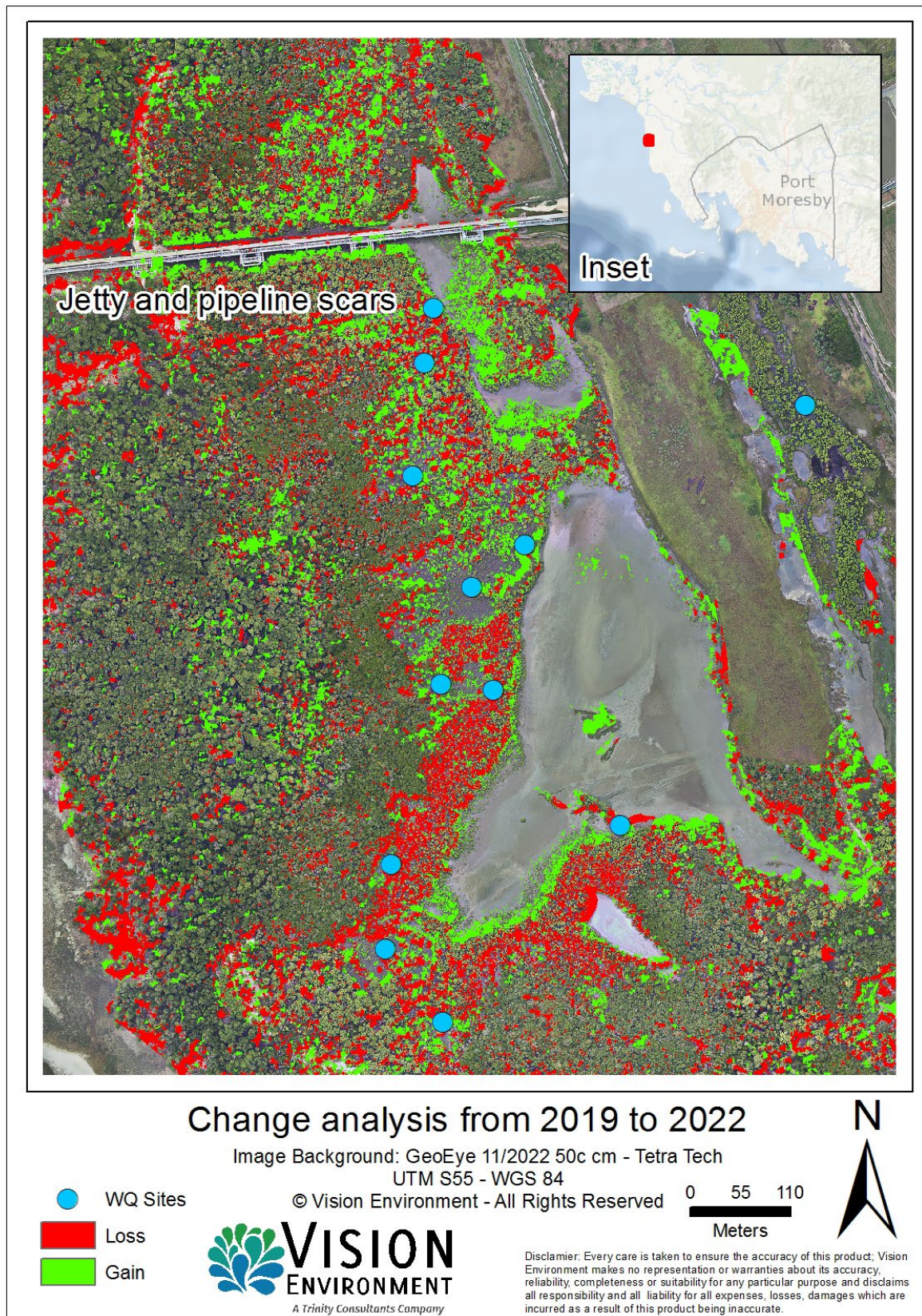


Figure A4. Change analysis from 2019 to 2022 of LNG Plant Jetty and PNG LNG pipeline mangrove removal areas.

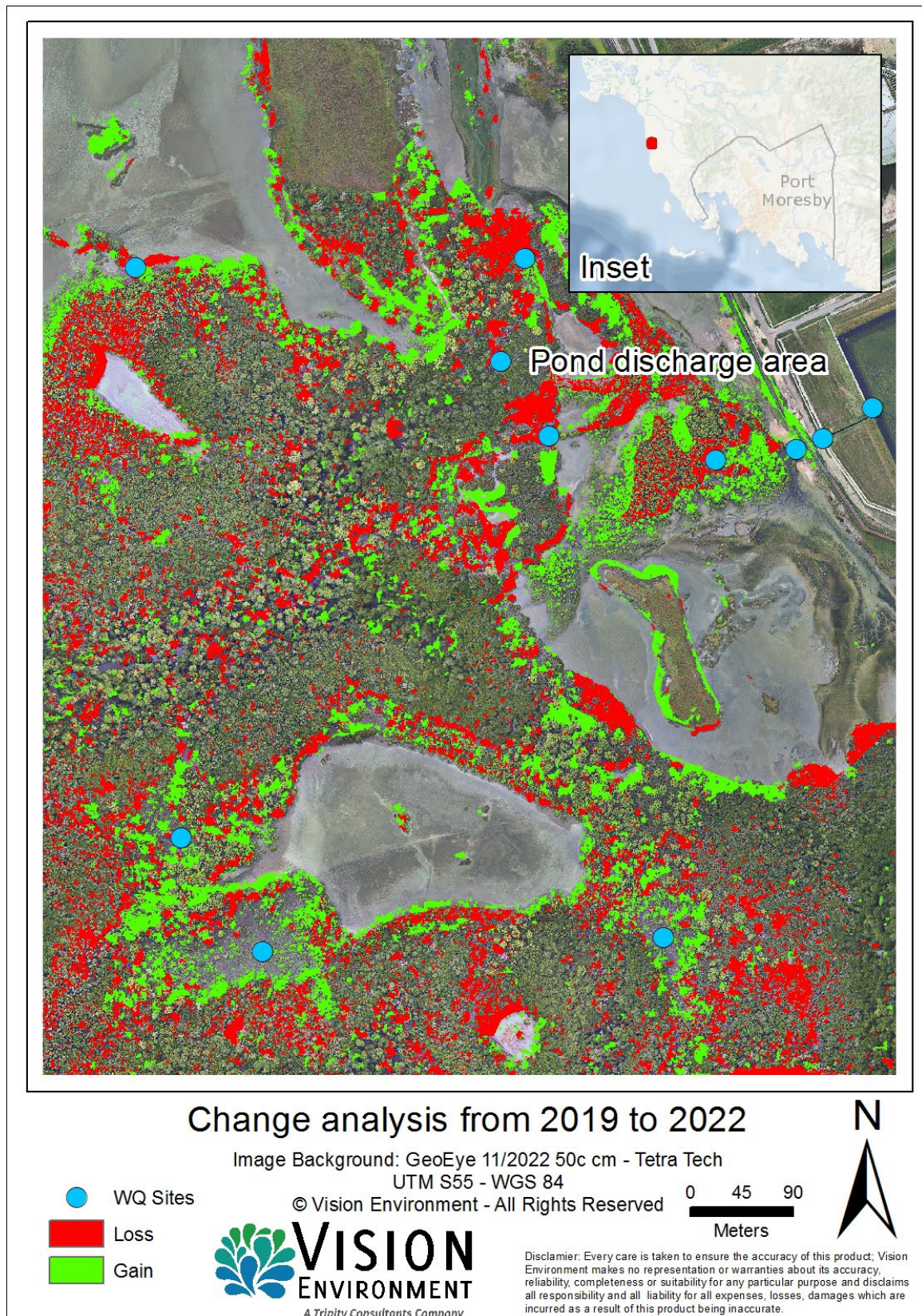


Figure A5. Change analysis from 2019 to 2022 of area adjacent to the retention and mixing pond discharges.

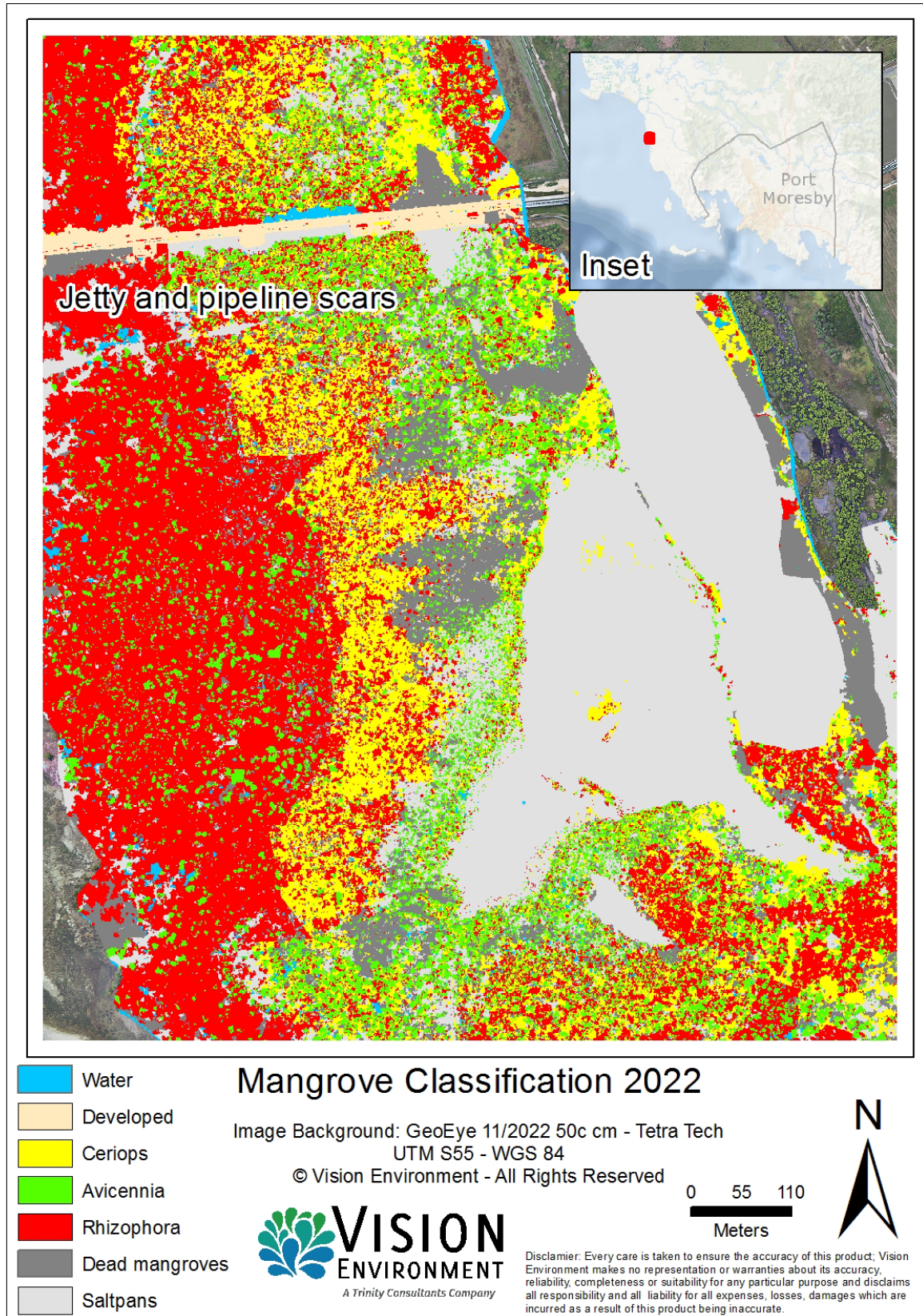


Figure A6. Mangrove classification (2022) of LNG Plant Jetty and PNG LNG pipeline mangrove removal areas.

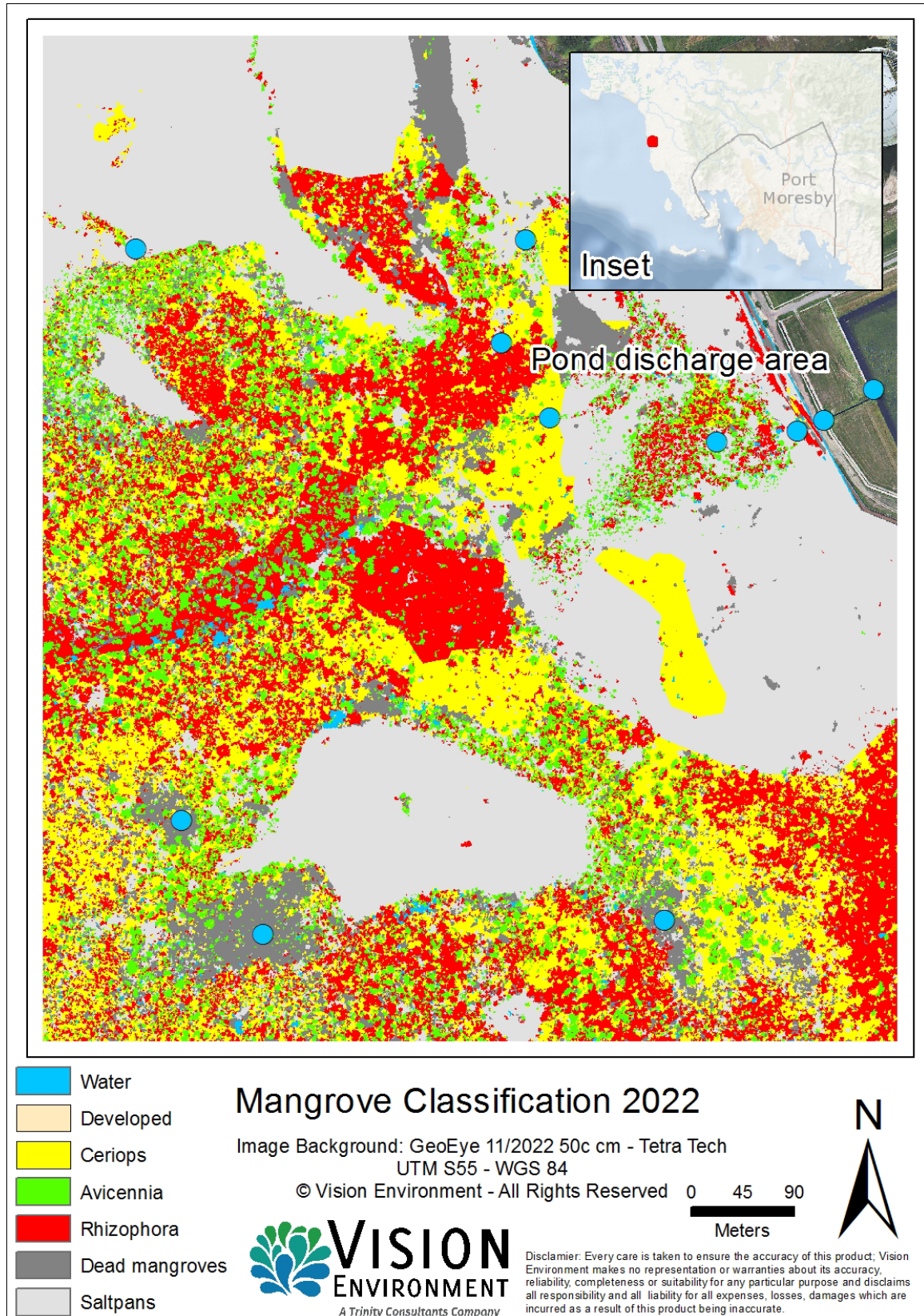


Figure A7. Mangrove classification (2022) of area adjacent to the retention and mixing pond discharges.

APPENDIX E: PORE WATER SAMPLING REPORT

Caution Bay intertidal mudflat pore water quality report

1. Introduction and background

This report provides the results of pore water sampling undertaken by Coffey Environments Australia Pty Ltd (Coffey) during baseline environmental field surveys.

Pore water sampling was undertaken in May 2019 at 15 locations in Caution Bay, on the intertidal mudflats adjacent to the existing ExxonMobil PNG (EMPNG) liquefied natural gas (LNG) Plant. This report summarises the methods used to collect the samples and presents the results from laboratory analysis.

The report was prepared for a previous scope of work and is of relevance to the environmental and social impact assessment for the Papua LNG Project - Downstream.

2. Objective

The objective of pore water sampling was to establish and document the existing pore water quality near the LNG Plant against which future conditions can be compared.

3. Method

One pore water sample was collected next to each of 15 mangrove ecology survey transects surveyed adjacent to the LNG Plant (Figure 1).

Pore water samples were collected using a 'PushPump' pore water extracting device. Pore water was extracted from the intertidal sediment by inserting the PushPump to a depth of approximately 30 cm and drawing the water out using a 60 ml plastic syringe. Samples were transferred from the syringe into laboratory-provided containers for analysis.

Samples were collected in accordance with the Coffey Marine Water and Sediment Quality Monitoring Manual, including the collection of field blanks and duplicates:

- Over the course of the sampling period, two duplicate samples were collected and submitted to the laboratory as discrete samples. Duplicate samples were collected by filling each bottle at the same time as the primary sample bottles. The analytical results of the duplicate samples provide information on the precision of the results and sample heterogeneity.
- One field blank was collected on each day of sampling by filling a set of sample bottles with deionised water using the same sample handling methods as for the primary samples. Samples were analysed to check the handling of the samples did not result in contamination.
- One equipment rinsate blank sample was collected per day of in-situ water quality testing. A piece of water sampling equipment e.g., water meter probe, was cleaned according to standard operating procedures. Decon90 (a concentrated cleaning agent) was sprayed on the equipment followed by rinsing it with deionised water. Deionised water was poured over the piece of

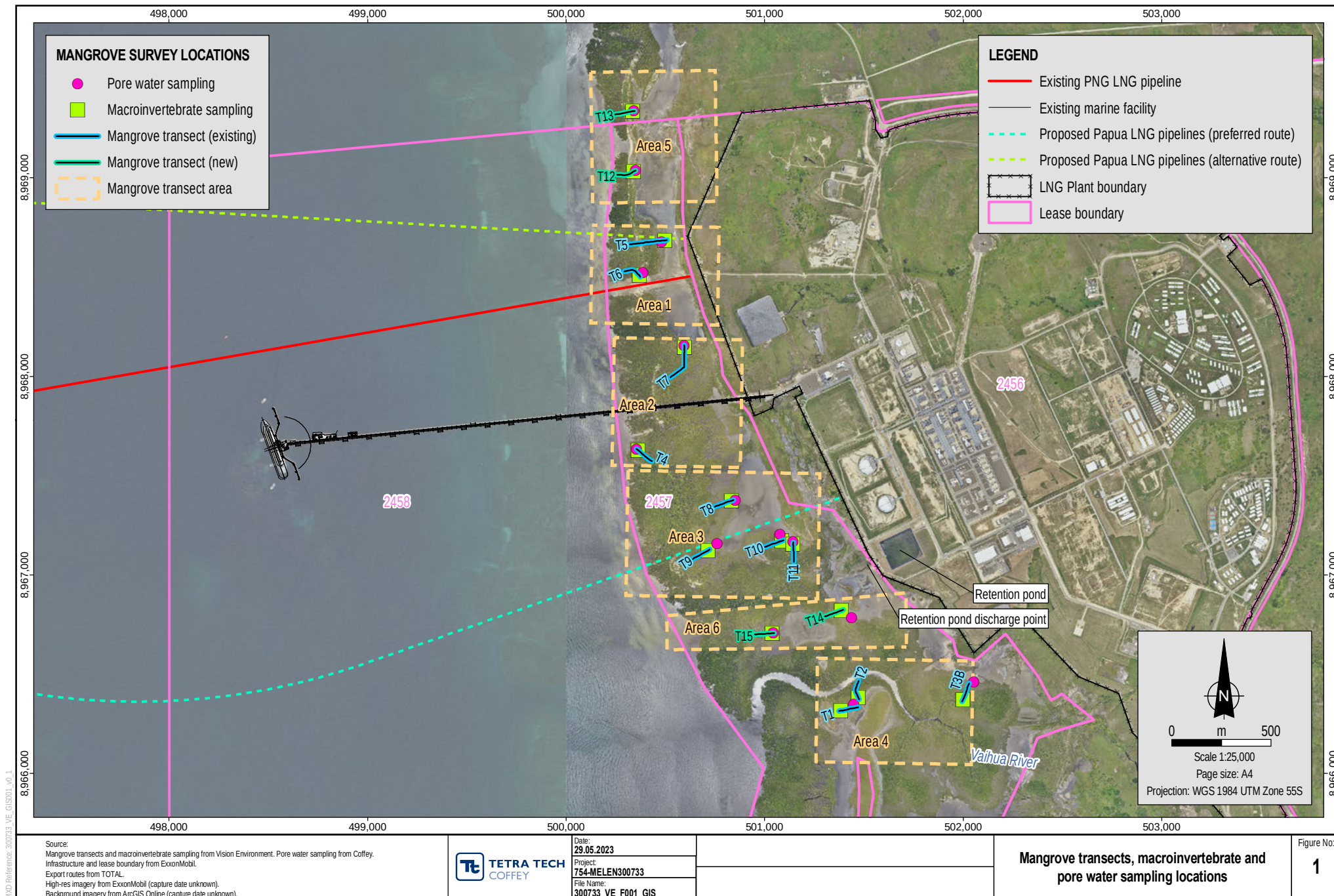
equipment into the suite of sample bottles, using the same sample handling methods as for the primary samples. Samples were analysed to check the handling of equipment did not result in contamination of the samples.

Care was taken not to disturb the sediment prior to sample collection and laboratory-provided gloves were worn to avoid contaminating the samples during and after collection. Sampling equipment was decontaminated between sampling locations following standard operating procedures.

All samples were shipped in eskies containing ice blocks to an accredited laboratory in Australia, ALS Laboratories, and analysed for:

- Total dissolved solids.
- Total suspended solids.
- Total and dissolved metals: Arsenic, barium, boron, cadmium, chromium (as hexavalent), cobalt, copper, iron, mercury, manganese, nickel, lead, selenium, silver, tin, vanadium and zinc.
- Nutrients: Total nitrogen, total kjeldahl nitrogen, nitrite, nitrate, ammonia, total phosphorus, reactive phosphorus.
- Potassium.
- Cyanide.
- Fluoride.
- BTEX, total petroleum hydrocarbons, speciated phenols and oil and grease.
- Chemical and biological oxygen demand.
- Sulphate and sulphide.
- Amines.

In-situ readings of pH, temperature, dissolved oxygen, conductivity, redox, salinity and turbidity of extracted pore water were also taken at each sampling site using a water quality meter (TPS 90FL-T multi-function Water Quality Meter and logger).



4. Results

In-situ water quality measurements are displayed in Table 4.1.

Table 4.1 In-situ water quality readings

Sample Location	pH	Temperature (°C)	Dissolved Oxygen (ppm)	Conductivity (mS)	Redox (mV)	Salinity (ppt)	Turbidity (NTU)
T1 / T2	7.55	30.6	1.94	17.99	83	8.99	236
T3b	7.09	29.3	5.97	18.32	96	9.19	187
T4	7.28	31.2	3.56	17.51	164	8.83	20.9
T5	7.43	35.0	*25.5	-	121	-	581
T6	7.40	28.0	0.17	-	145	-	38.2
T7	6.89	30.7	2.97	17.95	146	8.99	512
T8	7.03	30.4	3.8	18.05	88	9.06	2,500
T9	7.15	32.4	5.61	11.45	155	8.77	3,245
T10	7.11	30.7	0.31	17.89	165	8.96	513
T11	7.37	30.0	5.00	18.28	120	9.09	689
T12	7.38	31.5	3.46	-	86	-	251
T13	7.45	33.5	3.14	-	114	9.17	325
T14	6.50	30.7	1.30	18.08	79	9.11	310
T15	6.87	29.6	0.74	18.18	112	9.14	760

A dash (-) indicates that the water quality meter probe was unavailable or malfunctioning on the sampling day.

* DO was documented as a % value rather than ppm on this occasion.

A summary of results from laboratory analysis is provided in Attachment 1. Laboratory transcripts are provided in Attachment 2.

5. Quality assurance / quality control (QA/QC)

Samples were received by the laboratory for analysis within recommended holding times for all parameters except for biological oxygen demand (BOD). The recommended holding time for BOD of 48 hours was exceeded for some samples by up to one day despite immediate couriering of samples from the LNG Plant site to an accredited Australian-based laboratory (ALS laboratories).

Table 5.1 identifies duplicate, rinsate and blank samples reported in laboratory transcripts provided in Attachment 2.

Table 5.1 QA/QC samples collected

Date (2019)	Primary samples	Duplicate	Daily field blank	Daily rinsate
13/05	T7	T19	T21	T20
13/05	T4	-		
14/05	T8	-	T23	T22
14/05	T9	-		
14/05	T10	-		
15/05	T3b	-	T25	T24
15/05	T11	-		
15/05	T14	-		
15/05	T15	-		
16/05	T1/T2	T26	T27	T28
17/05	T5	-	T29	T30
17/05	T6	-		
17/05	T12	-		
17/05	T13	-		

The analytical results of the duplicate samples were compared to the primary samples collected at the same locations. Laboratory analysis indicated acceptable results for the field quality control samples, within the variation expected due to natural sample variability and laboratory methods. One exception was elevated levels of total manganese in the duplicate of site T7 (T19) which had 12,700 µg/L compared to 361 µg/L in the primary sample. This result is unexpected and appears likely to have resulted from cross-contamination of the duplicate. Oil and grease was also present at T19 (23 mg/L) but was below the detection limit of <5 mg/L in the primary sample. One of the primary samples also displayed elevated levels of manganese (site T8 with 21,800 mg/L total manganese) which is considered likely due to sampling or laboratory error, although it is noted that Sites T7 and T8 were sampled on different days.

Rinsate samples and field blank samples were collected on each day of pore water sampling. These samples showed low level detection of some metals as well as amines. The levels of metals in the QA/QC samples were below the results in the primary samples indicating that these metals were also present in the primary samples. Amines were present in some QA/QC results and either not present or at lower levels in the primary samples collected on the same day. This means that it is not possible to determine whether amines were present in the primary sample or if cross-contamination occurred from the field equipment or deionised water. Laboratory testing of the deionised water used for the survey showed that the water sourced from the PNG-based supplier displayed similar levels of metals upon purchase. Considering the low levels in the deionised water and use of the deionised water purely to rinse equipment for the collection of primary samples, it is not considered that this has compromised the validity of the primary samples.

Results from intra-laboratory QA/QC are provided in Attachment 3 and show acceptable ranges for laboratory duplicate, split and spiked results considering the potential variability within the samples and the level of accuracy for the various testing methods.

6. Conclusion

The pore water sample analysis results and in-situ pore water quality testing results can be used by specialists preparing the nearshore marine baseline report for the Papua LNG Project - Downstream, to assist in characterising the intertidal mudflat environment of Caution Bay, adjacent to the LNG Plant.

7. References

ANZG 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments. Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines.

Attachment 1 Pore water sample analysis results

Parameter	Sample Location													
	T1 / T2*	T3b	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15
Date	16/05/2019	15/05/2019	13/05/2019	17/05/2019	17/05/2019	13/05/2019	14/05/2019	14/05/2019	14/05/2019	15/05/2019	17/05/2019	17/05/2019	15/05/2019	15/05/2019
Total suspended solids (mg/L)	191	390	50	2,330	63	1,370	523	16,100	1,410	714	708	572	434	3,050
Sulphate (mg/L)	2,960	3,880	2,500	2,840	3,170	5,650	4,360	5,990	4,620	5,300	3,830	5,690	4,280	3,960
Dissolved mercury (mg/L)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Total recoverable mercury	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0005	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Total cyanide (mg/L)	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Fluoride (mg/L)	1.6	1.0	0.9	1.1	1.4	0.8	1.2	0.9	0.9	1.0	0.8	0.6	2.1	1.1
Ammonia as N (mg/L)	0.40	0.05	0.64	4.30	0.40	0.34	0.06	0.23	6.05	0.21	0.18	0.20	0.15	0.23
Nitrite as N (mg/L)	<0.01	<0.01	<0.1	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N (mg/L)	<0.01	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.09	<0.01	2.01	0.01	<0.01
Nitrite plus nitrite as N (NOx) (mg/L)	<0.01	<0.01	<0.1	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.09	<0.01	2.01	0.01	<0.01
Total kjeldahl nitrogen as N (mg/L)	3.2	3.5	<5.0	14.8	2.1	7.3	3.0	8.5	20.3	<2.0	8.1	3.5	5.1	15.7
Total nitrogen as N (TKN + NOx) (mg/L)	3.2	3.5	<5.0	14.8	2.1	7.3	3.0	8.5	20.3	<2.0	8.1	5.5	5.1	15.7
Total phosphorus as P (mg/L)	0.24	0.97	<0.50	2.27	<0.10	1.29	2.44	6.03	5.20	0.88	3.03	1.74	0.35	5.79
Reactive phosphorus as P (mg/L)	<0.01	0.13	0.07	0.67	0.06	1.24	0.15	1.18	1.18	0.12	0.76	1.15	0.03	2.06
Sulphide as S2 (mg/L)	0.4	<0.1	32.7	35.7	54.6	0.2	2.3	<0.1	63.7	<0.1	<0.1	<0.1	4.0	4.5
Chemical oxygen demand (mg/L)	938	1,000	<500	1,990	838	925	1,150	975	1,710	1,390	1,150	1,560	1,250	2,050
Biochemical oxygen demand (mg/L)	3	<2	11	55	31	3	<2	3	35	<2	2	<2	5	3
Oil and grease (mg/L)	<5	<5	<5	<5	<5	<5	<5	<5	14	<5	<5	<5	<5	<5
Dissolved antimony (µg/L)	<0.5	<0.5	<0.5	0.8	2.6	0.8	0.6	<2.5	1.7	<0.5	<0.5	<0.5	<2.5	1.1
Dissolved arsenic (µg/L)	2.5	3.4	1.0	26.8	56.1	8.8	5.7	5.7	26.0	3.5	7.8	8.5	<2.5	13.7
Dissolved beryllium (µg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1
Dissolved boron (µg/L)	4,290	5,400	4,030	5,030	4,520	5,290	5,730	7,830	6,130	4,500	5,960	4,470	5,960	5,400
Dissolved cadmium (µg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.5	<0.2	<0.1	<0.1	<0.1	<0.5	<0.1
Dissolved chromium (µg/L)	<0.5	<0.5	0.9	1.0	2.0	1.3	0.8	<0.25	0.8	0.7	<0.5	0.8	<2.5	1.9
Dissolved cobalt (µg/L)	0.6	1.8	0.4	<0.2	0.5	0.7	1.1	<0.5	<0.2	1.0	1.3	0.2	0.9	0.3
Dissolved copper (µg/L)	<1	5	<1	<1	<1	<1	1	<5	<1	2	7	4	<5	<1
Dissolved lead (µg/L)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<1.0	<0.2	<0.2	<0.2	<0.2	<1.0	0.2
Dissolved manganese (µg/L)	47.7	444	74.0	105	249	207	20,000**	14.4	171	104	186	3.8	188	352
Dissolved molybdenum (µg/L)	10.3	14.8	2.0	8.2	5.7	15.6	18.6	9.8	23.3	29.3	22.0	2.4	6.3	20.2
Dissolved nickel (µg/L)	0.8	4.4	1.3	<0.5	1.6	4.8	3.9	2.8	<0.5	2.8	3.2	1.5	<2.5	1.9
Dissolved selenium (µg/L)	18	24	21	21	27	31	27	42	29	36	26	40	27	27
Dissolved silver (µg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	<0.5	0.1	<0.1	<0.1	<0.1	<0.5	<0.1
Dissolved tin (µg/L)	<5	<5	<5	<5	<5	<5	<5	<25	<5	<5	<5	<5	<25	<5

Dissolved vanadium (µg/L)	3.5	5.1	2.7	2.2	2.3	4.4	6.7	6.4	2.1	2.6	10.3	8.6	<2.5	5.4
Dissolved zinc (µg/L)	<5	<5	<5	<5	<5	<5	<5	<25	<5	<5	<5	<5	<25	<5
Naphthalene (µg/L)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthylene (µg/L)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthene (µg/L)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Fluorene (µg/L)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Phenanthrene (µg/L)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Anthracene (µg/L)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Fluoranthene (µg/L)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Pyrene (µg/L)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benz(a)anthracene (µg/L)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chrysene (µg/L)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(b+j)fluoranthene (µg/L)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(k)fluoranthene (µg/L)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(a)pyrene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.8	<0.5	<0.5	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene) (µg/L)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dibenz(a.h)anthracene (µg/L)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(g.h.i)perylene (µg/L)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Sum of polycyclic aromatic hydrocarbons (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Benzo(a)pyrene TEQ (zero) (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
C6 – C9 Fraction (µg/L)	<20	<20	<100	<20	<20	<100	<20	<20	<100	<20	<20	<20	<20	<20
C10 – C14 Fraction (µg/L)	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
C15 – C28 Fraction (µg/L)	130	<100	<100	120	<100	100	<100	440	<100	<100	<100	1,240	<100	180
C29 – C36 Fraction (µg/L)	<50	<50	<50	70	<50	70	50	250	<50	<50	<50	270	<50	120
C10 – C36 Fraction (sum) (µg/L)	130	<50	<50	190	<50	170	50	690	<50	<50	<50	1,510	<50	300
C6 – C10 Fraction (µg/L)	<20	<20	<100	<20	<20	<100	<20	<20	<100	<20	<20	<20	<20	<20
C6 – C10 Fraction minus BTEX (µg/L)	<20	<20	<100	<20	<20	<100	<20	<20	<100	<20	<20	<20	<20	<20
>C10 – C16 Fraction (µg/L)	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
>C16 – C34 Fraction (µg/L)	140	<100	<100	170	<100	140	110	560	<100	<100	<100	1,480	<100	240
>C34 – C40 Fraction (µg/L)	<100	<100	<100	<100	<100	<100	<100	210	<100	<100	<100	370	<100	<100
C10 – C40 Fraction (sum) (µg/L)	140	<100	<100	170	<100	140	110	770	<100	<100	<100	1,850	<100	240
>C10 – C16 Fraction minus Naphthalene (F2) (µg/L)	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
Benzene (µg/L)	<1	<1	<5	<1	<1	<5	<1	<1	<1	<1	<1	<1	<1	<1
Toluene(µg/L)	<2	<2	<5	<2	<2	<5	<2	<2	<2	<2	<2	<2	<2	<2
Ethylbenzene (µg/L)	<2	<2	<5	<2	<2	<5	<2	<2	<2	<2	<2	<2	<2	<2
Meta & para-Xylene (µg/L)	<2	<2	<10	<2	<2	<10	<2	<2	<2	<2	<2	<2	<2	<2

Ortho-Xylene (µg/L)	<2	<2	<5	<2	<2	<5	<2	<2	<2	<2	<2	<2	<2	<2
Total Xylenes (µg/L)	<2	<2	<5	<2	<2	<5	<2	<2	<2	<2	<2	<2	<2	<2
Sum of BTEX (µg/L)	<1	<1	<5	<1	<1	<5	<1	<1	<1	<1	<1	<1	<1	<1
Naphthalene (µg/L)	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Ethanolamine (µg/L)	1	<1	<1	1	1	<1	<1	<1	<1	1	1	1	1	2
Diethanolamine (µg/L)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Methyl diethanolamine (MDEA) (µg/L)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

* One sample was collected at the point where T1 and T2 meet, due to the transect sites being located very close together (see Figure 1).

** This result for manganese is an outlier and is considered likely due to contamination of the sample in the field or laboratory error.

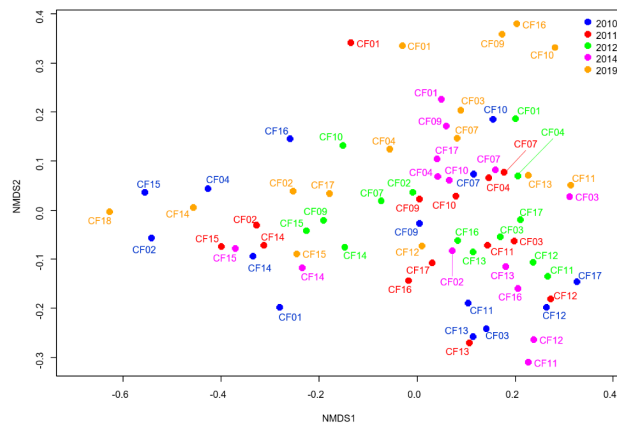
APPENDIX F: IMAGE ANALYSIS REPORT 2010 – 2019

Report to:



Caution Bay Nearshore Marine Ecological Monitoring

Image Analysis Report 2010 to 2019



January 2023

Caution Bay Nearshore Marine Ecological Monitoring Program

Image Analysis Report 2010 to 2019

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“Caution Bay Nearshore Marine Ecological Monitoring - Image Analysis Report: 2010 to 2019” CEE Pty Ltd report to Coffey Environments Australia Pty Ltd. Report authors Scott Chidgey, Peter Crockett, Joana Costa. CEE Pty Ltd Melbourne Australia.

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Caution Bay Marine Ecological Monitoring Program

Image Analysis Report 2010 to 2019

1 INTRODUCTION

This report presents the analysis of video images taken in the nearshore area of Caution Bay to support marine ecological baseline surveys undertaken in April 2019.

CEE Pty Ltd (CEE) was previously involved in data collection and analysis of marine ecological habitat data from ecological surveys at Caution Bay from 2010 to 2014 for the PNG LNG Project. CEE was set up with the previous completed database, image analysis protocols, software and expertise to analyse survey images captured in April 2019.

Tetra Tech Coffey Pty Ltd (Coffey) provided video files and survey positions from the April 2019 marine ecological survey of the monitoring habitats in Caution Bay to CEE in May 2019. The April 2019 survey images and data were analysed by CEE using the same methods as previous surveys. Data are presented here in the same format as previous surveys.

This data report integrates the April 2019 survey data with data from the four annual monitoring surveys undertaken for the PNG LNG Project from 2010 to 2014.

2 METHODS

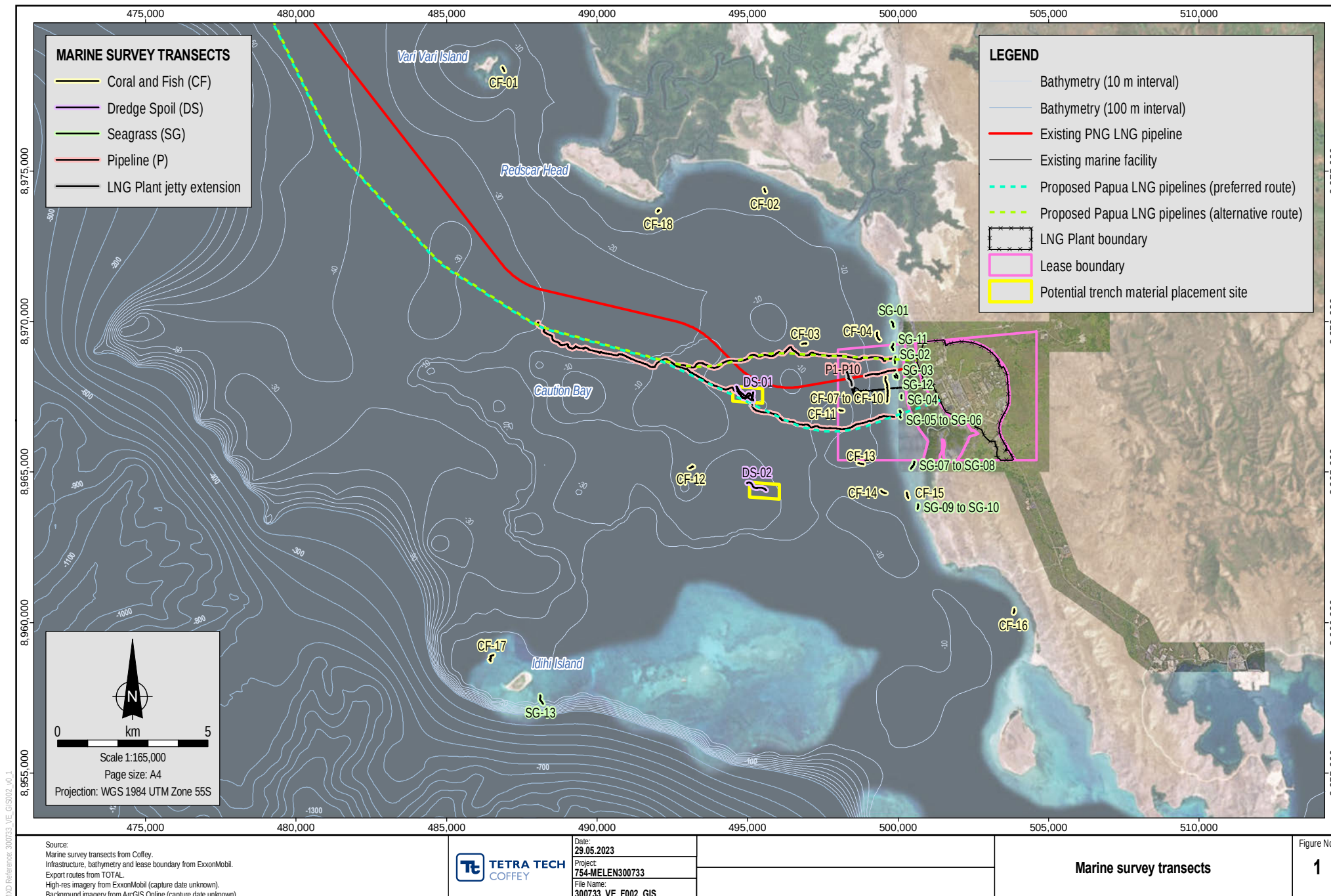
Twenty-five sites were surveyed in 2019 including 15 sites on predominantly coral habitat and 10 sites on predominantly seagrass habitat (Figure 1). The survey used towed underwater video to survey 100 m transects at each site. Video was recorded with the camera looking forwards and down towards the seabed. Several towed underwater video transects were recorded at each site. Transect position and alignment was varied due to the continuous manoeuvring as the vessel travelled along the approximate line across the site GPS position. The most representative and best quality transect images were analysed to ensure data quality consistency between sites and surveys.

The high-definition oblique video from each transect was analysed using a point-intercept technique following the procedure used in previous surveys. Fifty independent frames (still images) were analysed from each 100 m transect. Selected video frames were evenly spaced along the transect (around every 2 m) and only frames that showed a clear image of the seabed were used. Five-point intercepts were superimposed in a stratified-random array, spread evenly over the lower half of each frame (ensuring each point intersected seabed features, not the water column).

Each point was classified with the same categories as previous surveys as shown in Table 1, with each category having a number of sub-categories. The table lists all of the seabed features (seabed types, benthic flora and fauna, substrates and seabed conditions) that were identified from the video records. These categories and subcategories were used in both point-intercept analysis (quantitative) and general analysis (qualitative) of video transects. Many flora and fauna can be identified to the level of genus or even species, however detailed taxonomic identification of all flora and fauna is not possible using towed video.

Table 1. Flora, fauna and seabed categories

Categories	Subcategories
Coral reef (including large reef-forming hard corals)	Live coral (general)
	Coral rock (bare)
	<i>Acropora</i> (branching)
	<i>Acropora</i> (corymbose)
	<i>Acropora</i> (tabulate)
	<i>Euphyllia</i>
	Faviid (encrusting)
	Faviid (massive)
	Fungiidae
	Hard coral (other)
	<i>Montipora</i>
	<i>Mussidae</i>
	<i>Pavona</i>
	<i>Pectinidae</i> (foliose)
	<i>Pocillopora</i>
	<i>Porites</i>
	<i>Seriatopora</i>
Soft coral	<i>Lobophytum</i>
	Soft coral (other)
	<i>Sarcophyton</i>
	<i>Sinularia</i>
Gorgonian	Sea whip
	Sea fan
Sponge	Erect sponge
	Encrusting sponge
Other invertebrates	Echinoderm (general)
	Bryozoan (general)
	Other invertebrates (general)
Seagrass	<i>Cymodocea</i>
	<i>Enhalus acoroides</i>
	<i>Halimeda</i>
	<i>Syringodium isoetifolium</i>
Macroalgae Microalgae	Red macro algae
	Coralline algae
	Green macro algae
	<i>Halimeda</i>
	<i>Caulerpa</i>
	Brown macro algae
	<i>Padina</i>
	<i>Sargassum</i>
	<i>Turbinaria</i>
	Filamentous algae
	Microphytobenthos (MPB)
Unconsolidated seabed	Sediment (sand/silt)
	Coral rubble
	Bioturbated sediment



3 RESULTS OF MARINE ECOSYSTEM SURVEYS

This section presents the results of all surveys from 2010 to 2019 comprising: Pre-construction surveys carried out in February 2010 and January 2011; a mid-construction survey undertaken in February/March 2012; a post-construction survey carried out in April 2014; and an additional baseline survey carried out in April 2019. Data from the April 2019 survey provide a record of the baseline characterisation of conditions before the proposed expansion of the LNG Plant that is expected to include construction of additional LNG trains, an extension to the existing jetty and installation of new submarine pipelines.

3.1 Seagrass Sites

Ten seagrass sites were surveyed in 2019. Figure 2 and Figure 3 illustrate the abundance (% points) for species and substrate categories observed at the seagrass sites during the 2019 survey at sites north and south of the LNG jetty. Figure 1 shows the location of each site. Sites are ordered according to location along the coast – from the northernmost site (SG-01) to the southernmost site (SG-09-10) and offshore site (SG-13, Idihi Island).

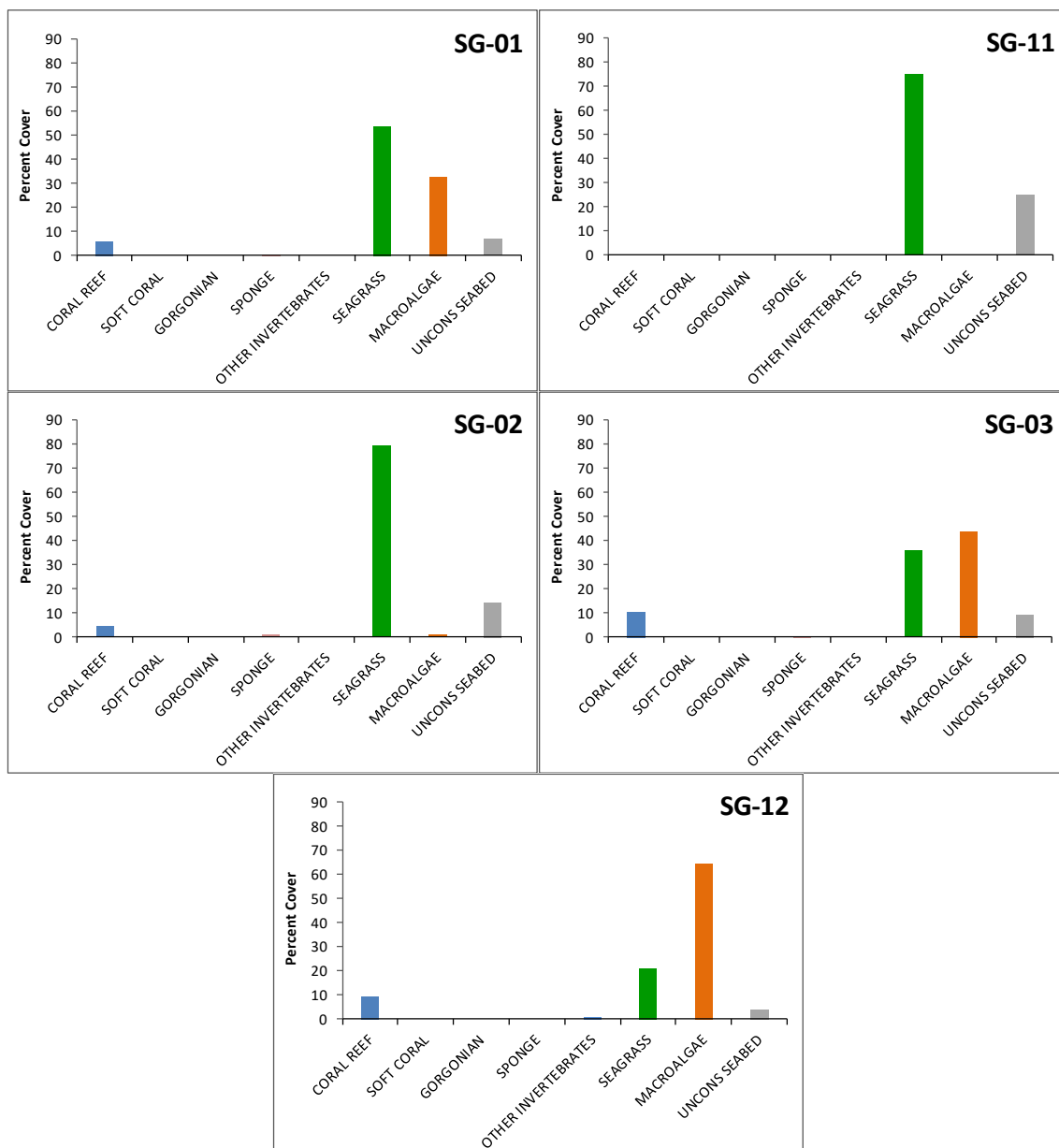


Figure 2. Seagrass site category abundances in 2019 – north of LNG jetty

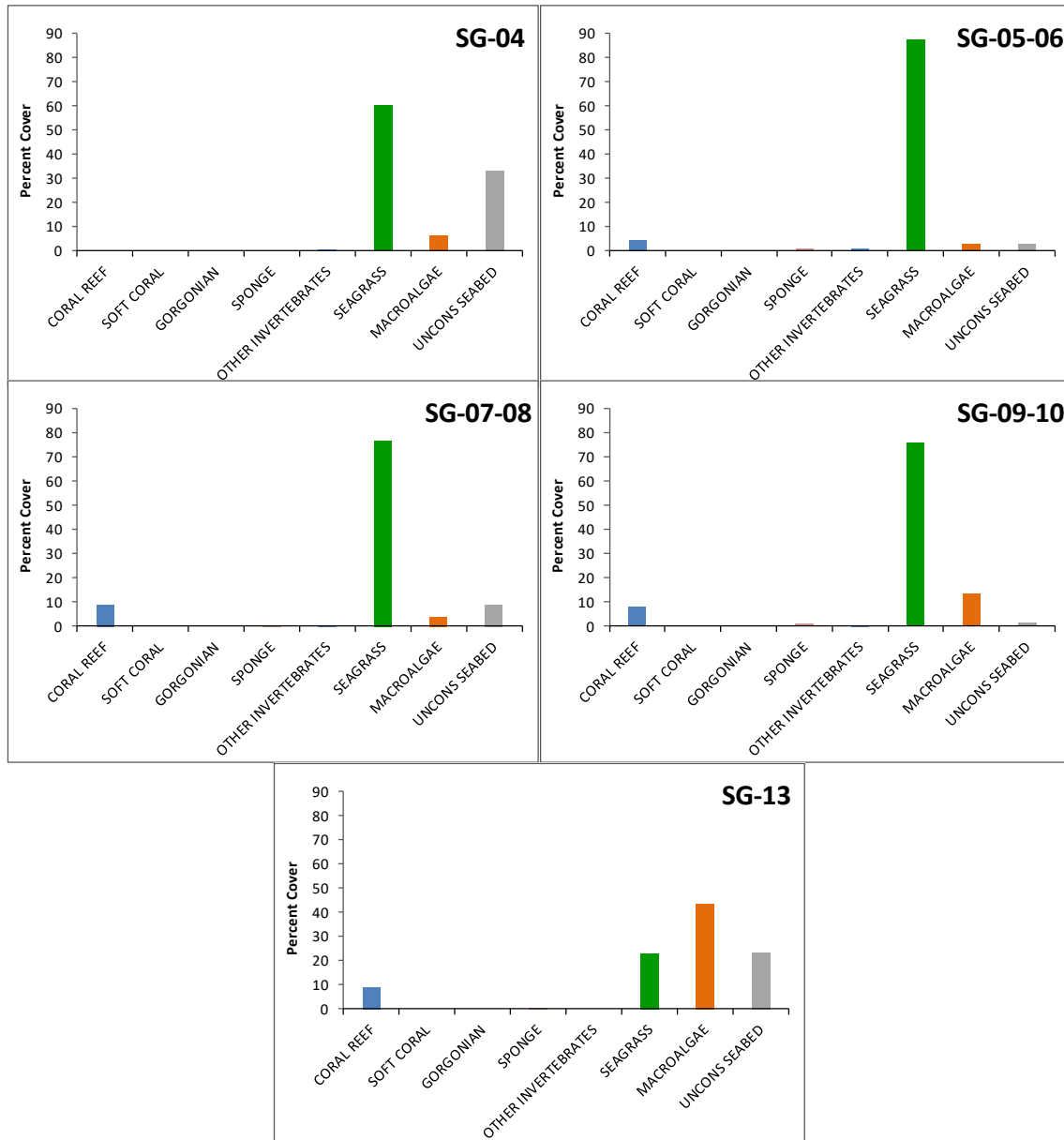


Figure 3. Seagrass site category abundances in 2019 – south of LNG jetty

The proportion of transects occupied by the three major categories (seagrass, macroalgae and bare unconsolidated substrate) at seagrass sites is shown for all five surveys in Figure 4.

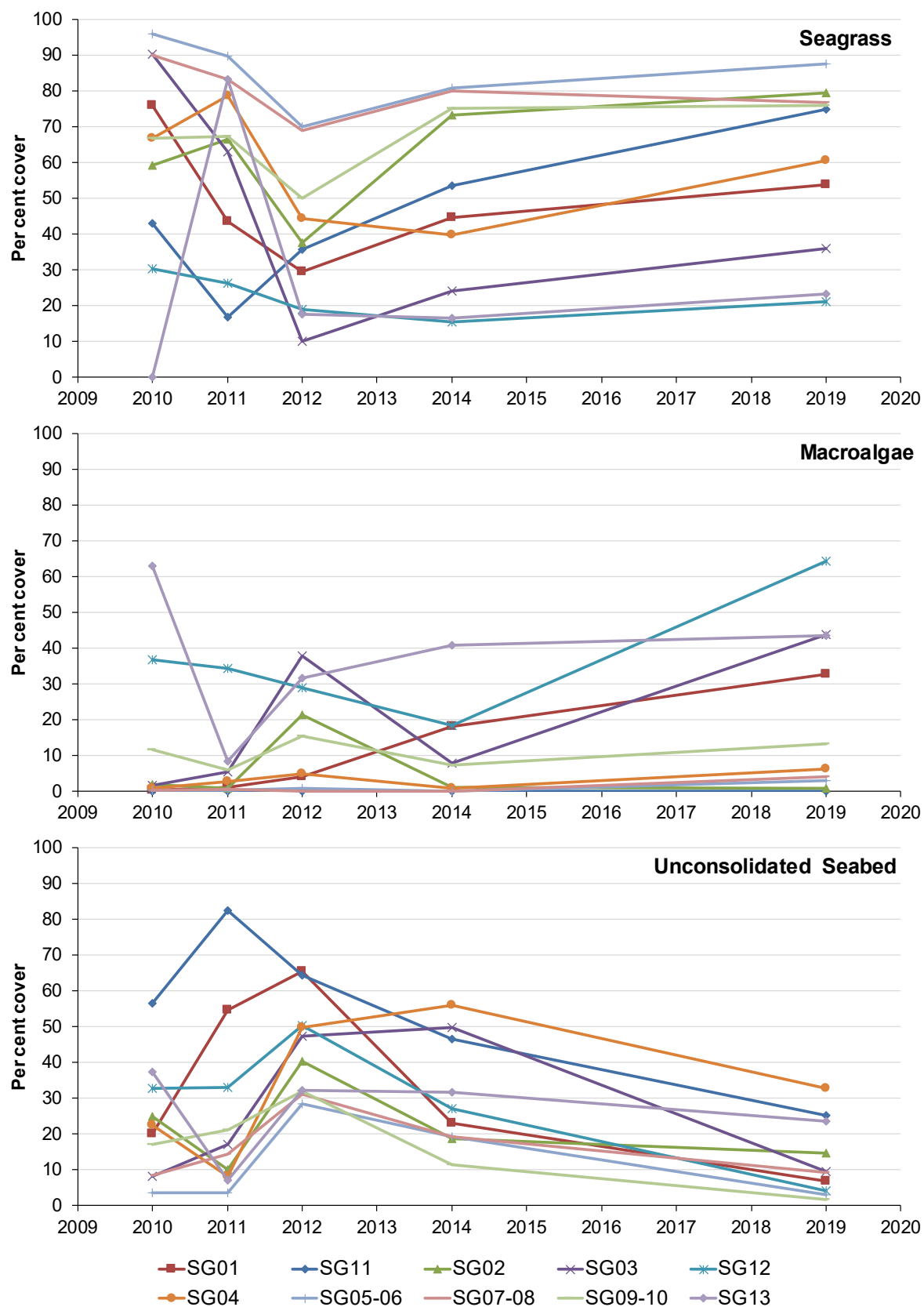


Figure 4. Seagrass, macroalgae and unconsolidated seabed at 'Seagrass' sites, 2010 to 2019

3.2 Coral and Fish Sites

Fifteen 'Coral and Fish' sites (CF) were surveyed in 2019. The site CF18 was introduced in the 2019 survey to obtain broader coverage of the survey area.

A single continuous transect was recorded from CF-07, through CF-09 to CF-10 to enable a direct assessment of potential seabed impacts from construction of the existing jetty. This long transect was assessed qualitatively (by Coffey), separately to other transects. Sections of video from this extended transect corresponding to the individual sites (CF07, CF09 and CF10) were extracted for quantitative analysis and comparison with results from other sites and from previous surveys.

Figure 5 shows the abundance of each category at the 'Coral and Fish' sites assessed in 2019. Figure 1 shows the location of each site.

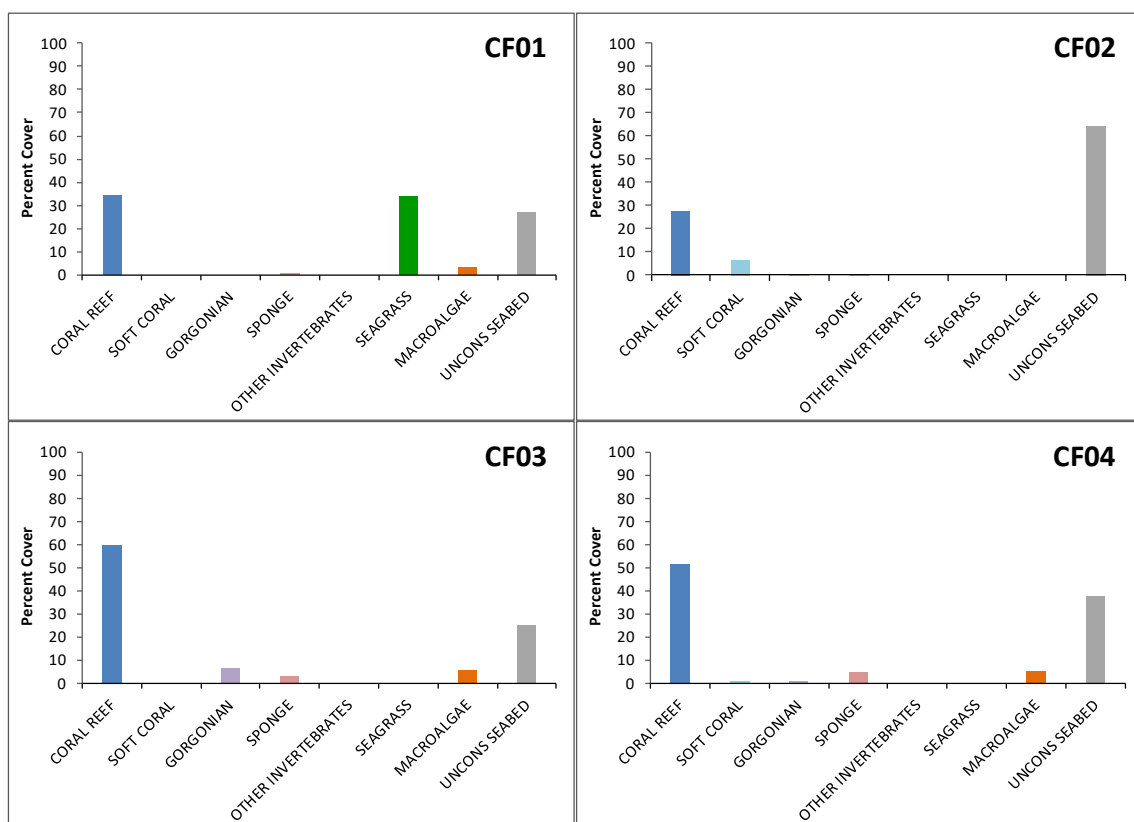


Figure 5. Coral and Fish site category abundances in 2019

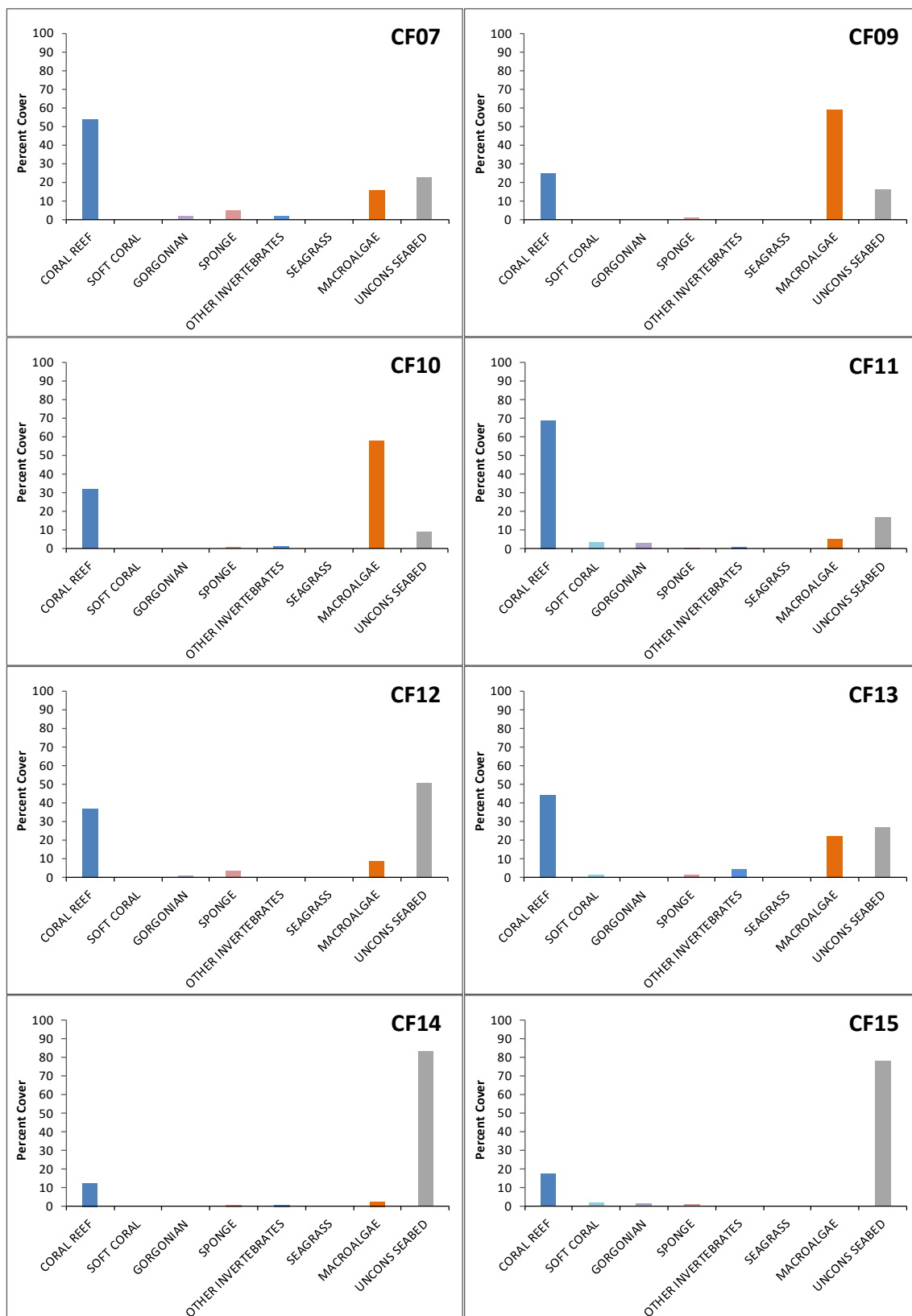


Figure 5 (cont'd). Coral and Fish site category abundances in 2019

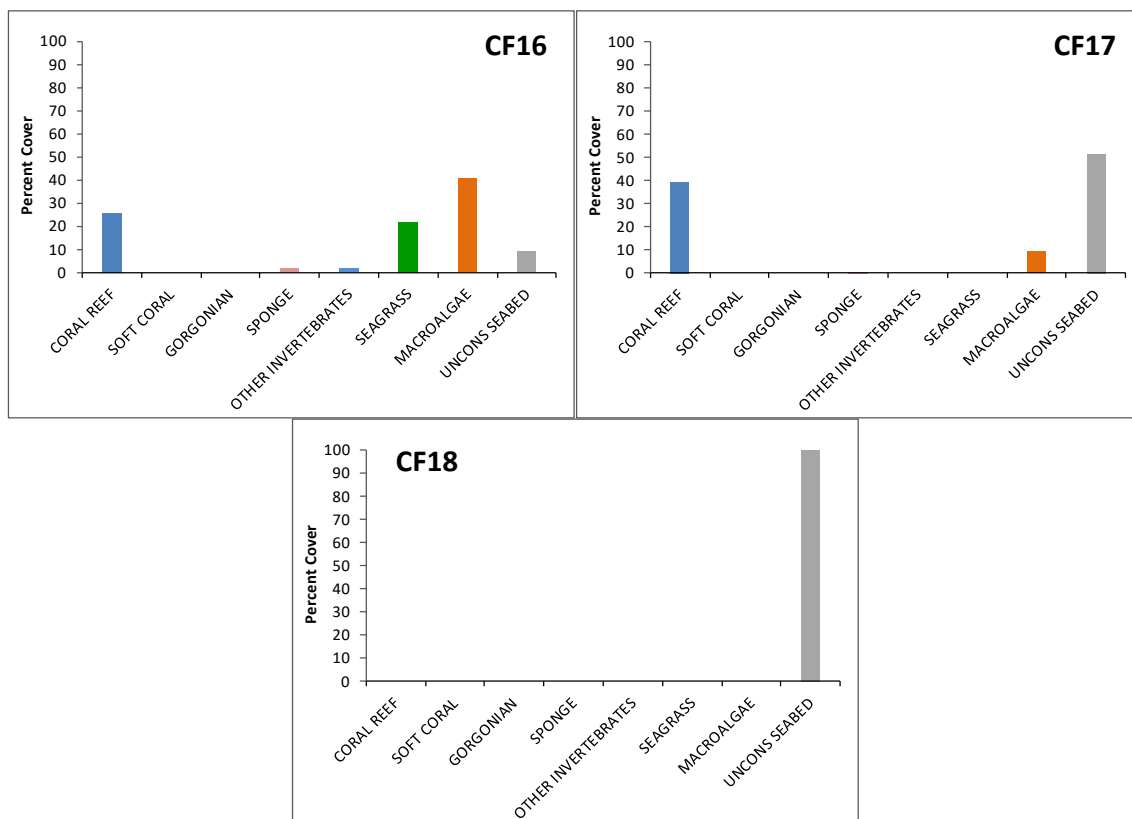


Figure 5 (cont'd). Coral and Fish site category abundances in 2019

Figure 6 and Figure 7 compare abundances of key categories at each Coral and Fish site in the five surveys in 2010, 2011, 2012, 2014 and 2019. Variation is due to minor differences in the alignment of the towed video transects and randomisation in the sampling method. There is no evidence of any sustained differences at sites closest to the jetty/pipeline due to construction impacts between the 2010 and 2019 results.

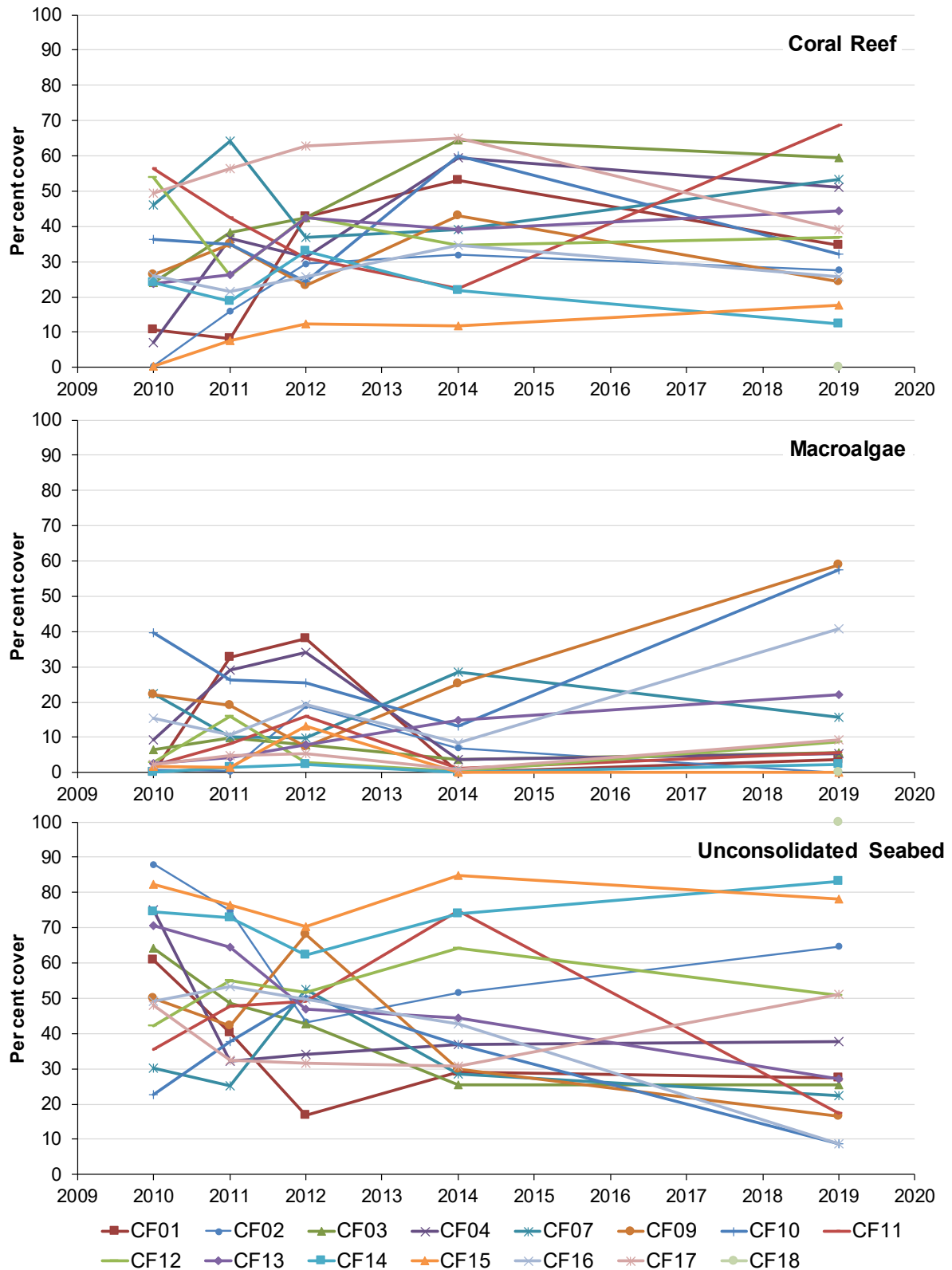


Figure 6. Dominant categories at 'Coral & Fish' monitoring sites, 2010 to 2019

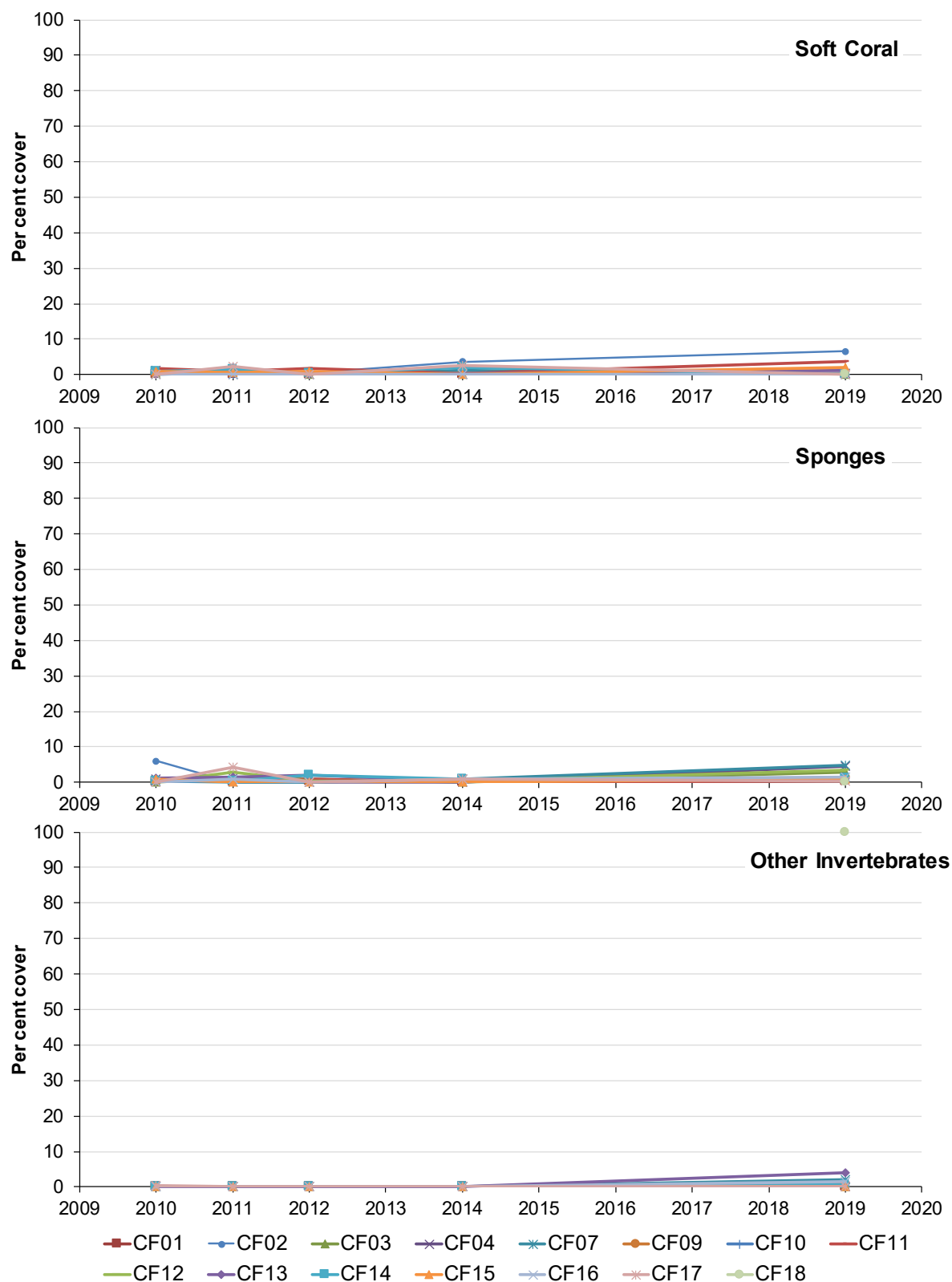


Figure 7. Less abundant categories at 'Coral & Fish' monitoring sites, 2010 to 2019

Figure 8 plots the abundance of each category at all seagrass and coral and fish monitoring sites in 2019.

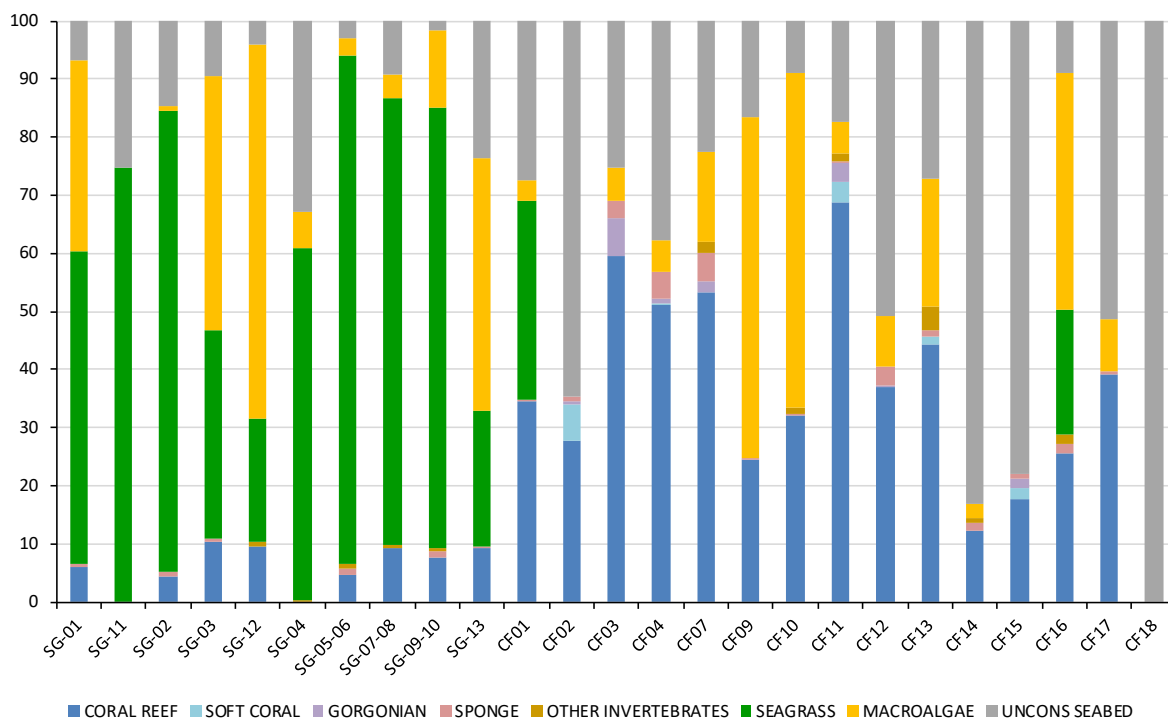


Figure 8. All categories at 'Seagrass' and 'Coral and Fish' monitoring sites in 2019

3.3 Multivariate Analysis

The characteristics of the biological community at the 'Coral & Fish' and 'Seagrass' sites were compared using multivariate analysis techniques. This standard technique used by ecologists involves:

- (1) Preparing a Bray-Curtis dissimilarity matrix from the point-intercept data for the habitat and species categories at each site
- (2) Using non-metric multidimensional scaling (nMDS) to find a representation of the dissimilarity matrix in two dimensions with a Kruskal stress value less than 0.2 (Clarke and Warwick, 1994).

Non-metric multidimensional scaling is used here to determine the degree of similarity or difference in sites' biological communities and represent these similarities and differences in a simple two-dimensional plot. Biological community variables explaining the similarities and differences are discussed with reference to the univariate data presented above.

CEE used the R software analysis package *Vegan* for nMDS analysis.

3.3.1 Seagrass and Coral & Fish sites in 2019

The nMDS plot for all sites in 2019 is shown in Figure 9. The Kruskal stress for the plot was low at 0.09 and indicates the plot provides a reliable representation of differences between sites (Clarke and Warwick, 1994). The plot shows clear separation between seagrass and coral & fish community sites, apart from CF-16 and CF-01 which group more closely with the seagrass sites, due to the presence of patches of seagrass observed during the 2019 survey.

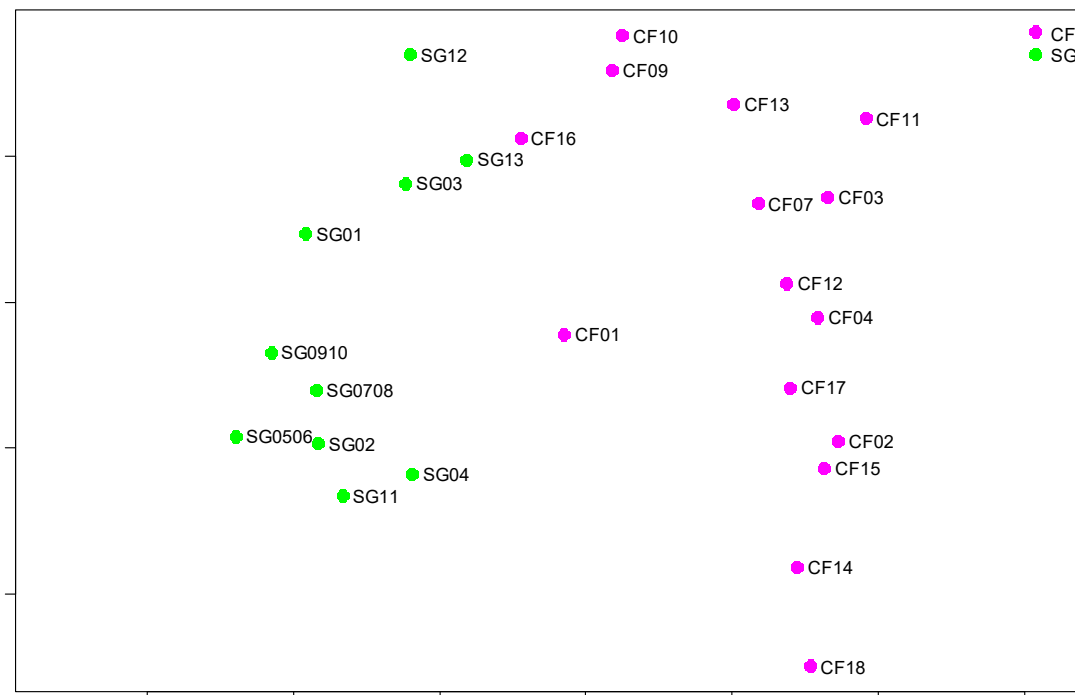


Figure 9. Non-Metric multidimensional scaling plot for 2019

3.3.2 Seagrass Sites – 2010 to 2019

The nMDS plot for seagrass sites between 2010 and 2019 is shown in Figure 10. The Kruskal stress for the plot was low at 0.08 and indicates the plot provides a reliable representation of differences between sites (Clarke and Warwick, 1994).

Figure 10 shows many points (site time) clustered in the middle left of the ordination, some points spread out to the upper right, and some sites spread to lower right of the plot. A plot with labels omitted is provided so the patterns are more easily seen.

The factors explaining the form of the multivariate MDS plot can be found by examining univariate plots for seagrass in Figure 2, Figure 3 and Figure 4. Seagrass sites SG-12 and SG-13 plotted in the upper right in each year and these sites were characterised by the highest macroalgae cover over the five surveys. Site SG-13 is located on the outer reef (Idihi Island). The proportion of macroalgae has varied substantially between surveys. Seagrass was high during the first survey but lower for the subsequent four. SG-13 is a reference site and changes are due to natural factors, not construction impacts. Points that plot in the lower left of the MDS plot were characterised by low macroalgae cover. The cluster of points in the middle left were characterised by higher seagrass cover than other sites/surveys.

Overall, the pattern of distribution of seagrass sites in the plot can be explained by natural variation and random variation in data due to the survey and analysis methods. The results show no apparent residual effects from pipeline or jetty construction.

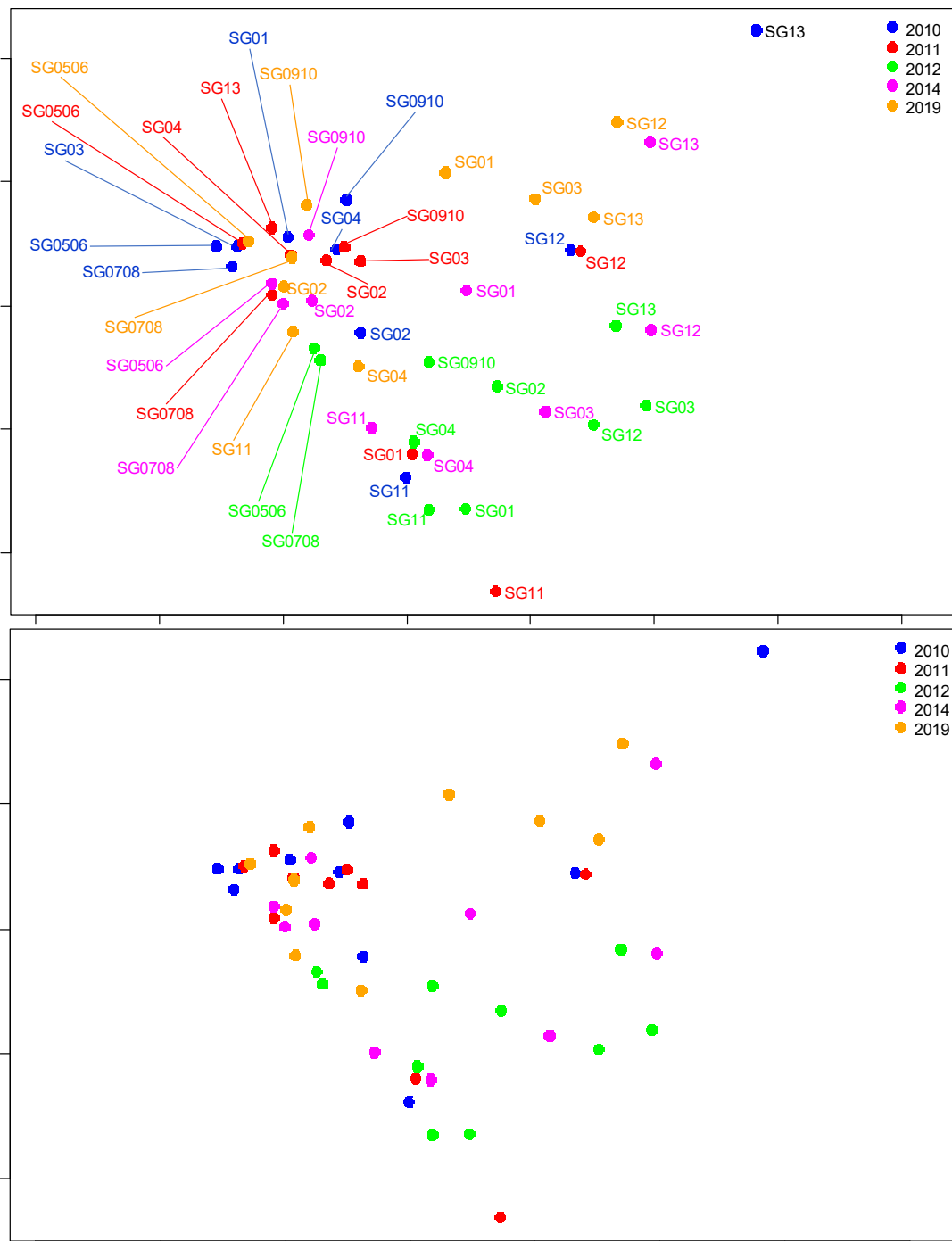


Figure 10. Non-Metric Multidimensional scaling plot for Seagrass sites, 2010 to 2019
Lower plot shows nMDS without site labels for clarity

3.3.3 Coral & Fish sites – 2010 to 2019

The nMDS plot for Coral & Fish sites between 2010 and 2019 is shown in Figure 11. The Kruskal stress for the plot was 0.15 and indicates the plot provides a reliable representation of differences between sites (Clarke and Warwick, 1994).

Figure 11 shows a wide distribution of points (site time) centred to the middle right of the plot (the inverse pattern to that for Seagrass sites). The factors explaining the form of the plot can be found by examining univariate data for coral fish sites in Figure 5 and Figure 6. Points (site time) to the extreme left of the MDS plot were characterised by a high proportion of unconsolidated seabed. Points in the upper right of the plot were characterised by high macroalgae cover. Points to the lower right of the plot were characterised by low macroalgae cover. Points in the mid-right of the plot were characterised by higher coral reef cover. As the relative locations of most sites have been similar over all the sampling periods, this indicates that substantial change in coral cover over time is not apparent (such as with sites CF-03, CF-07, CF-11, CF-12, CF-14, CF-15). Sites CF-09, CF-10 and CF-16 show an increase in macroalgae cover in 2019 compared to prior years (see macroalgae percent cover plot, Figure 6).

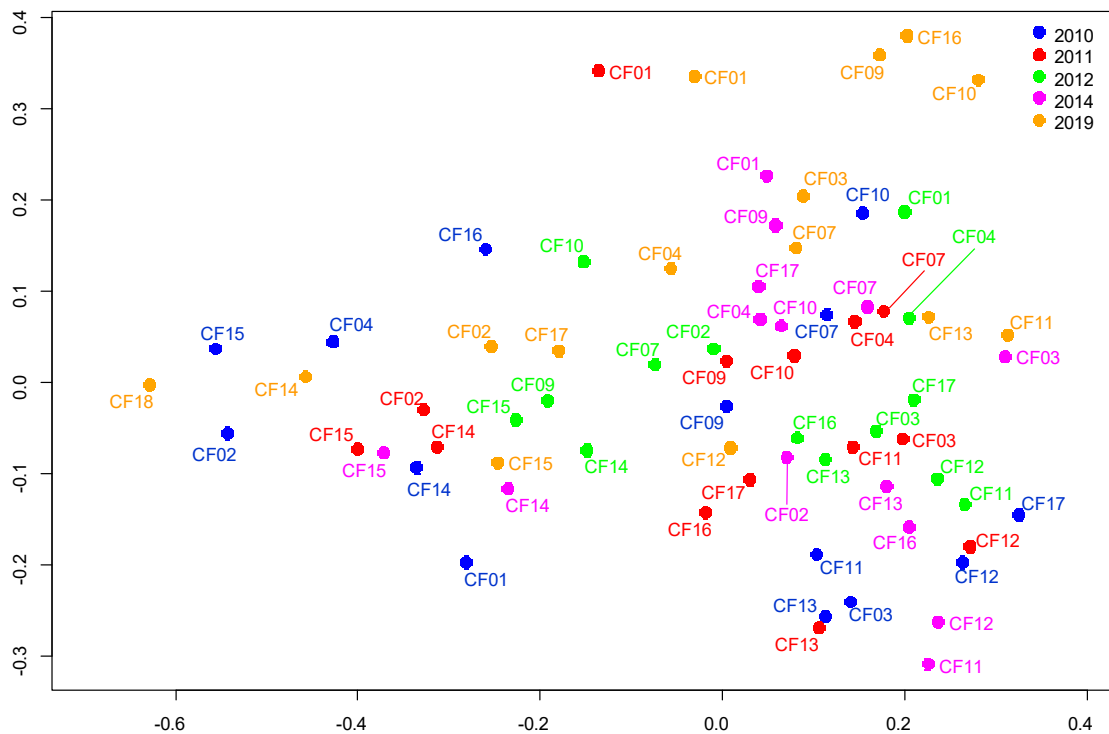


Figure 11. Non-Metric Multidimensional scaling plot for Coral & Fish sites, 2010 to 2019

APPENDIX G: QUALITATIVE DESCRIPTIONS: SEAGRASS AND CORAL FISH SITES 2010 - 2019

Table 1 Seagrass monitoring site descriptions

Site	Depth (m)	2010 Observations		2011 Observations		2012 Observations		2014 Observations		2019 Observations	
		Seabed Type(s)	Biota	Seabed Type(s)	Biota	Seabed Type(s)	Biota	Seabed Type(s)	Biota	Seabed Type(s)	Biota
SG-01	0.5 – 1	Soft sediment, with some rubble and occasional coral outcrops.	Moderately dense to dense multi-specific seagrass with some bare sand/rubble patches and occasional coral outcrops.	Mostly soft sediment with patchy rubble, some reef (coral). Sand waves visible on bare sediment.	Moderately dense multi-specific seagrass beds with areas of sparser seagrass or bare sand. Seagrass beds raised above bare sand. Some <i>Halimeda</i> visible, occasional <i>Sargassum</i> sp. Small isolated corals visible in places.	Mostly soft sediment with patchy rubble. Rubble often covered in thin layer of filamentous algae. Sand waves visible on bare sediment.	Moderately dense multi-specific seagrass beds with areas of sparser seagrass or bare sand. Seagrass beds raised above bare sand. Very sparse <i>Halimeda</i> and occasional <i>Sargassum</i> sp. Small isolated sponges visible in places.	Soft sandy sediment, with some rubble and occasional coral outcrops.	Patchy seagrass (<i>Enhalus</i> , <i>Cymodocea</i> , <i>Syringodium</i> spp.) over first two thirds transect, <i>Sargassum</i> and on <i>Padina</i> areas of rubble over last third of transect.	Mostly soft sediment with patchy rubble in areas where seagrass is less dense and macroalgae present.	Variable though generally dense multi-specific seagrass (<i>Enhalus</i> , <i>Cymodocea</i> , <i>Syringodium</i>). Patches of bare sand and rubble, rare observations of solitary coral. Well established <i>Sargassum</i> in places where transect drifted across deeper water.
SG-02	0.5 – 1	Soft sediment / rubble with some (dead) coral.	Multi-specific seagrass beds ranging from sparse to dense, substantial sand/rubble patches with some <i>Padina</i> sp. and coral.	Mostly a mixture of sediment and rubble with some low relief reef (to 0.2 m above surrounding seabed). Sediment often thin over underlying reef/rubble.	Dense multi-specific seagrass on sand/rubble, beds continuous except on reef. Some <i>Sargassum</i> on reef/rubble. Occasional <i>Padina</i> sp. on reef. Some isolated corals (mostly soft) on areas of reef. Fish sighted around reef.	Mixture of sediment and rubble with some low relief reef (to 0.2 m above surrounding seabed). Sediment often thin over underlying reef/rubble.	Dense multi-specific seagrass on sand/rubble, beds continuous except on reef. Some <i>Sargassum</i> on reef/rubble. Occasional <i>Padina</i> sp. on reef. Some isolated corals (mostly soft)	Soft sandy sediment, with some rubble and occasional coral outcrops.	Discontinuous multi-specific seagrass interspersed with rubble and reef outcrops. Some corals on areas of hard reef, <i>Sargassum</i> and <i>Padina</i> in places. Patches of bare sand and rubble.	Soft sandy sediment. Occasional rubble and low relief calcareous rock.	Seagrass beds generally dense and multi-specific (dominance varies between <i>Cymodocea/Enhalus</i> , with some <i>Syringodium</i>). Occasional <i>Sargassum</i> and more rarely <i>Padina</i> present on patches of bare sand and rubble. Few observations of solitary corals. Small fish sighted around low relief rock/rubble.

Site	Depth (m)	2010 Observations		2011 Observations		2012 Observations		2014 Observations		2019 Observations	
		Seabed Type(s)	Biota	Seabed Type(s)	Biota	Seabed Type(s)	Biota	Seabed Type(s)	Biota	Seabed Type(s)	Biota
							and sponges on areas of reef. Fish sighted around reef.				
SG-03	0.7 – 1	Soft sediment and rubble, occasional larger rubble/coral.	Multi-specific seagrass beds, mostly dense, with sand patches and some coral rubble supporting <i>Sargassum</i> sp.	Soft sediment and low relief (0.2 m) reef.	Mostly dense multi-specific seagrass beds, some areas of sparse <i>Enhalus acoroides</i> . Scattered <i>Sargassum</i> on reef patches. Few fish or corals sighted.	Soft sediment and low relief (0.2 m) reef and rubble.	Patchy multi-specific seagrass beds, some areas of sparse <i>Enhalus acoroides</i> . Scattered <i>Sargassum</i> on reef patches. Few fish or corals sighted.	Sand, coral rubble and low-profile reef.	Patches of <i>Cymodocea</i> and <i>Enhalus</i> seagrasses on sand and coral rubble. Bare reef, with some corals. <i>Sargassum</i> , and <i>Padina</i> macroalgae on areas of large rubble and reef.	Patchy assemblage of sand, coral rubble and low-profile reef on flat seabed.	Mixed densities of <i>Sargassum</i> and some <i>Padina</i> growth, attached to rock and rubble. <i>Cymodocea</i> and some <i>Enhalus</i> seagrass meadows also observed, typically with occasional <i>Turbinaria</i> and <i>Sargassum</i> interspersed. Few small reef fish seen.
SG-04	0.9 – 1.1	Substantial areas of bare rubble, larger coral rubble but mostly soft sediment and rubble.	Some areas of bare sediment/rubble with patchy but dense multi-specific seagrass beds.	Soft sediment and low relief reef, sediment often thin over reef/rubble.	Mostly dense multi-specific seagrass beds with some bare sediment patches. Sparse <i>Sargassum</i> on reef, some <i>Halimeda</i> amongst reef/rubble towards end of transect.	Soft sediment and low relief reef, sediment often thin over reef/rubble. Some patches of bare sand.	Mostly dense multi-specific seagrass beds with some bare sediment patches. No <i>Sargassum</i> or <i>Halimeda</i> sighted.	Sand, coral rubble and low-profile reef.	Patchy and sparse <i>Enhalus</i> on sand. Areas of rubble and broken reef with <i>Enhalus</i> , <i>Cymodocea</i> and <i>Syringodium</i> . Low, flat reef with some macroalgae (<i>Halimeda</i> , turf).	Soft sands	Mostly dense seagrass beds dominated by <i>Cymodocea</i> and some <i>Enhalus</i> . Mixed seagrass assemblage of <i>Sargassum</i> and <i>Padina</i> less common, in areas with more bare sediment patches.
SG-05 – SG-06	0.5 – 1	Soft sediment with some rubble, rubble patches.	Generally dense multi-specific seagrass beds, occasional patches of	Mostly soft sediment with some rubble and low relief reef.	Dense multi-specific seagrass. Some patches of bare sediment. Very sparse single <i>Sargassum</i>	Mostly soft sediment with some rubble and low relief dead coral reef.	Dense multi-specific seagrass. Some patches of bare sediment. Very sparse	Sand and coral rubble.	Discontinuous multi-specific seagrass (<i>Enhalus</i> , <i>Cymodocea</i> and <i>Syringodium</i>).	Mainly soft sediments and sand. Some large rocks and rubble thinly covered in	Diadema urchins, holothurians and small fish around areas of rock/reef. Occasional solitary corals. Mixed dense <i>Cymodocea</i> , <i>Enhalus</i> and <i>Syringodium</i>

Site	Depth (m)	2010 Observations		2011 Observations		2012 Observations		2014 Observations		2019 Observations	
		Seabed Type(s)	Biota	Seabed Type(s)	Biota	Seabed Type(s)	Biota	Seabed Type(s)	Biota	Seabed Type(s)	Biota
			bare rubble / sediment.		plants. No fish sighted. Occasional corals and sponges sighted.		single <i>Sargassum</i> plants. Occasional urchins, sea cucumbers, corals and sponges visible. Abundant bioturbation evidenced through mounds and burrows.		Occasional corals.	filamentous algae.	seagrass growth and some <i>Sargassum</i> .
SG-07 – SG-08	0.5 – 1	Soft sediment with isolated coral rubble.	Moderately dense to dense multi-specific seagrass beds.	Generally deep sediments with sand waves visible on bare sediment. Some isolated patches of rubble and reef.	Medium density <i>Enhalus acoroides</i> in places. Some fish sighted amongst seagrass. Very sparse isolated corals and sponges.	Soft sediment with isolated coral rubble.	Moderately dense to dense multi-specific seagrass beds. Individual sea cucumber. Very sparse isolated corals and sponges.	Sand, coral rubble, small areas of reef.	Mostly continuous multi-specific seagrass on sand (<i>Enhalus</i> , <i>Cymodocea</i> and <i>Syringodium</i>). Some patches of bare sand/rubble. Occasional <i>Sargassum</i> on reef.	Flat seabed with a mixture of sand, low relief rock and reef rubble.	Mainly a very dense assemblage of mixed-species seagrass beds. Some patchy, heterogenous areas of macrophytes including <i>Sargassum</i> , <i>Syringodium</i> , <i>Cymodocea</i> , <i>Enhalus</i> and <i>Padina</i> sp. Occasional corals on rocky substrate, some small reef fish, bioturbation (mounds) on bare sands
SG-09 – SG-10	0.7 – 1.3	Soft sediment and rubble with areas of large coral rubble.	Patchy moderately dense to dense multi-specific seagrass beds interspersed with coral rubble	Bare areas of coral rubble and reef remainder of transect comprising sediment and rubble.	Mostly bare rock with some <i>Sargassum</i> . <i>Halimeda</i> sp. amongst rubble in places. Dense multispecific seagrass beds, with some	Soft sediment and rubble with areas of large rocks thinly covered in sediment or filamentous algae.	Moderately dense to dense multi-specific seagrass beds interspersed with coral rubble supporting	Low profile reef and boulders at start of transect. Remaining three quarters of transect	Some corals and algae on reef and boulders. Discontinuous multi-specific seagrass beds (<i>Enhalus</i> , <i>Syringodium</i>	Soft sediment and rubble with areas of large rocks and rubble.	Mixed seagrass community of mainly <i>Enhalus</i> and <i>Cymodocea</i> on sand/soft sediment. Dense <i>Sargassum</i> and some <i>Padina</i> amongst rock and rubble.

Site	Depth (m)	2010 Observations		2011 Observations		2012 Observations		2014 Observations		2019 Observations	
		Seabed Type(s)	Biota	Seabed Type(s)	Biota	Seabed Type(s)	Biota	Seabed Type(s)	Biota	Seabed Type(s)	Biota
			supporting <i>Sargassum</i> sp.		sparse seagrass and <i>Sargassum</i> toward southern end of transect.		<i>Sargassum</i> sp. Sparse <i>Padina</i> and <i>Halimeda</i> plants. Occasional urchins, sea cucumbers, sea stars, corals and sponges visible. Some bioturbation evidenced through mounds and burrows.	sand and coral rubble with occasional reef patches and boulders.	and <i>Cymodocea</i>). Some <i>Sargassum</i> on low profile reef and boulders.		
SG-11	1 – 2	100% soft seabed comprising fine silty sediment. No hard substrate.	Generally dense, multi-specific seagrass beds, occasional patches of bare rubble/sediment.	100% soft seabed comprising fine silty sediment. No hard substrate.	Variable, though generally low cover of multi-specific seagrass beds. Large patches of bare sand/substrate.	Mostly bare sand. Sand waves visible on bare sediment.	Moderate to dense multi-specific seagrass beds interspersed with patches of sand. Occasional sea cucumber and sponge. Moderate bioturbation evidenced through mounds and burrows. One cartilaginous fish (ray).	Sand.	Unvegetated sand, discontinuous multi-specific seagrass (<i>Enhalus</i> , <i>Cymodocea</i>) and continuous <i>Enhalus</i> and <i>Cymodocea</i> .	Sand.	Dense continuous seabed meadow of <i>Enhalus</i> and <i>Cymodocea</i> .
SG-12	1	Soft sediments often covered	Site transitions between dense multi-	Soft sediments and patchy coral rubble.	Site transitions between dense, multi-specific	Soft sediments and patchy	Patchy dense multi-specific seagrass,	Low profile patchy reef,	<i>Sargassum</i> common on areas of reef/rubble.	Low profile patchy reef, rubble and	Mixed mosaic of macrophytes and biota mainly dominated by

Site	Depth (m)	2010 Observations		2011 Observations		2012 Observations		2014 Observations		2019 Observations	
		Seabed Type(s)	Biota	Seabed Type(s)	Biota	Seabed Type(s)	Biota	Seabed Type(s)	Biota	Seabed Type(s)	Biota
		in coral rubble.	specific seagrass growth into an area of mixed <i>Sargassum</i> / seagrass growth.		seagrass growth, areas of mixed <i>Sargassum</i> / seagrass growth, and monospecific stands of <i>Sargassum</i> . Occasional small reef fish (unidentified) observed.	coral rubble.	areas of mixed <i>Sargassum</i> and seagrass growth, some invertebrates (sponges) on hard substrate.	rubble and sand.	Some patches of <i>Enhalus</i> on rubble and sand. Numerous fish around reef outcrops. Patches of <i>Enhalus</i> and <i>Cymodocea</i> over last third of transect.	sand / soft sediments.	<i>Sargassum</i> with <i>Padina</i> , limited seagrass, a single observed anemone and solitary corals associated with areas of reef/rubble. Dense <i>Enhalus</i> and <i>Cymodocea</i> meadows on sand.
SG-13	2	Soft sediments throughout site, with abundance of rubble corresponding to increasing density of <i>Sargassum</i> .	Transect initially characterised by section of dense multi-specific seagrass, transitioning into dense, monospecific macroalgae (<i>Sargassum</i>) bed. Small reef fish observed, though uncommon.	Soft sediments throughout site, with abundance of rubble corresponding to increasing density of <i>Sargassum</i> .	Transect initially characterised by section of dense multi-specific seagrass, transitioning into dense, monospecific macroalgae (<i>Sargassum</i>) bed. Small reef fish observed, though uncommon.	Soft sediments and coral rubble. Some patches of bare sand with visible waves.	Site transitions from multi-specific seagrass growth to mostly coral rubble supporting moderate <i>Sargassum</i> growth. Few fish sighted. Some invertebrates (sponges) on hard substrate.	Sand and coral rubble over first third of transect. Patchy reef, boulders, rubble and sand over remaining two thirds of transect.	Mostly continuous multi-specific seagrass (<i>Enhalus</i> , <i>Syringodium</i> , <i>Cymodocea</i>). Some gaps in seagrass where seagrass bed eroded (with signs of recolonisation by seagrass). <i>Sargassum</i> , <i>Padina</i> and other macroalgae on areas of reef, rubble and boulder. Some small fish around reef and boulders.	Combination of sediments and rubble throughout site, generally corresponding to depth.	Dense <i>Sargassum</i> associated with increasing abundance of rubble and depth. Dense <i>Cymodocea</i> and <i>Syringodium</i> seagrass beds with occasional sparse areas present in shallows. Some small damselfish, dwarf angelfish, wrasse and butterflyfish around rubble and boulders. Single guitarfish observed on sand patch in seagrass meadow.

Table 2 Coral and fish monitoring sites

Site	Video Quality	Depth (m)	Seabed Type(s)	Biota	Changes Compared with Previous Surveys
CF-01	Fair. Seabed features occasionally unidentifiable and particulate matter in water column visible reduced visibility.	2 – 5	Soft sediment, rubble, coral reef and rock outcrops.	Areas of low-complexity rock/reef structure and rubble colonised by coralline and filamentous algae. Intact hard corals including some large colonies of <i>Porites</i> and numerous branching <i>Acropora</i> also observed both in isolation and on areas of higher complexity reef structure. The transect crossed patches of soft seabed colonised by intermittent seagrass beds of variable diversity and density (mainly <i>Cymodocea</i> spp.) and macroalgae (<i>Sargassum</i> sp.) growth. Bioturbation present in bare soft sediments via (occasionally large) mounds and burrows. Low numbers of reef-associated surgeonfish, bream, triggerfish, butterflyfish, and damselfish spp. observed.	Site ecological characteristics similar to past surveys. Observed differences include a slightly higher prevalence of live hard corals on intact reef.
CF-02	Good. Major seabed features largely identifiable.	7 – 8	Soft sediment, expansive areas of coral rubble, and moderate relief rocky / coral outcrops and bombyra. Occasionally high though typically low structural complexity.	Most rock colonised by coralline, filamentous and macroalgae (mainly <i>Halimeda</i> and some <i>Turbinaria</i>) growth, with extensive hard coral, soft coral and sponge growth present on some sections of reef structure. Very dense concentrations of <i>Junceella</i> sp. sea whip growth present on some areas of hardstand benthic structures. Patchy coral growth also observed amongst lower relief areas of rubble. Abundant bioturbation (mounds and burrows) and microphytobenthos present in areas of soft sediment. Fish including bream, butterflyfish, and damselfish some were seen around coral formations.	Site had similar ecological characteristics to past surveys, though more extensive coral growth observed in 2019.
CF-03	Good. Seabed features largely identifiable.	5 – 9	Generally low structural complexity hard substrates including coral, and extensive rubble coverage. Some areas of higher relief reef. Sediments between patches of hard substrate.	Scattered assemblage of reef building hard corals, with low coverage observed overall, primarily dominated by <i>Acropora</i> , <i>Turbinaria</i> and <i>Porites</i> spp. Coralline algae dominates rocky reef structure, with filamentous and macroalgal (<i>Halimeda</i> spp.) growth also observed. <i>Junceella</i> sp sea whips common while soft corals, sponges and sea fans occur as isolated colonies. Numerous small reef associated-fish including wrasse, dwarf angelfish, surgeonfish, bream, goatfish, butterflyfish, and damselfish spp. observed around intact hard corals.	Site ecological characteristics remained similar to past surveys.
CF-04	Good. Seabed features largely identifiable.	7 – 9	Extensive reef area in this location. Seabed varies between intact high complexity to	Individual hard corals colonise contiguous reef/rock habitat (many moderately sized table and branching growth form <i>Acropora</i> and <i>Pocillopora</i> , massive and encrusting growth form <i>Porites</i> , <i>Platygyra</i> , and <i>Favid</i> (<i>Faviidae</i>) sp. and others). Coral rock, rubble and abiotic coral skeletons primarily colonised by various macro algae (mostly <i>Halimeda</i> ,	Structural site characteristics generally consistent with previous surveys however three-dimensional complexity visibly increased in 2019, potentially due

Site	Video Quality	Depth (m)	Seabed Type(s)	Biota	Changes Compared with Previous Surveys
			patchy rubble/rock base. Rubble and soft sediments between areas of hard substrate.	<i>Turbinaria</i> , coralline and filamentous algae). Numerous small and solitary corals including <i>Fungia</i> and <i>Herpolitha</i> present. Gorgonians (sea whips) observed in small patches. Tridacnid clam, granulated sea star (<i>Choriaster granulatus</i>) and urchins observed. Numerous small reef-associated and reef-attached fish present. Bioturbation (mounds and burrows) prominent on soft sediments.	to variance of transect alignment. Limited observations of sedimentation (fewer than 2012). <i>Sargassum</i> observed in 2012 not present in 2019 survey.
CF-07 – CF10	Good. Seabed features largely identifiable.	3 – 6	Variable, though generally low to moderate complexity intact rock/reef structure. Soft sandy sediments and rubble between areas of fragmented rock/reef.	Majority of biota present on generally low relief coral rock/reef, colonised by filamentous and red coralline algae, <i>Sargassum</i> , <i>Turbinaria</i> and <i>Halimeda</i> (macroalgae). <i>Sargassum</i> growth is dense and conspicuous in some locations due to size and coverage of plants. Live hard coral growth is patchy and generally scattered despite substantial amount of rock/reef structure. Individual large reef-building hard corals mainly include table growth form <i>Acropora</i> spp., massive and encrusting growth form <i>Platygyra</i> , <i>Goniastrea</i> , <i>Faviid</i> , <i>Symphyllia</i> , and <i>Porites</i> , branching <i>Seriatopora</i> , <i>Stylophora</i> , <i>Pocillopora</i> , and other spp. Most corals healthy though some abiotic coral skeletons observed. <i>Tridacnid</i> sp. clam, feather stars, sponges, sea urchins observed. Gorgonians (<i>Junceella</i> sp.) numerous in some areas, soft corals uncommon. Various small reef associated fish species, including schools of fusilier. Bioturbation (mounds and burrows) common on soft sediments.	Very similar ecological characteristics to 2014 survey. Patches of reef include a mosaic of <i>Sargassum</i> , <i>Turbinaria</i> , <i>Halimeda</i> , and filamentous and red coralline algae growth. <i>Sargassum</i> remains dominant macrophyte biota. Sedimentation present in 2012 which was not typically observed in 2014, was also not observed in 2019.
CF-11	Fair. Seabed features occasionally unidentified. Generally low water clarity due to high particulate content.	7 – 10	Predominantly discontinuous low rugosity reef, with some areas of higher relief. Extensive rubble present amidst fragmented reef.	Intact sections of reef were generally of low species diversity, though this increases in association with areas of higher structural complexity. Signs of degradation were observed, with high volumes of rubble and some sedimentation present away from intact reef, and most reef fragments and rubble colonised by macroalgae and filamentous algae. Individual hard corals of varying size are scattered sparsely over reef/rock habitat, mostly table and branching growth form <i>Acropora</i> and <i>Porites</i> spp. Occasional soft corals (<i>Sinularia</i> and <i>Sarcophyton</i> spp.), gorgonians and sponges (<i>Petrosiidae</i> and other) also observed. Reef-associated fish fauna was typically present around intact hard coral formations.	Overall, ecological characteristics were similar to past surveys. Similar high visible presence of rubble with some sedimentation present away from intact reef.
CF-12	Good. Seabed features generally identifiable.	9 – 10	Coral rubble and generally low to moderate complexity, low profile coral reef. Occasional larger coral bomboras.	Site transitions low complexity rubble/coral fragments colonised by coralline red algae, filamentous algae and other macroalgae, and higher complexity, typically patchy reef with a mosaic of soft coral and hard coral growth. Some larger connected and well-established areas of mixed hard coral growth, gorgonians and anemones also observed. Moderate diversity and abundance of fish primarily associated with intact coral formations, including damselfish (Pomacentridae), anemonefish (Amphiprioninae) surgeonfish (Acanthuridae), bream (Nemipteridae), goatfish (Mullidae), pufferfish (Tetraodontidae), butterflyfish (Chaetodontidae), wrasse (Labridae), dwarf angelfish (Pomacanthidae) grouper (Serranidae) and triggerfish (Balistidae).	Site ecological characteristics remained broadly similar to past surveys. Changes include an absence of <i>Sargassum</i> (observed previously), and coral growth appears to have increased in established areas.

Site	Video Quality	Depth (m)	Seabed Type(s)	Biota	Changes Compared with Previous Surveys
CF-13	Good. Seabed features generally identifiable.	9 – 10	Rubble and fragmented reef of variable, though generally low complexity. Occasional larger coral bomboras. Soft sediments in patches between reef/rubble.	Most of this site is characterised by extensive coral rubble spread across the seabed, that is colonised by calcareous coralline and macroalgae, and filamentous algae. Overall, the ecosystem features exist in a degraded state, however scattered and occasionally large solitary colonies of <i>Porites</i> , <i>Acropora</i> , gorgonians, sponges and soft corals (<i>Sarcophyton</i> and <i>Sinularia</i> sp.) are present. Isolated small colonies of various species are also present. Other hard coral growth is limited to occasional moderately diverse and structurally complex reef structure in some areas (species including <i>Favites</i> , <i>Turbinaria</i> , <i>Symphyllia</i> , <i>Acropora</i> and <i>Porites</i>). Some bioturbation present in soft sediment. Occasional observations of small reef fish including goatfish, butterflyfish, damselfish, dwarf angelfish, wrasse, and surgeonfish.	Site retains similar ecological characteristics to past surveys, however prominent <i>Pavona</i> sp. 'Cactus Coral' observed in 2014 not readily observable. This colony may not have been captured by video records in 2019 or may have degraded further and become abiotic/rubble.
CF-14	Fair. Seabed features occasionally unidentified.	9 – 11	Mostly fine soft sediments, patches of rubble and fragmented reef.	Site mainly characterised by soft sediments and rock/rubble outcrops. Live hard corals are uncommon due to the fragmented hardstand substrates, however, occasionally large <i>Acropora</i> , <i>Porites</i> , <i>Turbinaria</i> and <i>Faviid</i> corals are present. Some large individual barrel sponges (Petrosiidae), gorgonians and soft corals (<i>Sarcophyton</i>) were also observed. An extremely large <i>Pavona</i> clavus colony spanning several metres and providing habitat for numerous small reef fish, was observed, as in prior surveys. Some abiotic sections of the coral skeleton were observed, likely due to the colony growing and splitting over time. Echinoderms (cushion stars, basket stars and sea cucumbers) observed around very large intact. Bioturbation (mounds) and organic debris present on soft sediments/rubble.	Site retains similar ecological characteristics to past surveys. The very large <i>Pavona</i> colony seen in previous surveys (aside from 2014) was again observed and appeared to be in similar condition to those surveys.
CF-15	Fair. Seabed features often unidentified and not all footage usable.	5 – 6	Mix of extensive generally low-profile reef and also soft sediments with rubble / organic matter. Occasional larger bomboras.	In intact sections of reef, scattered hard corals mainly comprise <i>Porites</i> and <i>Acropora</i> , with occasional signs of damage observed. Small reef fish are common in association with corals, particularly one very large coral colony (<i>Leptoria</i> sp.), and generally absent elsewhere. Rubble and fragmented reef substrates are largely colonised by macroalgae and filamentous algae with some sedimentation present. Solitary gorgonians and soft corals are also present in areas of fragmented reef. Relatively little hardstand calcareous habitat and consequently low biological diversity in latter portion of transect (mainly uniform soft sediment), with limited bioturbation (small mounds) observed.	Small differences in transect position appear to have resulted in observable differences between surveys. In 2011 site was characterised as soft sediments, in 2012 and 2014 survey identified areas of intact, though low-quality reef and various sessile invertebrates. In 2019 site traversed intact reef, fragmented rubble habitat and areas of soft sediment, no seagrass observed.
CF-16	Good. Seabed features generally identifiable.	3 – 6	Coral rubble, fine sandy sediment, patchy reef and limestone outcrops	Site supports a highly mixed assemblage of seagrass, macroalgae, fragmented rock and rubble, and some substantial coral growth, mainly on low rugosity seabed. Intact hard coral growth largely comprises <i>Acropora</i> and <i>Porites</i> spp, usually in the form of numerous isolated large colonies though some intact complex aggregations are present. Some sea whips,	Similar ecological characteristics to past surveys, however coral growth appeared to be more developed with larger and healthier corals present.

Site	Video Quality	Depth (m)	Seabed Type(s)	Biota	Changes Compared with Previous Surveys
				anemones and bioturbation (small mounds) present around soft sediments/rubble and seagrass.	
CF-17	Good. Seabed features generally identifiable.	5 – 7	Extensive coral reef structure surrounded by fine sandy sediments and coral rubble.	Diverse and complex high relief reef structure containing extensive intact and healthy (no obvious disease or bleaching) hard coral, soft coral, gorgonian and sponge growth. Areas of dead coral and rubble primarily limited to reef fringe. Macroalgae (<i>Turbinaria</i>) occasionally observed on reef structure in areas where coral is absent. Reef associated fish species common near live coral, mainly including damselfish (Pomacentridae), surgeonfish (Acanthuridae), wrasse (Labridae), fusiliers, (Caesionidae), butterflyfish (Chaetodontidae) and Angelfish (Centropyge).	Site ecological characteristics very similar to past surveys. No noteworthy visual change. The 2019 transect alignment appears to have deviated somewhat from the main reef, hence a higher proportion of fragmented reef, rubble and sediment was present in some sections of the video.

APPENDIX H: CORAL AND FISH SITE FISH COUNTS

Table 1a Coral and fish site CF-01, CF-02, CF-03, CF-04, CF-07 – CF-10, CF-11 fish counts (2019)

CF-01	CF-02	CF-03	CF-04	CF-07 – CF-10	CF-11
Moorish Idol (<i>Zanclus cornutus</i>) ¹	Surgeonfish (<i>Ctenochaetus</i> spp.) ²	Bream (<i>Scolopsis</i> sp.) ²	Surgeonfish (<i>Acanthurus</i> spp.) ²	Moorish Idol (<i>Z. cornutus</i>) ¹	Moorish Idol (<i>Z. cornutus</i>) ¹
Damselfish (Pomacentridae spp.) ³	Damselfish (Pomacentridae spp.) ²	Surgeonfish (<i>Acanthurus</i> spp.) ³	Damselfish (<i>Neopomacentrus</i> spp.) ³	Damselfish (Pomacentridae spp.) ³	Blue Devil Damselfish (<i>Chrysiptera cyanea</i>) ³
Surgeonfish (<i>Zebrasoma</i> spp.) ¹	Damselfish (<i>Dascyllus</i> spp.) ³	Surgeonfish (<i>Ctenochaetus</i> spp.) ²	Damselfish (Pomacentridae spp.) ³	Damselfish (<i>Neopomacentrus</i> spp.) ³	Damselfish (<i>Dascyllus</i> sp.) ²
Wrasse (Labridae spp.) ¹	Vagabond Butterflyfish (<i>Chaetodon vagabundus</i>) ¹	Damselfish (Pomacentridae spp.) ³	Damselfish (<i>Dascyllus</i> sp.) ²	Damselfish (<i>Amblyglyphidodon</i> sp.) ³	Bream (<i>Scolopsis</i> sp.) ¹
Butterflyfish (Chaetodontidae spp.) ²	Humphead Bannerfish (<i>Heniochus varius</i>) ¹	Damselfish (<i>Dascyllus</i> spp.) ³	Damselfish (<i>Amblyglyphidodon</i> sp.) ¹	Damselfish (<i>Chromis</i> spp.) ²	Wrasse (Labridae spp.) ³
Vagabond Butterflyfish (<i>C. vagabundus</i>) ¹	Wrasse (Labridae spp.) ³	Damselfish (<i>Chromis</i> spp.) ²	Damselfish (<i>Stegastes</i> spp.) ³	Damselfish (<i>Stegastes</i> spp.) ³	Bluestreak Cleaner Wrasse (<i>Labroides dimidiatus</i>) ¹
Bream (<i>Scolopsis</i> sp.) ²	Sweetlips (<i>Plectorhinchus</i> sp.) ¹	Pufferfish (<i>Arothron</i> sp.) ¹	Damselfish (Chrysiptera spp.) ²	Damselfish (<i>Dascyllus</i> spp.) ³	Bicolour Angel (<i>C. bicolour</i>) ¹
Titan Triggerfish (<i>Balistoides viridescens</i>)	Long-beaked Coralfish (<i>Chelmon rostratus</i>) ¹	Bicolour Angel (<i>C. bicolour</i>) ²	Damselfish (<i>Chromis</i> spp.) ²	Eastern Triangular Butterflyfish (<i>Chaetodon baronessa</i>) ¹	Grouper (Serranidae sp.) ¹
Other unidentifiable spp. ³	Pearl-scaled Angelfish (<i>Centropyge vroliki</i>) ¹	Goatfish (<i>Parupeneus</i> spp.) ¹	Vagabond Butterflyfish (<i>C. vagabundus</i>) ¹	Wrasse (Labridae spp.) ³	Bicolour Goatfish (<i>Parupeneus barberinoides</i>) ¹
	Bream (<i>Scolopsis</i> spp.) ²	Redfin Butterflyfish (<i>Chaetodon lunulatus</i>) ¹	Bluespot Butterflyfish (<i>C. plebeius</i>) ¹	Bluestreak Cleaner Wrasse (<i>L. dimidiatus</i>) ¹	Vagabond Butterflyfish (<i>C. vagabundus</i>) ¹
	Grouper (Serranidae sp.) ¹	Long-beaked Coralfish (<i>C. rostratus</i>) ¹	Redfin Butterflyfish (<i>C. lunulatus</i>) ¹	Bream (<i>Scolopsis</i> sp.) ³	Butterflyfish (<i>Coradion</i> sp.) ¹
	Other unidentifiable spp. ³	Vagabond Butterflyfish (<i>C. vagabundus</i>) ²	Masked Bannerfish (<i>Heniochus monoceros</i>) ¹	Grouper (Serranidae sp.) ¹	Flagtail Triggerfish (<i>S. chrysopterus</i>) ¹
		Highfin Coralfish (<i>Coradion altivelis</i>) ¹	Eastern Triangular Butterflyfish (<i>C. baronessa</i>) ²	Hogfish (<i>Bodianus</i> sp.) ¹	Checkerboard Wrasse (<i>H. hortulanus</i>) ¹

CF-01	CF-02	CF-03	CF-04	CF-07 – CF-10	CF-11
		Bluespot Butterflyfish (<i>C. plebeius</i>) ¹	Bluestreak Cleaner Wrasse (<i>L. dimidatus</i>) ¹	Saddled Butterflyfish (<i>Chaetodon ephippium</i>) ¹	Saddled Toby (<i>Canthigaster valentini</i>) ¹
		Butterflyfish (Chaetodontidae spp.) ²	Wrasse (Labridae spp.) ³	Blueblotch Butterflyfish (<i>C. plebeius</i>) ¹	Saddled Butterflyfish (<i>C. ephippium</i>) ¹
		Speckled Butterflyfish (<i>Chaetodon citrinellus</i>) ¹	Hogfish (<i>Bodianus</i> sp.) ¹	Butterflyfish (Chaetodontidae spp.) ¹	Surgeonfish (<i>Ctenochaetus</i> spp.) ³
		Saddled Butterflyfish (<i>C. ephippium</i> spp.) ¹	Longnose Filefish (<i>Oxymonacanthus longirostris</i>) ¹	Surgeonfish (Acanthuridae spp.) ²	Six-line wrasse (<i>Pseudocheilinus hexataenia</i>) ¹
		Sunburst butterflyfish (<i>C. kleinii</i>) ²	Fusilier (Caesionidae sp.) ²	Redfin Butterflyfish (<i>C. lunulatus</i>) ²	Parrotfish (Scarinae spp.) ¹
		Wrasse (Labridae spp.) ²	Triggerfish (<i>Balistidae</i> sp.) ¹	Vagabond Butterflyfish (<i>C. vagabundus</i>) ¹	Barred Rabbitfish (<i>Siganus doliatus</i>) ¹
		Bluestreak Cleaner Wrasse (<i>L. dimidatus</i>) ¹	Sunburst butterflyfish (<i>C. kleinii</i>) ¹	Long-beaked Coralfish (<i>C. rostratus</i>) ¹	Highfin Coralfish (<i>C. altivelis</i>) ¹
		Flagtail Triggerfish (<i>Sufflamen chrysopterum</i>) ¹	Other unidentifiable spp. ²	Sweeper (<i>Pempheridae</i> sp.) ¹	Other unidentifiable spp. ³
		Saddled Toby (<i>C. valentini</i>) ¹		Goatfish (<i>Parupeneus</i> sp.) ²	
		Other unidentifiable spp. ³		Other unidentifiable spp. ³	

Table 1b Coral and fish site CF-12, CF-13, CF-14, CF-15, CF-16, CF-17 fish counts (2019)

CF-12	CF-13	CF-14	CF-15	CF-16	CF-17
Surgeonfish (Acanthurus spp.) ²	Moorish Idol (<i>Z. cornutus</i>) ¹	Surgeonfish (Acanthuridae sp.) ¹	Surgeonfish (Acanthurus spp.) ¹	Damselfish (Pomacentridae spp.) ¹	Moorish Idol (<i>Z. cornutus</i>) ¹
Surgeonfish (Acanthurus spp.) ²	Moorish Idol (<i>Z. cornutus</i>) ¹	Surgeonfish (Acanthuridae sp.) ¹	Surgeonfish (Acanthurus spp.) ¹	Damselfish (Pomacentridae spp.) ¹	Moorish Idol (<i>Z. cornutus</i>) ¹
Damselfish (Pomacentridae spp.) ³	Surgeonfish (Acanthuridae spp.) ³	Damselfish (<i>Neopomacentrus</i> spp.) ²	Damselfish (Pomacentridae spp.) ³	Damselfish (<i>Stegastes</i> spp.) ²	Surgeonfish (<i>Ctenochaetus</i> spp.) ²
Damselfish (<i>Dascyllus</i> sp.) ³	Bicolour Angel (<i>Centropyge bicolour</i>) ²	Damselfish (Pomacentridae) ³	Regal Demoiselle (<i>Neopomacentrus taeniurus</i>) ³	Clown Anemonefish (<i>Amphiprion percula</i>) ¹	Surgeonfish (Acanthurus spp.) ²
Damselfish (Amphiprion sp.) ³	Damselfish (<i>Neopomacentrus</i> spp.) ²	Damselfish (<i>Chromis</i> spp.) ³	Three-spot Dascyllus (<i>Dascyllus trimaculatus</i>) ¹	Damselfish (<i>Chromis</i> spp.) ²	Surgeonfish (<i>Zebrasoma</i> spp.) ²
Damselfish (<i>Dascyllus aruanus</i>) ³	Damselfish (Pomacentridae spp.) ²	Damselfish (<i>Dascyllus</i> spp.) ²	Bream (Scolopsis sp.) ²	Blueblotch Butterflyfish (<i>Chaetodon plebeius</i>) ¹	Blue Devil Damselfish (<i>C. cyanea</i>) ²
Bicolour Angel (<i>C. bicolour</i>) ²	Damselfish (<i>Amblyglyphidodon</i> sp.) ¹	Bream (<i>Scolopsis</i> sp.) ²	Longfin Bannerfish (<i>Heniochus acuminatus</i>) ¹	Vagabond Butterflyfish (<i>C. vagabundus</i>) ¹	Damselfish (<i>Neopomacentrus</i> spp.) ²
Bream (Scolopsis sp.) ²	Damselfish (<i>Dascyllus</i> sp.) ³	Wrasse (Labridae spp.) ³	Picasso Triggerfish (<i>Rhinecanthus aculeatus</i>) ¹	Wrasse (Labridae spp.) ¹	Damselfish (<i>Neoglyphidodon</i> spp.) ²
Flagtail Triggerfish (<i>Sufflamen chrysopterus</i>) ²	Bicolour Fangblenny (<i>Plagiotremus laudandus</i>) ¹	Bluestreak Cleaner Wrasse (<i>L. dimidatus</i>) ¹	Wrasse (Labridae spp.) ²	Stingray (<i>Dasyatidae</i> sp.) ¹	Scissortail Sergeant (<i>Abudefduf sexfasciatus</i>) ³
Wrasse (Labridae spp.) ³	Vagabond Butterflyfish (<i>C. vagabundus</i>) ¹	Blenny (Blennidae) ²	Long-beaked Coralfish (<i>C. rostratus</i>) ¹	Other unidentifiable spp ²	Damselfish (<i>Stegastes</i> spp.) ³
Bluestreak Cleaner Wrasse (<i>L. dimidatus</i>) ¹	Blueblotch Butterflyfish (<i>C. plebeius</i>) ¹	Anthias sp. (Serranidae) ³	Redfin Butterflyfish (<i>C. lunulatus</i>) ¹		Damselfish (<i>Dascyllus</i> spp.) ³
Checkerboard Wrasse (<i>Halichoeres hortulanus</i>) ¹	Butterflyfish (Chaetodontidae spp.) ¹	Sandperch (<i>Parapercis</i> sp.) ¹	Blueblotch Butterflyfish (<i>C. plebeius</i>) ¹		Damselfish (<i>Amblyglyphidodon</i> spp.) ²
Vagabond Butterflyfish (<i>C. vagabundus</i>) ²	Long-beaked Coralfish (<i>C. rostratus</i>) ¹	Other unidentifiable spp. ³	Other unidentifiable spp ³		Damselfish (<i>Chromis</i> spp.) ³

CF-12	CF-13	CF-14	CF-15	CF-16	CF-17
Sunburst butterflyfish (<i>Chaetodon kleinii</i>) ¹	Bicolour Angel (<i>C. bicolour</i>) ¹				Damselfish (<i>Chrysiptera</i> spp.) ²
Saddled Butterflyfish (<i>C. ephippium</i> spp.) ¹	Goatfish (Mullidae sp.) ¹				Sunburst butterflyfish (<i>C. kleinii</i>) ²
Bicolour Goatfish (<i>P. barberinoides</i>) ¹	Dash-dot Goatfish (<i>Parupeneus barberinus</i>) ¹				Vagabond Butterflyfish (<i>C. vagabundus</i>) ¹
Saddled Toby (<i>C. valentini</i>) ¹	Bicolour Goatfish (<i>P. barberinoides</i>) ¹				Speckled Butterflyfish (<i>C. citrinellus</i>) ¹
Orange-Lined triggerfish (<i>Balistapus undulatus</i>) ¹	Saddled Toby (<i>C. valentini</i>) ¹				Eastern Triangular Butterflyfish (<i>C. baronessa</i>) ¹
Barred Rabbitfish (<i>Siganus doliatus</i>) ²	Bluestreak Cleaner Wrasse (<i>L. dimidatus</i>) ¹				Redfin Butterflyfish (<i>C. lunulatus</i>) ¹
Highfin Coral Grouper (<i>Plectropomus oligacanthus</i>) ¹	Wrasse (Labridae spp.) ²				Blueblotch Butterflyfish (<i>C. plebeius</i>) ¹
Blueblotch Butterflyfish (<i>C. plebeius</i>) ¹	Bridled Monocle Bream (<i>Scolopsis bilineatus</i>) ¹				Jansen's Wrasse (<i>Thalassoma janseni</i>) ¹
Parrotfish (Scarinae spp.) ²	Other unidentifiable spp ²				Bluestreak Cleaner Wrasse (<i>L. dimidatus</i>) ²
Long-beaked Coralfish (<i>C. rostratus</i>) ¹					Wrasse (Labridae spp.) ³
Other unidentifiable spp. ³					Checkerboard Wrasse (<i>H. hortulanus</i>) ¹
					Hogfish (<i>Bodianus</i> sp.) ¹
					Goatfish (<i>Parupeneus</i> sp.) ²
					Bicolour Angel (<i>C. bicolour</i>) ¹

CF-12	CF-13	CF-14	CF-15	CF-16	CF-17
					Bluestreak Fusilier (<i>Pterocaesio</i> tile) ³
					Regal Angelfish (<i>Pygoplites diacanthus</i>) ¹
					Bream (<i>Lethrinidae</i> spp.) ²
					Parrotfish (<i>Scarinae</i> spp.) ¹
					Pennant Bannerfish (<i>H. acuminatus</i>) ¹
					Squirrelfish (<i>Holocentridae</i> sp.) ²
					Triggerfish (<i>Balistidae</i> sp.) ¹
					Other unidentifiable spp. ³

¹ Relatively low abundance: < 5 individuals observed.

² Moderate abundance: 6 – 20 individuals observed.

³ Relatively high abundance: >20 individuals observed.

APPENDIX I: MARINE MACROBENTHIC INFAUNA DATA



Project No: 2022-0693

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14 December 2022

**Tetra Tech Coffey
1/254 Montreal Street
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New Zealand**

Dear Ivan Steward,

Thank you for considering Benthic Australia Pty Ltd for your project deliverables. This document sets out the methods for laboratory taxonomy and a summary report of benthic communities.

If you have any further inquiries, please don't hesitate to contact me.

Yours Faithfully

Shona Menzies

Shona Menzies MPhil (Marine Ecology)

Director/ Principal Aquatic Ecologist
Benthic Australia Pty Ltd



Introduction

Tetra Tech Coffey conducted benthic communities' surveys in Papua New Guinea. Sediment samples were collected from a shallow inshore water location for the purpose of accessing the benthic faunal community structure. Due to no replication been done at each site, only a basic discussion can be presented in this report on these communities.

Methodology

Macro-invertebrate Taxonomy

Benthic samples were securely packed and transported to Benthic Australia laboratory in Gladstone Queensland. On receiving the samples, all were unpacked and checked to ensure their integrity.

The ethanol from the sample was drained into a storage container through a 500um sieve to capture any fauna. The remaining sample was then poured into the sieve, and using water from a bench tap excess mud/ fine particles and residue ethanol were washed away.

Once sieved, the remaining sample was placed into a petri-dish. Laboratory picking was conducted under a dissecting-microscope, with all benthic fauna being removed from the sediment. Picking quality assurance checks were done on 10% of the total samples (1 samples), with a <5% picking error rate. If the picking error was above 5% then previous samples are checked, until a satisfactory error rate is met. All picked benthic fauna are stored in separate sample vials with 70% ethanol.

Benthic fauna is defined as animals that live on or in the seabed sediment and are larger than 500um. Identification of benthic fauna was to family taxonomic level. Only fauna that live on or in the sediment where counted, and only fauna that were living at the time of sample collection were counted. Fragments of fauna (e.g., legs, worm bodies etc.) were not counted only unique segments with head structures. Benthic Australia has an extensive specimen reference collection for Northern Australia, Gulf of Carpentaria and PNG area from work conducted over the last 10 years. This reference collection was available to assist with identification of fauna.

Statistical Analysis

Statistical packages used to conduct the diversity indices P.A.S.T v2.17b (Hammer, 2001).

Diversity Indices

Diversity indices are mathematical measures of species diversity and richness that provide more information about community composition than simply using raw abundance. Four indices were selected to provide information relevant to diversity, richness and evenness, these are:



- Margalef's index (d), selected to assess the species richness;
- Shannon's index (H), selected to assess the species diversity;
- Evenness index (EH), selected to assess evenness within samples; and
- Dominance (D), selected to assess taxon dominance within the sample.

Species Richness Index (Margalef's Index) (S) is the number of species or taxa present at each sampling site. It is often represented as a single total per site; however, this is dependent on the volume of the samples collected in the grab. Species richness is more accurately represented by Margalef's index (d), which is a measure of the number of species present for a given total number of individuals. Diversity Index (Shannon-H) is the most commonly used diversity index, which accounts for both abundance and evenness of the species present.

Evenness Index (Shannon - EH) expresses how evenly the individuals are distributed among the different species. For example, if two samples each comprising 100 individuals and four species had species abundances of 25, 25, 25, 25 and 97, 1, 1, 1, then the former has high evenness and low dominance, while the latter has low evenness and high dominance. Evenness is scaled on a value between 0 and 1, with 1 being complete evenness.

Dominance (1-Simpson Index) as shown above in evenness, expresses the degree to which a taxon is more numerous than other fauna in an ecological community. Index ranges from 0 (all taxa are equally present) to 1 (one taxon dominates the community completely).

Multivariate Analysis

Cluster and multidimensional scaling (MDS) analyses were conducted. MDS were performed to find natural groupings of sample sites, based on those sites with similar faunal and community composition.

Raw abundance data was first standardised, this is essential for sampling techniques where exact sampling volumes are unknown and sampling bias can occur between replicates. Transformation is required for datasets where very abundant species could completely overshadow the rarer species when determining similarity between samples.

The MDS analysis was based on a similarity matrix produced using the Bray-Curtis coefficient. The adequacy of an MDS plot is represented by a stress value, in the range of 0.0 to >0.3. Interpretation of the stress value was as follows:

- <0.05 gives an excellent representation of sites;
- <0.1 is a good ordination with no real prospect of misleading interpretation;
- <0.2 still gives a potentially useful ordination, although values at the upper end of this scale should not be relied upon in great detail.
- >0.3 indicates that the points are close to being arbitrary and placement of sites within the ordination is completely random.

SIMPER (Similarity Percentage) is a simple method for assessing which taxa are primarily responsible for an observed similarity between sites on the MDS.



Results

The sediment collected was primarily a thick sticky mud/clay. After washing through a 500um sieve the remaining material was approximately 250g to 400g ($\frac{1}{2}$ cup to 1 cup of material), this was made up of broken shell and shell grit mixed with sand. Site SED32 had become anoxic at the bottom of the sample jar (Figure 1).



Figure 1: Samples jar of site SED32 with anoxic base.

In total, 104 individuals from 33 taxonomic families were collected during the survey. The top three most abundant species across all sites were the sea flea, *Melitidae* ($n=13$); the tanaid, *Apseudidae* ($n=13$) and the peanut worm ($n=10$) (Figure 1). Fauna across the survey area consisted of a mixture of smaller individuals and larger mature individuals, indicating that the community was an established population, that had not experienced any recent environmental disturbances (e.g., Cyclones; freshwater inundation).



Figure 2: Representative images of the top three most abundant fauna. Not to scale. (A) *Melitidae* 1; (B) *Apseudidae*; (C) *Sipuncula*. Photo by Benthic Australia Pty Ltd

Sites presented with between 6 to 12 taxa and 9 to 34 individuals, with very high to complete evenness. This indicates that the individual counts are distributed evenly among the different species. Dominance was low across all sites showing that no one species population dominated the area.

Raw abundance data should not be relied upon in accessing benthic communities. This is due to sampling techniques used in benthic surveys not being quantitative, exact sampling volumes are unknown and sampling bias occurs. Studies on the effectiveness of soft sediment sampling devices have been conducted by Blomqvist (1991). He found that most benthic sampling grabs yielded semi-quantitative samples only and that quantitative samples are best obtained using instruments based on coring methods. Additional, studies of the bite profile have also shown that unequal depth sampling per unit surface area is a common error when using benthic grabs (Gallardo, 1965; Riddle, 1978; Elliot & Drake, 1981).

Two Indices were selected Margalef's species richness and Shannon's-H diversity indices. Diversity was highest at site SED73 and lowest at site SEDT1. Species richness was highest at SED30 and lowest at SEDT1.

Table 1: Diversity indices across all sites

	Taxa	Individuals	Shannon-H Diversity	Margalef Species Richness	Evenness	Dominance
SED32	11	16	2.307	3.607	0.9128	0.1094
SED31	10	34	1.967	2.552	0.715	0.1747
SED73	12	17	2.395	3.883	0.9137	0.1003
SED30	11	13	2.352	3.899	0.9548	0.1006
SEDT1	6	9	1.581	2.276	0.81	0.2593
SEDT5	8	15	1.802	2.585	0.7576	0.2089

An MDS plot of Faunal composition across sites showed that SEDT1 and SEDT5 (Group 1) were similar to each other and grouped on the left of the MDS plot. While sites SED30, SED31, SED32 and SED73 (Group 2) were grouped together with more similarity on the right side of the MDS. Each of these two groups was defined by a 20% similarity in faunal composition (Figure 3).

A SIMPER analysis is used to determine which species contribute the most to the similarity between sites. Due to no replication of samples being done during the survey, the sites were grouped together based on the MDS 20% groups.

Group 1 had an overall faunal similarity of 24%, with the Sipuncula peanut-worm contributing the most to the similarity (59%). Group 2 had an overall faunal similarity of 33%, with the Apseudidae tanaid contributing the most to the similarity between sites (28%). There was an 81% dissimilarity in faunal composition between the two groups, once again the Apseudidae tanaid and the Sipuncula peanut-worm contributed the most to this difference (9% & 8% respectively).

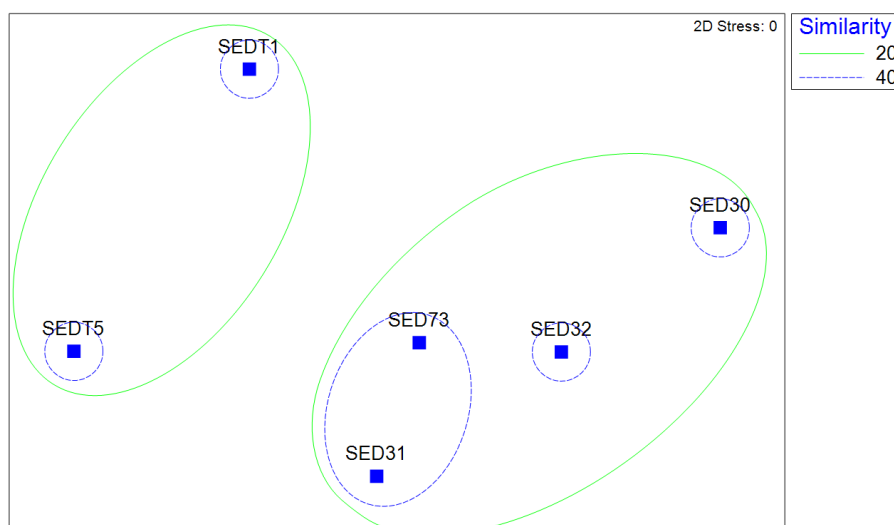


Figure 3: Faunal composition MDS plot of all sites across the survey area.

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Appendix A

Macroinvertebrate abundance dataset

Table 2: Macroinvertebrate abundance dataset

Phylum	Class/Order	Family	SED32	SED31	SED73	SED30	SED71	SED75
Annelida	Polychaeta	Amphinomidae	0	2	0	0	0	4
Annelida	Polychaeta	Capitellidae	0	0	1	0	1	1
Annelida	Polychaeta	Cossuridae	0	0	0	0	1	0
Annelida	Polychaeta	Eunicidae	0	0	2	0	0	0
Annelida	Polychaeta	Magelonidae	0	0	1	0	1	0
Annelida	Polychaeta	Nephtyidae	0	0	1	1	0	0
Annelida	Polychaeta	Nereididae	0	0	0	0	0	1
Annelida	Polychaeta	Onuphidae	1	0	1	0	0	0
Annelida	Polychaeta	Paralacydonidae	0	0	1	0	0	0
Annelida	Polychaeta	Paraonidae	0	0	0	1	0	0
Annelida	Polychaeta	Sabelleridae	0	0	0	0	0	1
Annelida	Polychaeta	Spionidae	3	0	0	1	0	0
Annelida	Polychaeta	Sternapsidae	1	1	1	0	0	1
Chordata	Actinopterygii	Actinopterygii	1	0	0	0	0	0
Cnidaria	Hydrozoa	Hydrozoa	1	0	0	0	0	0
Cnidaria	Zoanthozoa	Zoanthozoa	0	0	0	0	0	1
Crustacea	Amphipoda	Ampeliscidae	0	0	0	2	0	0
Crustacea	Amphipoda	Aoridae	0	0	0	1	0	0
Crustacea	Amphipoda	Ischyroceridae	2	5	0	1	0	0
Crustacea	Amphipoda	Melitidae	0	10	3	0	0	0
Crustacea	Brachyura	Goneplacidae	1	0	0	0	0	0
Crustacea	Copepoda	Copepoda	0	0	0	1	0	0
Crustacea	Isopoda	Anthuridea	1	0	0	0	0	0
Crustacea	Ostracoda	Ostracoda	2	0	2	2	0	0
Crustacea	Tanaidacea	Apseudidae	2	4	2	1	4	0
Crustacea	Tanaidacea	Pseudozeuxoidae	0	0	0	0	1	0
Crustacea	Tanaidacea	Tanaidae	0	7	1	0	0	0
Mollusca	Bivalvia	Bivalvia-juv	0	1	0	0	0	0
Mollusca	Bivalvia	Tellinidae	0	0	0	1	0	1
Mollusca	Gastropoda	Olividae	0	1	0	0	0	0
Nematode	Nematode	Nematode	0	1	0	0	0	0
Nemertea	Nemertea	Nemertea	0	0	0	1	0	0
Sipuncula	Sipuncula	Sipuncula	1	2	1	0	1	5

PAPUA NEW GUINEA MACROFAUNA SAMPLES COLLECTED APRIL 2019

SUBMITTED FOR
EXTRACTION AND IDENTIFICATION
BY COFFEY A TERTA TECH COMPANY

Prepared for
COFFEY A TERTA TECH COMPANY

by
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JULY 8, 2019

EXECUTIVE SUMMARY

Sixteen samples were sent for the extraction, identification and enumeration of the macrofauna. Identifications were to be made to the taxonomic level of Family.

The sediments were of silt and shells. The shells were whole or broken. Sample MI-03 also contained coral rubble. No large deposits of terrestrial organic material were encountered. Pieces of seagrass leaves were recovered in some samples, but these appeared to have been detritus and the samples did not look as if they had been collected from seagrass beds.

From the 16 samples, 971 macrofauna animals were collected and separated into 74 taxa. One sample, MI-01 was relatively depauperate with only four individuals belonging to four taxa. The next lowest number of animals in a sample was 22 and the highest 173. From the samples received, there was no obvious reason why MI-01 was depauperate.

Most of the taxa recorded were those expected to be present in Papua New Guinea inshore samples. There was one exception, Station MI-16, where 59 of the 178 animals were oligochaetes. Oligochaetes are unusual in marine samples and not expected to occur in large numbers.

Three notable characteristics of these samples were:

- the absence or low abundances of some common taxa
- the low percentage of snails and bivalve shells present
- the high proportion of small and immature specimens present.

The high proportion of immature specimens suggests that the macrofauna community was in a developmental stage when sampled. Subsequent sampling at this location may find a different macrofauna community depending on how it has evolved, or what larvae have been available for re-populating the community at the time of sampling.

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VERSION CONTROL

Version	Date	Notes on version
Original	July 08, 2019	First release

1.0 INTRODUCTION

Coffey had collected macrofauna samples from a shallow water inshore location in Papua New Guinea. The samples were prepared, fixed and preserved in the field by Coffey and forwarded to Dr Moverley in Melbourne for processing and enumeration of macrofauna at the Family taxonomic level.

1.1 MATERIAL PROVIDED

Coffey submitted 16 macrofauna samples for processing. Coffey instructed Dr Moverley to use the same methods as for past Gulf of Papua, LPG project samples.

Coffey reported that the samples had been collected by 152 x 152 mm Petit Ponar grab. Due to the substrate, difficulties were encountered in collecting samples at some stations. To collect samples, multiple partial grabs had been combined where single, good samples could not be collected. Therefore, the samples are not quantitative.

Coffey also reported samples had been washed through a 0.5 mm sieve, and then fixed and preserved in 5% seawater formalin before being shipped to Australia.

Dr Moverley processed all 16 macrofauna samples.

Coffey provided a map of the sampling stations, but due to client confidentiality, this has not been used in this Report. The samples had been collected from a location far removed from any locations previously sampled and analysed by Dr Moverley.

1.2 REPORT OBJECTIVES

This Report:

- documents the methods and procedures used for processing the samples
- records the results of the sorting, identification to the Family taxonomic level and counting for the macrobenthos samples
- documents the observations of the sediments retained on the 0.5 mm sieve when collecting the macrofauna samples
- documents any unusual observations made on the macrofauna samples.

1.3 REPORT OVERVIEW

The Report contains:

- an executive summary
- an introduction to the project
- the methods used
- the results
- a list of the references cited in this Report.

The Report includes these appendices:

- Appendix A contains details on the methods used
- Appendix B contains the macrofauna counts for the samples
- Appendix C contains a copy of the sample log book.

2.0 METHODS

For this Report, macrofauna is defined as the animals that live in or on the seabed which after preservation in seawater formalin are retained on a 0.5 mm sieve.

The samples were processed under the standards set in ISO 16665:2014(E) (Water quality – Guidelines for quantitative sampling and sample processing of marine soft-bottom macrofauna International Organization for Standardization, 2014).

Details of the methods used are given in Appendix A. The process was:

- samples were sieved on a 0.5 mm (500 µm) sieve
- fine sand (< 1 mm) and organic material were sorted under a dissecting microscope
- only animals that live in or on the sediment were counted
- taxa advised to be excluded by ISO 16665:2014(E) were recorded in the sample log but not included in the results
- only whole animals or unique segments like heads or mouth parts were counted.

2.1 SAMPLE IDENTIFICATION

The samples are identified by a set of MI codes provided by Coffey. Duplicate samples were collected from Station MI-6, which Coffey instructed be referred to as MI-6 and MI-6 (duplicate). In tables and figures, MI-6 (duplicate) has been labelled MI-6D.

3.0 RESULTS

3.1 SAMPLE OBSERVATIONS

A copy of the sample log is placed in Appendix C.

These notes were made on material sieved in the field and washed and sieved using a 0.5 mm sieve in the laboratory. These observations are of the sieved material and not the natural sediments.

The samples came from stations with a sediment of silt and shell. Most samples had only a small volume of shell present, exceptions were Stations MI-3, MI-4 and MI-16 (Figure 1).

Organic material in the samples ranged from virtually none to small amounts. Only one sample, MI-12, contained organic material that could be identified as terrestrial plant matter. Organic matter from seagrass was identified in some samples.

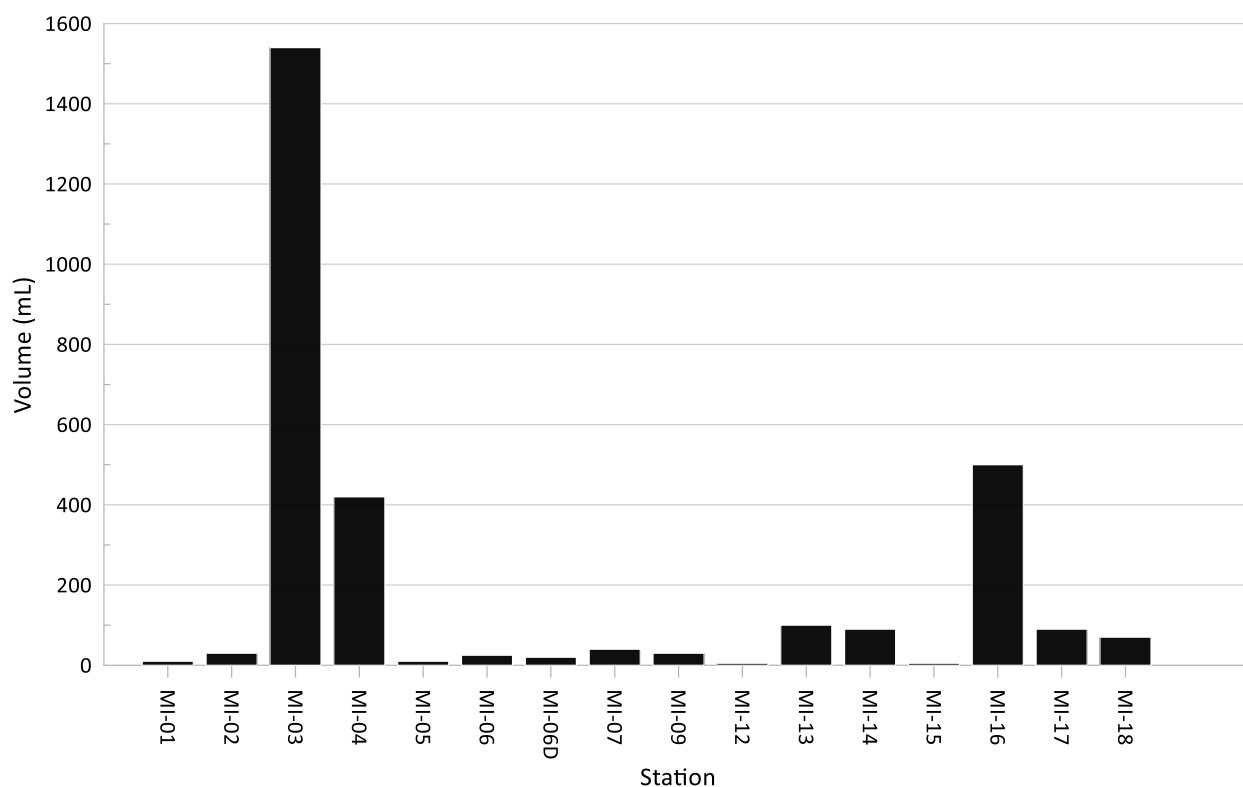


Figure 1 Volume of samples after sieving.

3.2 MACROFAUNA OBSERVATIONS

The taxonomic listing of macrofauna and the numbers collected in the samples are presented in Appendix B.

Note the data is presented in numbers per sample because quantitative samples could not be collected at all stations.

These results are summarised in Table 1, where the total numbers of macrofauna per sample are presented.

Table 1 Numbers of individuals and taxa recorded in the samples.

Sample	Individuals	Taxa
MI-01	4	4
MI-02	47	19
MI-03	117	19
MI-04	126	32
MI-05	24	14
MI-06	64	28
MI-06D	60	26
MI-07	35	17
MI-09	114	39
MI-12	58	20
MI-13	31	12
MI-14	36	18
MI-15	35	15
MI-16	173	31
MI-17	22	12
MI-18	31	16

There were 971 individuals collected in 74 taxa.

The numbers collected from the stations ranged from 4 to 173, and the taxa ranged from 4 to 39 (Table 1). The two samples from Station MI-06 were similar, 64 individuals in 28 taxa for Sample MI-06 and 60 individuals in 26 taxa for sample MI-06 (Duplicate).

Sample MI-01 had only 4 macrofauna individuals. The sample showed no obvious reason for the low numbers. It was a mixture of shell and silt like the other samples. The volume and appearance of the sample were like the other samples, and no problems were observed with the preservation and storage of the sample. The sediment did sieve down to a small volume of only 10 mL. However, there were two other samples, MI-12 and MI-15 that sieved down to lower volumes (Figure 1). These two samples had over 30 individuals in each.

In all but one sample, the taxa present were those expected to be found in shallow tropical muddy environments. The exception was Station MI-16, where 59 of the 178 animals were oligochaetes. Oligochaetes are unusual in marine samples and not expected to occur in large numbers.

The only noteworthy animal in the samples was the Leptocardii. These are cephalochordates commonly known as amphioxus or lancelets. There were 17 collected from five stations. Leptocardii is usually regarded as unusual, but this is probably because most of the benthic ecology work has been done in temperate environments. They can be locally common in tropical waters, and thus should not be considered unusual in these samples.

An obvious difference in these samples and most samples from other inshore locations is not in what taxa are present, but what taxa are absent from this location. There are several taxa expected to be common that are absent or in low abundance in these samples. This is highlighted by the Molluscs (snail and bivalve shells), which are only 3% of the total macrofauna. The absence of the Mollusc taxon Nassariidae (dog whelks) is surprising. These are generally common to abundant in muddy habitats. As the only material left after sieving the samples was shells and shell fragments, many shells were looked at in processing these samples. In all these only two dead Nassariidae shells were seen, suggesting they are rare in this location.

Data on the size distribution of individuals was not collected in this survey. However, because the samples were broken down into animals collected on 2 mm, 1 mm and 0.5 mm sieves, non-documented, general observations on size distribution were made. For most macrobenthic samples, over 80% of the animals are retained on the 1 mm and 2 mm sieves. In these samples, over 70% of animals passed through the 1.0 mm sieve and were collected on the 0.5 mm sieve. These animals appeared to be small, immature individuals. Few adult polychaetes were observed, and most crustaceans were also immature.

The observation of such a large proportion of immature animals suggests the macrofauna community was in a state of flux when the samples were collected. The area may be subjected to frequent disturbances. In such a case, being in a state of flux could be the normal condition, or the community may have been recovering from an isolated event.

It could be expected that future microbenthic sampling at this location may find a different macrobenthic community. If the macrobenthos in the location is in a constant state of flux, what is present at a future time would depend on what larvae have recently been available to repopulate the area. If the macrofauna is in recovery, then it will have evolved into a more mature community in the future.

4.0 REFERENCES

International Organization for Standardization. 2014. ISO Water quality – Guidelines for quantitative sampling and sample processing of marine soft-bottom macrofauna (ISO Standard No. 16665 Second edition 2014-01-15).

APPENDIX A METHODS

I. STAFF TRAINING AND EXPERIENCE

The samples were processed by Dr Moverley, who has been processing macrofauna samples for over 40 years. Dr Moverley has undergone training in the sorting and identification of benthos at these institutes:

- Queensland Museum
- Australian Museum
- Victorian Museum
- University of Queensland
- University of Tasmania
- Plymouth Marine Laboratory (England).

II. RECORD KEEPING

Details of the project are maintained in a dedicated folder system on an encrypted drive and backed up to encrypted cloud storage.

An electronic log is maintained for the sorting of samples. This log records general notes on the sample such as:

- estimated volume of material received
- general appearance
- volume after laboratory sieving
- material in the sieved sample
- any anomalies in fixation
- if the sample takes an excessive time to process and why.

A project management log is also maintained that records the times taken to process each sample through each step of the project.

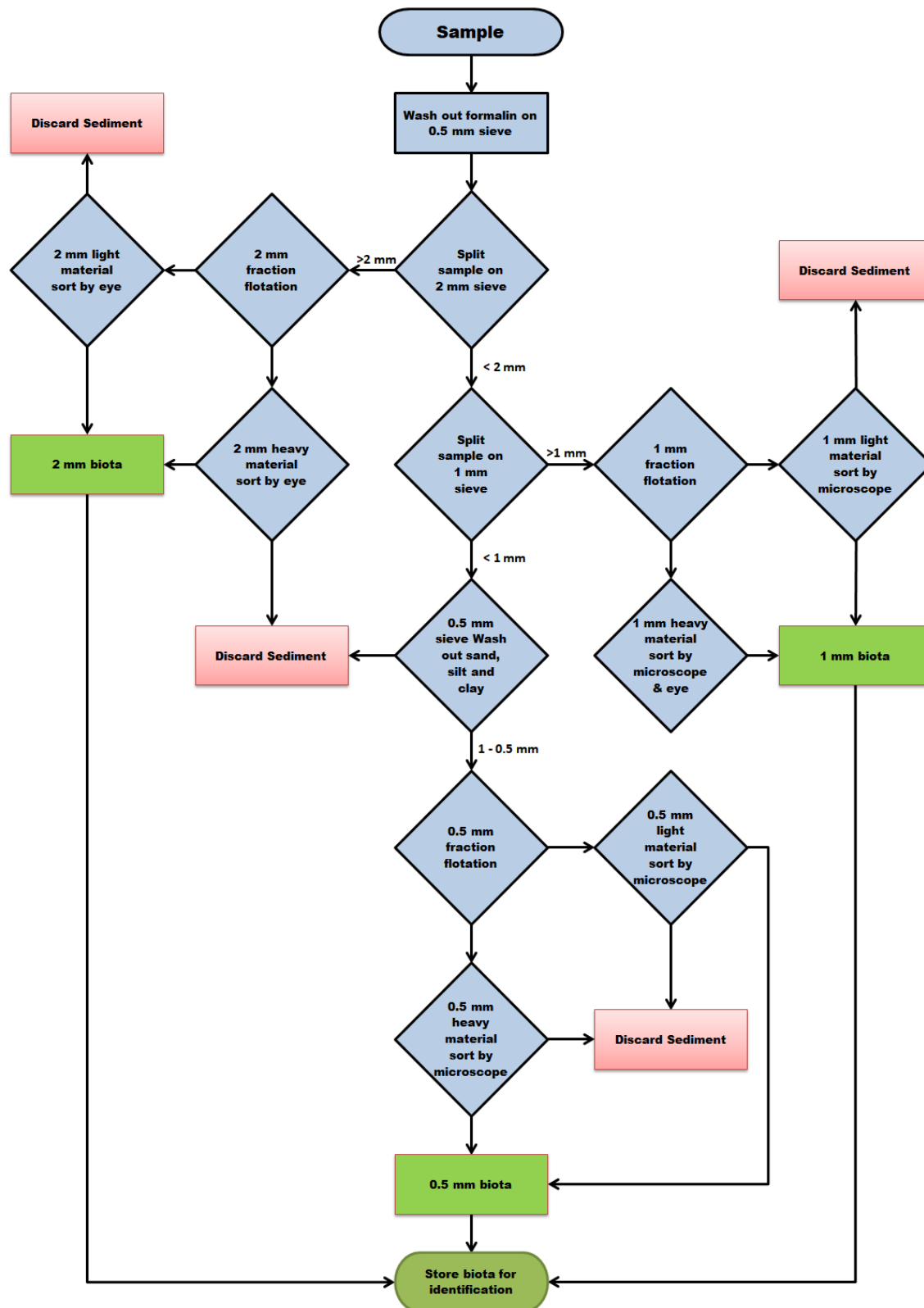


Figure A-1 Flow chart for macrofauna extraction

III. MACROFAUNA EXTRACTION

After removal from the container that the sample was shipped in, the sample is described and photographed. Additional photographs may be taken throughout the extraction process when required. Dr Moverley will archive these photographs in the project folder. The sample is washed in a 0.5 mm sieve to remove any formalin and silt remaining after washing in the field. Depending on the sample volume, the sample may be divided into manageable portions processed individually, the extracted macrofauna being combined at completion of the extractions.

The samples were split into three size fractions using 2 mm, 1 mm and 0.5 mm sieves. For each fraction, the lighter material in the sample was then separated from the sand, gravel and shell by flotation. For each fraction this was done by:

- placing the sample fraction in a sorting tray
- covering the sample with water
- suspending the lighter material by gently agitating the sample in a panning motion
- pouring the overlying water and suspended material into a 0.5 mm sieve.

This process was repeated several times until no material was being washed out.

The animals in the different size fractions were then recovered by:

- the 2 mm light fraction was placed in a sorting tray and sorted by eye
- the 2 mm heavy fraction was placed in a sorting tray and sorted by eye
- the 1 mm light fraction was sorted under a dissecting microscope
- the 1 mm heavy fraction was sorted under a dissecting microscope
- if after 15 minutes of sorting under the microscope, no animals have been found in the 1 mm heavy fraction, the remainder of the material was placed in a sorting tray and sorted by eye
- if any animals were found while sorting by eye, the 1 mm heavy fraction was then sorted under the dissecting microscope
- the 0.5 mm light fraction was sorted under a dissecting microscope
- the 0.5 mm heavy fraction was sorted under a dissecting microscope

- if after 15 minutes of sorting under the microscope no animals have been found in the 0.5 mm heavy fraction, the remainder of the material was placed in a sorting tray and sorted by eye
- if any animals were found while sorting by eye, the 0.5 mm fraction was then sorted under the dissecting microscope.

IV. MACROFAUNA IDENTIFICATIONS

The macrofauna were to be identified to Family taxonomic level, or lowest possible taxonomic level and placed into putative¹ families.

To assist with identifications, a reference library Dr Moverley had built up over 40 years and online taxonomic keys were used. This includes interactive keys for polychaetes and molluscs.

At the time of undertaking the work, the online Crustacea interactive keys were down for updating. A desktop copy of the keys was used, but this lacked the diagrams that needed to be sourced from the website. Therefore, this identification resource was only of limited use and other online keys and identification guides were sourced.

V. MACROFAUNA ENUMERATION PROCEDURES

As per ISO 16665:2014(E), these animal groups were not counted, but if present recorded in the sample log:

- Foraminifera
- Nematoda
- Cirripedia
- colonial Porifera, Cnidaria and Bryozoa
- planktonic organisms

Harpacticoid copepod counts have also been excluded from the results but included in the sample log. This group is usually considered meiofauna, and most pass through the 0.5 mm sieve. ISO 16665:2014(E) does advise the exclusion of such animals from macrofauna counts.

¹ Putative; commonly put forth or accepted as true on inconclusive grounds.

All other metazoan² benthic animals in the sample are recorded. Only whole animals or fragments of body parts that could be unequivocally identified, usually heads but mouthparts for brittle stars, were counted. This prevents multiple counting of fragmented specimens.

² Multicellular animals

APPENDIX B MACROFAUNA COUNTS

Taxa	MI-01	MI-02	MI-03	MI-04	MI-05	MI-06	MI-06D	MI-07	MI-09	MI-12	MI-13	MI-14	MI-15	MI-16	MI-17	MI-18
Platyhelminthes			1				1									
Nemertea 1		1	3	5		2	2	1	3	2		2	2	8	2	1
Nemertea 2		1				2	1		1					1	1	
Nemertea 3							1									
Sipuncula	1				1	3	1	2	4	2				6	2	
Oligochaeta						1								59		
Ampharetidae				8			1		2					2		
Capitellidae	1	5	8	7	1	1	4	3	5	3	4	2	3	8	5	4
Cirratulidae		2		1		5	2			4		2	1	2	1	
Cossuridae	1				1	1			4				1		1	
Dorvilleidae														2		
Eunicidae			1	1					2	4	1	5	7			
Flabelligeridae							5		2	3				4		2
Glyceridae		2	7	3			1		2			1				1
Goniadidae			4						1						2	1
Hesionidae		4	2	5	1	1	1		1						1	1
Lumbrineridae		5			1	2			2		1		1	1		1
Magelonidae		2		2	1	1			2					4	1	
Maldanidae	1	2		5		1		2	2	2			3	2		
Nephtyidae		1		1		2	2	4	5	8				6		3
Nereididae						3		1		2	1			2		1
Opheliidae		1	6	4		1			1							
Orbiniidae			1						2					1		
Phyllodocidae				2	1		1									
Paraonidae		6		2	2		1	2	1	2	1	1			1	2
Pisionidae			1													
Poecilochaetidae									1		2			2		
Sigalionidae								1								
Spionidae		4	16	30	6	7	11	3	25	8	4	7	5	33	4	7
Sternaspidae				4	1				3	3				4		
Syllidae			42	1	1	1	2	2	1		6	2		11		1
Terebellidae				3						7						
Trichobranchidae			1			1										
Myodocopa 01						3			1				1			
Myodocopa 02					1		2					1		1		
Diastylidae				1										1		
Gynodiastylidae						1	2	2	5			2				

Taxa	MI-01	MI-02	MI-03	MI-04	MI-05	MI-06	MI-06D	MI-07	MI-09	MI-12	MI-13	MI-14	MI-15	MI-16	MI-17	MI-18
Leuconidae													1			
Ampeliscidae		1	2	2		4			2	1	1		2			2
Corophiidae		3	11				5	1	1				3	1		
Leucothoidae						1								1		
Melitidae					5	8	5		9			1				
Phoxocephalidae			4	1		4	3	6	9	1	1				1	2
Gigantapseudidae						1			1				1	1		
Kalliapseudidae				3		2	1	2	4		8	4	1			
Leptocheliidae				1			1		2		1					
Numbakullidae						2										
Antheluridae										2			2	3		
Anthuridae				1								1				1
Cirolanidae								1				1				
Gnathiidae												1				
Alpheidae				1					1			1				
Callianassidae				1	1				1			1	2			
Hippolytidae			1													
Diogenidae				1		1										
Paguridae				1												
Paguroidea			5													
Portunidae			1													
Phoronida 1									1							
Nudibranchia									1							
Gadilidae		4						1	1							
Philinidae							1			1						
Cerithiidae								1								
Naticidae		1														
Haminoeidae				1												
Tellinidae														1		
Cultellidae										1						
Mactridae							1									
Anomiidae														1		
Veneridae				2		2	2									
Laternulidae				4					1					1		
Ophiuroidea 1		1		9					1	1				2		
Ophiuroidea 2														1		1
Leptocardii		1		13					1	1		1				

APPENDIX C SAMPLE LOG

Samples collected from Papua New Guinea by Coffey Environments for extraction, identification and enumeration of macrofauna to be processed using a 0.5 mm sieve.

Note samples were sieved in the field before being sent for analysis. The volume and description is of this field-sieved material not the natural sediment.

Sam	Commenced	Notes
MI-01	27/06/2019	Sample labelled MI-1 not Sed 14. Original Volume 1.75 L of grey mud. Sieved volume 10 mL. Shell fragments, small shells, some foraminifera shells and worm tubes. There was virtually no organic material present.
MI-02	24/06/2019	Original Volume 1.25 L of grey mud. Sieved volume 30 mL mostly shell fragments, small shells and some foraminifera shells. There was a little terrestrial organic material and some marine animal tubes. Nematodes were common but not counted.
MI-03	27/06/2019	Original Volume 2.5 L of shell grit. Sieved volume 1540 mL of coral rubble, shell fragments, small shells, some foraminifera. There was a little organic material present, which was sorted under the microscope. There was 500 ml retained on the 2 mm sieve, 400 mL on the 1 mm sieve and 640 mL on the 0.5 mm sieve. Other fractions sorted by microscope and eye. Two nematodes and four harpacticoids recorded.
MI-04	29/06/2019	Several pieces of seagrass leaves with encrusting bryozoans growing on them present. Original Volume 1.5 L of grey mud. Sieved volume 420 mL, 70 mL retained on 1 mm sieve and 350 mL on the 0.5 mm sieve. Not much organic matter. Four nematodes and one harpacticoid recorded.
MI-05	29/06/2019	Original Volume 1.5 L of grey mud. Sieved volume 10 mL mostly shell fragments, small shells and some foraminifera shells. Pteropod shells present. There was little organic material present.
MI-06	25/06/2019	Original Volume 1.5 L of grey mud. Sieved volume 25 mL mostly shell fragments, small shells and some foraminifera shells. Pteropod shells present. There was a small amount of organic material. Nematodes were common but not counted.

Sam	Commenced	Notes
MI06D	26/06/2019	Original Volume 2.5 L of grey mud. Sieved volume 20 mL mostly shell fragments, small shells and some foraminifera shells. Pteropod shells present. There was some organic material present.
MI-07	26/06/2019	Original Volume 1 L of grey mud. Sieved volume 40 mL mostly shell fragments, small shells and some foraminifera shells. Pteropod shells present. There was a small amount of organic material. One nematode recorded.
MI-09	25/06/2019	Original Volume 2.25 L of grey mud. Sieved volume 30 mL mostly shell fragments, small shells and some foraminifera shells. Sample zip lock bag had opened for approximately 5 cm and most water was lost. And what was in the sample bag and on the outside of other sample bags in the esky were washed down and the inside of the esky and this material was included in the sample. There was a little organic material. A sand dollar, which appeared dead at the time of collection present. Ten nematodes recorded.
MI-12	30/06/2019	Original Volume 1 L of grey mud. Sieved volume 5 mL of material. Shell fragments and small shells. There was a little organic material.
MI-13	28/06/2019	Original Volume 1.5 L of grey mud. Sieved volume 100 mL of shell fragments, small shells, some foraminifera. There was no organic material present. Mucous tubes present (5 mL) but few animals tangled in it. There was 15 ml retained on the 2 mm sieve, 25 mL on the 1 mm sieve and 60 mL on the 0.5 mm sieve. The 2 mm sieve sorted by eye and microscope. Shell fragments, small shells, some foraminifera. There was no organic material present. Sediment contained a small amount (<3 mL) of black particles that looked like sand, some could be broken by crushing, so presumably hard clay. Three nematodes recorded.
MI-14	1/07/2019	Original Volume 1.5 L of grey mud. Sieved volume 90 mL. There was 50 ml retained on the 2 mm sieve, 20 mL on the 1 mm sieve and 20 mL on the 0.5 mm sieve. Shell fragments, small shells, some foraminifera. There was virtually no organic material present.

Sam	Commenced	Notes
MI-15	30/06/2019	Original Volume 1.5 L of grey mud. Sieved volume 5 mL of material. Shell fragments and small shells, some shells and shell pieces retained on 2 mm sieve. There was a little organic material.
MI-16	3/07/2019	Original Volume 1.75 L of grey mud with shells through it. Sieved volume 500 mL, 70 mL retained on 2 mm sieve, 260 mL retained on 1 mm sieve and 170 mL retained on 0.5 mm sieve. Sediment in all three fractions contained a small volume of black particles that looked like sand, some could be broken by crushing, so presumably hard clay. One nematode recorded.
MI-17	26/06/2019	Original Volume 3 L of grey mud. Sieved volume 90 mL. More coarse material than previous samples, there was 15 ml retained on the 2 mm sieve, 35 mL on the 1 mm sieve and 40 mL on the 0.5 mm sieve mostly shell fragments, small shells and some foraminifera shells. There was little organic material present.
MI-18	27/06/2019	Original Volume 1.5 L of grey mud. Sieved volume 70 mL. There was 25 ml retained on the 2 mm sieve, 25 mL on the 1 mm sieve and 20 mL on the 0.5 mm sieve. Shell fragments, small shells, some foraminifera. There was a little organic material present.

APPENDIX J: 2019 WATER QUALITY RESULTS TABLES DISPLAYING PARAMETERS WITH ENVIRONMENT PERMIT CRITERIA

Table 1 Water quality parameters 2019 – general

Site	Date		COD (mg/L)	BOD (mg/L)	Sulphide (mg/L) [§]	Nitrate as N mg/L	Potassium (mg/L)	Oil and grease (mg/L)	Phenol (mg/L)	Pentachlorophenol (mg/L)	Faecal coliforms (MPN/100 mL)
		Environment Permit (Annex 2, Table 1-1 Criteria)	125	25	0.002	45	600	10	0.270	0.011	200 CFU/100 mL
		Schedule 1 Criteria	-	-	0.002	45	450	None	0.002	-	-
WQ1	Feb-10		<100	<4	<0.007	<0.1	320	<5	<0.001	-	<1
	Jan-11		<100	<2	<0.007	<0.005	460	<5	<0.001	-	<1
	Apr-14		540	43	<0.5	<0.005	-	<5	<0.001	-	-
	Apr-19		<100	-	-	-	-	-	-	-	-
	Aug-19		-	<2	<0.1	<0.01	-	<5	-	-	-
WQ2	Feb-10		<100	<4	<0.007	<0.1	340	<5	<0.001	-	<1
	Jan-11		<100	<2	<0.007	<0.005	450	<5	<0.001	-	<1
	Apr-14		<500	<5	<0.5	<0.005	-	<5	<0.001	-	-
	Apr-19		-	-	-	-	-	-	<0.001	<0.002	-
	Aug-19		-	<2	<0.1	<0.01	-	<5	-	-	-
WQ3	Feb-10		<100	<4	<0.007	<0.1	340	<5	<0.001	-	-
	Jan-11		<100	<2	<0.007	<0.005	430	<5	<0.001	-	<1
	Apr-14		740	55	<0.5	<0.005	-	<5	<0.001	-	-
	Apr-19		-	-	-	-	-	-	<0.001	<0.002	-
	Aug-19		430	<2	<0.1	<0.01	-	<5	-	-	-
WQ4	Feb-10		<100	<4	<0.007	<0.1	340	<5	<0.001	-	<1
	Jan-11		<100	<2	<0.007	<0.005	460	<5	<0.001	-	<1
	Apr-14		590	55	<0.5	<0.005	-	<5	<0.001	-	-
	Apr-19		-	-	<0.1	-	-	-	<0.001	<0.002	-
	Aug-19		<400	<2	-	<0.01	-	<5	-	-	-
WQ5	Feb-10		<50	<4	<0.007	<0.1	370	<5	<0.001	-	<1

Site	Date	Environment Permit (Annex 2, Table 1-1 Criteria)	COD (mg/L)	BOD (mg/L)	Sulphide (mg/L) ^s	Nitrate as N mg/L	Potassium (mg/L)	Oil and grease (mg/L)	Phenol (mg/L)	Pentachlorophenol (mg/L)	Faecal coliforms (MPN/100 mL)
			125	25	0.002	45	600	10	0.270	0.011	200 CFU/100 mL
			-	-	0.002	45	450	None	0.002	-	-
WQ6	Jan-11		<100	<2	<0.007	<0.005	460	<5	<0.001	-	<1
	May-14		680	19	<0.5	<0.005	-	<5	<0.001	-	-
	Apr-19		-	-	<0.1	-	-	-	<0.001	<0.002	-
	Aug-19		480	<2	-	<0.01	423	<5	-	-	>2,419.6
	Feb-10		<50	<4	<0.007	<0.1	350	<5	<0.001	-	<1
WQ7	Jan-11		<100	<2	<0.007	<0.005	460	<5	<0.001	-	<1
	May-14		<500	19	<0.5	<0.005	-	<5	<0.001	-	-
	Apr-19		-	-	-	-	-	-	<0.001	<0.002	-
	Aug-19		<400	<2	<0.1	<0.01	395	<5	-	-	>2,419.6
	Feb-10		70	<4	<0.007	<0.1	310	<5	<0.001	-	<1
WQ8	Jan-11		<100	<2	<0.007	<0.005	460	<5	<0.001	-	<1
	May-14		810	37	<0.5	<0.005	-	<5	<0.001	-	-
	Apr-19		-	-	-	-	400	-	<0.001	<0.002	-
	Aug-19		<400	<2	<0.1	<0.01	400	<5	-	-	870.4
	Feb-10		70	<4	<0.007	<0.1	310	<5	<0.001	-	<1
WQ9	Jan-11		<100	<2	<0.007	<0.005	460	<5	<0.001	-	<1
	May-14		810	37	<0.5	<0.005	-	<5	<0.001	-	-
	Apr-19		-	-	<0.1	-	-	-	<0.001	<0.002	-
	Aug-19		420	<2	-	<0.01	409	<5	-	-	960.4
	Feb-10		70	<4	<0.007	<0.1	310	<5	<0.001	-	<1
WQ9	Jan-11		<100	<2	<0.007	<0.005	460	<5	<0.001	-	<1
	May-14		810	37	<0.5	<0.005	-	<5	<0.001	-	-

Site	Date	Environment Permit (Annex 2, Table 1-1 Criteria)	COD (mg/L)	BOD (mg/L)	Sulphide (mg/L) [§]	Nitrate as N mg/L	Potassium (mg/L)	Oil and grease (mg/L)	Phenol (mg/L)	Pentachlorophenol (mg/L)	Faecal coliforms (MPN/100 mL)
			125	25	0.002	45	600	10	0.270	0.011	200 CFU/100 mL
			-	-	0.002	45	450	None	0.002	-	-
WQ10	Apr-19		-	-	<0.1	-	-	-	<0.001	<0.002	-
	Aug-19		_*	_*	-	_*	_*	_*	-	-	-
	Feb-10		70	<4	<0.007	<0.1	310	<5	<0.001	-	<1
	Jan-11		<100	<2	<0.007	<0.005	460	<5	<0.001	-	<1
	May-14		810	37	<0.5	<0.005	-	<5	<0.001	-	-
	Apr-19		-	-	<0.1	-	-	-	<0.001	<0.002	-
WQ11	Aug-19		<400	<2	-	<0.01	-	<5	-	-	-
	Feb-10		70	<4	<0.007	<0.1	310	<5	<0.001	-	<1
	Jan-11		<100	<2	<0.007	<0.005	460	<5	<0.001	-	<1
	May-14		810	37	<0.5	<0.005	-	<5	<0.001	-	-
	Apr-19		-	-	<0.1	-	-	-	<0.001	<0.002	-
WQ12	Aug-19		550	<2	-	<0.01	-	<5	-	-	-
	Feb-10		70	<4	<0.007	<0.1	310	<5	<0.001	-	<1
	Jan-11		<100	<2	<0.007	<0.005	460	<5	<0.001	-	<1
	May-14		810	37	<0.5	<0.005	-	<5	<0.001	-	-
	Apr-19		-	-	-	-	-	-	-	-	-
WQ13	Aug-19		<100	<2	<0.1	<0.01	-	<5	-	-	-
	Apr-19		-	-	-	-	-	-	<0.001	<0.002	-
WQ14	Aug-19		<400	<2	<0.1	<0.01	-	<5			-
	Apr-19		-	-	<0.1	-	-	-	<0.001	<0.002	-
WQ15	Aug-19		620	<2	-	<0.1	396	<5			960.4
	Apr-19		-	-	<0.1	-	-	-	<0.001	<0.002	-

Site	Date		COD (mg/L)	BOD (mg/L)	Sulphide (mg/L) [§]	Nitrate as N mg/L	Potassium (mg/L)	Oil and grease (mg/L)	Phenol (mg/L)	Pentachlorophenol (mg/L)	Faecal coliforms (MPN/100 mL)
		Environment Permit (Annex 2, Table 1-1 Criteria)	125	25	0.002	45	600	10	0.270	0.011	200 CFU/100 mL
		Schedule 1 Criteria	-	-	0.002	45	450	None	0.002	-	-
	Aug-19		<400	<2	-	<0.01	-	<5	-	-	-
WQ16	Apr-19		-	-	<0.1	-	-	-	<0.001	<0.002	-
	Aug-19		<400	<2	-	<0.01	-	<5	-	-	-

§ Environmental Monitoring Plan criterion is less than limit of detection.

Red text: Indicates a value above the Environment Permit criteria (if present).

* Some parameters were not tested for at WQ09 as sampling on this day was cancelled due to poor weather.

Table 2 Water quality parameters – selected dissolved metals (mg/L)

Site	Date	As	Ba	B	Cd	Cr ^I	Co	Cu	Fe	Pb	Mn	Hg	Ni	Se	Ag	Sn	Zn
WQ1	Dec-07 Jan-08*	0.0017	–	–	<0.0002	<0.0005	<0.0002	<0.001	0.027	<0.0002	0.0041	–	0.0006	<0.002	<0.0001	–	<0.005
	Feb-10	<0.005	0.012	4.8	<0.001	<0.01	<0.0016	<0.0016	<0.02	<0.001	<0.005	<0.0001	<0.005	<0.007	<0.002	<0.001	0.068
	Jan-11	<0.005	0.0082	4.29	<0.0007	<0.002	0.0035	0.0012	0.02	0.0024	<0.005	<0.0001	<0.003	<0.005	<0.001	0.0039	0.011
	Apr-14	0.0011	0.0068	4.5	<0.0001	–	<0.0001	<0.001	<0.02	0.0046	0.0018	<0.0001	0.00012	<0.0002	<0.001	<0.001	0.0049
	Apr-19	0.0014	0.01	3.52	<0.0002	0.0005	<0.0002	<0.001	<0.005	<0.0002	0.0021	<0.0001	<0.0005	0.009	<0.0001	<0.005	0.008
WQ2	Dec-07 Jan-08*	0.0018	–	–	<0.0002	<0.0005	<0.0002	<0.001	<0.005	<0.0002	0.0011	–	<0.0005	<0.0002	<0.0001	–	<0.005
	Feb-10	<0.005	0.0093	5.5	<0.001	<0.01	<0.0016	<0.0016	<0.02	<0.001	<0.005	<0.0001	<0.005	<0.007	<0.002	<0.001	0.038
	Jan-11	<0.005	0.0087	4.27	<0.0007	<0.002	0.0064	<0.001	0.02	<0.001	<0.005	<0.0001	<0.003	<0.005	<0.001	0.0017	0.0068
	Apr-14	0.001	0.0055	4.2	<0.0001	–	<0.0001	0.0015	<0.02	<0.001	0.0017	<0.0001	<0.0001	<0.0002	<0.001	<0.001	0.003
	Apr-19	0.0017	0.005	4.29	<0.0001	<0.0005	<0.0002	0.001	0.005	<0.0002	0.0007	<0.0001	<0.0005	0.009	<0.0001	<0.005	<0.005
WQ3	Dec-07 Jan-08*	0.0018	–	–	<0.0002	<0.0005	<0.0002	<0.001	0.014	<0.0002	0.0014	–	<0.0005	<0.002	<0.0001	–	<0.005
	Feb-10	<0.005	0.0092	5	<0.001	<0.01	<0.0016	<0.0016	0.055	<0.001	<0.005	<0.0001	<0.005	<0.007	<0.002	<0.001	0.044
	Jan-11	<0.005	0.0083	4.46	<0.0007	<0.002	0.0078	0.0011	0.02	<0.001	<0.005	<0.0001	<0.003	<0.005	<0.001	0.0012	0.0093
	Apr-14	0.0011	0.0056	4.7	<0.0001	–	<0.0001	<0.001	<0.02	<0.001	0.0011	<0.0001	0.00012	<0.0002	<0.001	<0.001	0.0026
	Apr-19	0.0015	0.004	4.58	<0.0001	0.0794	<0.0002	<0.001	<0.005	<0.0002	<0.0005	<0.0005	<0.0005	0.01	0.0004	<0.005	<0.005
WQ4	Dec-07 Jan-08*	0.0018	–	–	<0.0002	<0.0005	<0.0002	<0.001	0.01	<0.0002	0.0013	–	<0.0005	<0.002	<0.0001	–	<0.005
	Feb-10	<0.005	0.0096	4.9	<0.001	<0.01	<0.0016	<0.0016	0.021	<0.001	<0.005	<0.0001	<0.005	<0.007	<0.002	<0.001	0.044
	Jan-11	<0.005	0.0084	4.27	<0.0007	<0.002	0.0083	<0.001	0.02	<0.001	<0.005	<0.0001	<0.003	<0.005	<0.001	0.0011	0.0076
	Apr-14	0.0011	0.0054	4.7	<0.0001	–	<0.0001	<0.001	<0.02	<0.001	0.0008	<0.0001	0.00014	<0.0002	<0.001	<0.001	0.0021
	Apr-19	0.0016	0.006	4.23	<0.0001	<0.0005	<0.0002	0.001	<0.005	<0.0002	<0.0005	<0.0001	<0.0005	0.01	<0.0001	<0.005	<0.005
WQ5	Dec-07 Jan-08*	0.0018	–	–	<0.0001	<0.0005	<0.0002	<0.001	0.011	<0.0002		–	<0.0005	<0.002	<0.0001	–	<0.005
	Feb-10	<0.005	0.0099	5.3	<0.001	<0.01	<0.0016	<0.0016	0.076	<0.001	<0.005	<0.0001	<0.005	<0.007	<0.002	<0.001	0.069
	Jan-11	<0.005	0.0087	4.2	<0.0007	<0.002	0.0085	<0.001	0.02	<0.001	<0.005	<0.0001	<0.003	<0.005	<0.001	<0.001	0.0088
	May-14	0.0012	0.0047	1.8	<0.0001	–	<0.0001	<0.001	<0.02	<0.001	0.0011	<0.0001	<0.0001	<0.0002	<0.001	<0.001	0.0048
	Apr-19	0.0015	0.005	4.34	<0.0001	<0.0005	<0.0002	<0.001	0.005	<0.0002	0.0011	<0.0001	<0.0005	0.01	<0.0001	<0.005	<0.005

Site	Date	As	Ba	B	Cd	Cr ¹	Co	Cu	Fe	Pb	Mn	Hg	Ni	Se	Ag	Sn	Zn
WQ6	Feb-10	<0.005	0.01	5.2	<0.001	<0.01	<0.0016	<0.0016	<0.020	<0.001	<0.005	<0.0001	<0.005	<0.007	<0.002	<0.001	0.036
	Jan-11	<0.005	0.0085	4.46	<0.0007	<0.002	0.0071	0.0016	0.02	<0.001	<0.005	<0.0001	<0.003	<0.005	<0.001	<0.001	0.019
	May-14	0.0012	0.0049	4.8	<0.0001	–	<0.0001	<0.001	<0.02	<0.001	0.001	<0.0001	0.00011	<0.0002	<0.001	<0.001	0.0032
	Apr-19	0.0018	0.004	4.47	<0.0001	<0.0005	<0.0002	0.001	<0.005	<0.0002	0.001	<0.0001	<0.0005	0.01	<0.0001	<0.005	0.007
WQ7	Dec-07 Jan-08*	0.0018	–	–	<0.0002	<0.0005	<0.0002	<0.001	0.025	<0.0002	0.0016	–	<0.0005	<0.002	<0.0001	–	<0.005
	Feb-10	<0.005	0.01	5.6	<0.001	<0.01	<0.0016	<0.0016	<0.020	<0.001	<0.005	<0.0001	<0.005	<0.007	<0.002	<0.001	0.052
	Jan-11	<0.005	0.0082	4.42	<0.0007	<0.002	0.0056	0.0015	0.02	<0.001	<0.005	<0.0001	<0.003	<0.005	<0.001	0.0014	0.008
	May-14	0.0013	0.0048	4.9	<0.0001	–	<0.0001	<0.001	<0.02	<0.001	0.0011	<0.0001	0.00011	<0.0002	<0.001	<0.001	0.0033
	Apr-19	0.0018	0.005	4.42	<0.0001	<0.0005	<0.0002	0.001	<0.005	<0.0002	0.0009	<0.0001	<0.0005	0.009	<0.0001	<0.005	<0.005
WQ8	Feb-10	<0.005	0.01	5.3	<0.001	<0.01	<0.0016	<0.0016	<0.020	<0.001	<0.005	<0.0001	<0.005	<0.007	<0.002	<0.001	0.058
	Jan-11	<0.005	0.0089	4.16	<0.0007	<0.002	0.0061	0.0012	0.02	<0.001	<0.005	<0.0001	<0.003	<0.005	<0.001	<0.001	0.0068
	May-14	0.0013	0.0054	4.9	<0.0001	–	<0.0001	<0.001	<0.02	<0.001	0.0021	<0.0001	0.0001	<0.0002	<0.001	<0.001	0.0024
	Apr-19	0.0018	0.005	4.46	<0.0001	<0.0005	<0.0002	0.001	<0.005	<0.0002	0.0018	<0.0001	0.0009	0.01	<0.0001	<0.005	<0.005
WQ9	Feb-10	<0.005	0.012	5.1	<0.001	<0.01	<0.0016	<0.0016	<0.020	<0.001	0.013	<0.0001	<0.005	<0.007	<0.002	<0.001	0.076
	Jan-11	<0.005	0.013	4.09	<0.0007	<0.002	0.0044	0.0015	0.02	<0.001	0.026	<0.0001	<0.003	<0.005	<0.001	0.0018	0.011
	May-14	0.0012	0.01	4.7	<0.0001	–	<0.0001	<0.001	<0.02	<0.001	0.013	<0.0001	0.00022	<0.0002	<0.001	<0.001	0.004
	Apr-19	0.0016	0.01	4.30	<0.0001	0.0007	<0.0002	<0.001	0.006	<0.0002	0.0196	<0.0001	0.0006	0.01	<0.0001	<0.005	<0.005
WQ10	Dec-07	0.0014	–	–	<0.0002	0.0008	0.0003	<0.001	0.381	<0.0002	0.143	–	0.0023	<0.002	<0.0001	–	<0.005
	Feb-10	<0.005	0.088	5	<0.001	<0.01	<0.0016	<0.0016	<0.020	<0.001	<0.005	<0.0001	<0.005	<0.007	<0.002	<0.001	0.037
	Jan-11	<0.005	0.0084	4.21	<0.0007	<0.002	0.0078	<0.001	0.02	<0.001	<0.005	<0.0001	<0.003	<0.005	<0.001	0.0011	0.0066
	May-14	0.0012	0.0057	4.8	<0.0001	–	<0.0001	<0.001	<0.02	<0.001	0.00085	<0.0001	0.00012	<0.0002	<0.001	<0.001	0.0045
	Apr-19	0.0014	0.006	4.20	<0.0001	<0.0005	<0.0002	<0.001	<0.005	<0.0002	<0.0005	<0.0001	<0.0005	0.01	<0.0002	<0.005	<0.005
WQ11	Dec-07 Jan-08*	0.0018	–	–	<0.0002	<0.0005	<0.0002	<0.001	0.014	<0.0002	0.0014	0.0001	<0.0005	<0.002	<0.0001	–	<0.005
	Feb-10	<0.005	0.0099	5.2	<0.001	<0.01	<0.0016	<0.0016	<0.020	<0.001	<0.005	<0.0001	<0.005	<0.007	<0.002	<0.001	0.038
	Jan-11	<0.005	0.008	4.11	<0.0007	<0.002	0.007	0.0012	0.02	<0.001	<0.005	<0.0001	0.0036	<0.005	<0.001	<0.001	0.0065
	May-14	0.0011	0.006	4.7	<0.0001	–	<0.0001	<0.001	<0.02	<0.001	0.0011	<0.0001	<0.0001	<0.0002	<0.001	<0.001	0.003
	Apr-19	0.0015	0.006	4.27	<0.0001	<0.0005	<0.0002	0.001	<0.005	<0.0002	0.0013	<0.0001	<0.0005	0.009	<0.0001	<0.005	<0.005
WQ12	Dec-07 Jan-08*	0.0018	–	–	<0.0002	<0.0005	<0.0002	<0.001	<0.005	<0.0002	0.0011	0.0001	<0.0005	<0.002	<0.0001	–	<0.005

Site	Date	As	Ba	B	Cd	Cr ¹	Co	Cu	Fe	Pb	Mn	Hg	Ni	Se	Ag	Sn	Zn
	Feb-10	<0.005	0.0096	5.1	<0.001	<0.01	<0.0016	<0.0016	<0.020	<0.001	<0.005	<0.0001	<0.005	<0.007	<0.002	<0.001	0.038
	Jan-11	<0.005	0.0085	4.24	<0.0007	<0.002	0.007	0.0011	0.02	<0.001	<0.005	<0.0001	<0.003	<0.005	<0.001	<0.001	0.0062
	May-14	0.0013	0.0044	5	<0.0001	–	<0.0001	<0.001	<0.02	<0.001	<0.0006	<0.0001	0.00019	<0.0002	<0.001	<0.001	0.0028
	Apr-19	0.0013	0.009	3.64	<0.0002	<0.0005	<0.0002	<0.001	<0.005	<0.0002	0.001	<0.0001	<0.0005	0.01	<0.0001	<0.005	<0.005
WQ13	Apr-19	0.0015	0.006	4.14	<0.0001	<0.0005	<0.0002	0.003	<0.005	<0.0002	<0.0005	<0.0001	<0.0005	0.009	<0.0001	<0.005	<0.005
WQ14	Apr-19	0.0015	0.006	4.17	<0.0001	<0.0005	<0.0002	0.001	<0.005	<0.0002	<0.0005	<0.0001	<0.0005	0.01	<0.0001	<0.005	<0.005
WQ15	Apr-19	0.0017	0.004	4.45	<0.0001	<0.0005	<0.0002	<0.001	<0.005	<0.0002	0.0006	<0.0001	<0.0005	0.008	<0.0001	<0.005	<0.005
WQ16	Apr-19	0.0019	0.004	4.45	<0.0001	<0.0005	<0.0002	<0.001	<0.005	<0.0002	0.0005	<0.0001	<0.0005	0.01	<0.0001	<0.005	<0.005
Environment Permit (Annex 2, Table 1-1 Criteria)		-	1.0	10	0.001	0.01	DL	0.03	1.0	0.004	2.0	0.0002	1.0	0.01	0.05	0.5	5.0
ANZG (2018) ² 95%		ID	-	ID	0.0055 ^B _C	0.0044	0.001	0.0013	ID	0.0044	ID	0.0004 ^C	0.07 ^C	ID	0.0014	ID	0.015 ^C
Schedule 1		0.05	1.0	2.0	0.001	0.01	DL	0.03	1.0	0.004	2.0	0.0002	1.0	0.01	0.05	0.5	5.0

DL Detection limit.

* Data for 2007/2008 are for total metals, not dissolved concentrations.

- No result.

IDI Insufficient data to derive a reliable trigger value.

¹ Chromium as VI.

² ANZG (2018). Trigger values for marine water (ug/L) level of protection 95% (% species). Trigger value for typical slightly-moderately disturbed systems.

^A Figure may not protect key species from acute toxicity (and chronic). 'A' indicates that trigger value > acute toxicity figure.

^B Chemicals for which possible bioaccumulation and secondary poisoning effects should be considered.

^C Figure may not protect key species from chronic toxicity (this refers to experimental chronic figures or geometric mean for species).

APPENDIX K: LABORATORY WATER AND SEDIMENT QUALITY RESULTS

CERTIFICATE OF ANALYSIS

Work Order	: EB1909792	Page	: 1 of 9
Amendment	: 1		
Client	: COFFEY ENVIRONMENTS PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: ERICA COLLEY	Contact	: Andrew Epps
Address	: LEVEL WORKPLES BUILDING SAVANNAH HEIGHTS SECTION 531, LOT 12 WAIGANI DRIVE HOHOLA, NCD PNG	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: 64277004057	Telephone	: +61 7 3552 8639
Project	: 754-MELEN224697 JDD PROJECT	Date Samples Received	: 15-Apr-2019 12:25
Order number	: BN/065/19	Date Analysis Commenced	: 15-Apr-2019
C-O-C number	: ----	Issue Date	: 29-May-2019 13:17
Sampler	: ERICA COLLEY		
Site	:		
Quote number	: EN/222		
No. of samples received	: 13		
No. of samples analysed	: 13		



Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics, Smithfield, NSW
Edwandy Fadjjar	Organic Coordinator	Sydney Organics, Smithfield, NSW
Franco Lentini		Sydney Organics, Smithfield, NSW
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

Ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- EP131B : LOR is raised due to high amount of moistures is present.
- **pH, Total Nitrogen and Organics analysis will be conducted by ALS Environmental, Sydney, NATA accreditation no. 825, Site No. 10911 (Micro site no. 14913).**
- Amendment (29/05/2019): This report has been amended as a result of a request to change sample identification numbers (IDs) received by ALS from E.Colley on 27/05/2019. All analysis results are as per the previous report.
- EK061G: Poor matrix spike recovery due to sample heterogeneity. Confirmed by re-digestion and re-analysis.



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	SED 14	SED 26	SED 15	----	----
Client sampling date / time					06-Apr-2019 00:00	06-Apr-2019 00:00	08-Apr-2019 00:00	----	----
Compound	CAS Number	LOR	Unit		EB1909792-001	EB1909792-002	EB1909792-003	-----	-----
				Result	Result	Result	Result	----	----
EA002: pH 1:5 (Soils)									
pH Value	----	0.1	pH Unit		8.5	8.5	9.0	----	----
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%		51.9	53.6	21.7	----	----
EA150: Particle Sizing									
+75µm	----	1	%		22	24	86	----	----
+150µm	----	1	%		5	4	85	----	----
+300µm	----	1	%		1	<1	76	----	----
+425µm	----	1	%		<1	<1	59	----	----
+600µm	----	1	%		<1	<1	43	----	----
+1180µm	----	1	%		<1	<1	22	----	----
+2.36mm	----	1	%		<1	<1	11	----	----
+4.75mm	----	1	%		<1	<1	5	----	----
+9.5mm	----	1	%		<1	<1	<1	----	----
+19.0mm	----	1	%		<1	<1	<1	----	----
+37.5mm	----	1	%		<1	<1	<1	----	----
+75.0mm	----	1	%		<1	<1	<1	----	----
EA150: Soil Classification based on Particle Size									
Clay (<2 µm)	----	1	%		36	33	14	----	----
Silt (2-60 µm)	----	1	%		40	42	<1	----	----
Sand (0.06-2.00 mm)	----	1	%		24	25	72	----	----
Gravel (>2mm)	----	1	%		<1	<1	14	----	----
Cobbles (>6cm)	----	1	%		<1	<1	<1	----	----
EA152: Soil Particle Density									
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3		2.30	2.42	2.74	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg		0.2	0.4	<0.1	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg		1320	1330	130	----	----
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg		1320	1330	130	----	----
EP003: Total Organic Carbon (TOC) in Soil									
Total Organic Carbon	----	0.02	%		0.93	0.96	0.10	----	----
EP003TC: Total Carbon (TC) in Soil									
Total Carbon	TC	0.02	%		5.14	5.22	11.7	----	----



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	SED 14	SED 26	SED 15	----	----
Client sampling date / time					06-Apr-2019 00:00	06-Apr-2019 00:00	08-Apr-2019 00:00	----	----
Compound	CAS Number	LOR	Unit		EB1909792-001	EB1909792-002	EB1909792-003	-----	-----
				Result	Result	Result	Result	----	----
EP003TIC: Total inorganic Carbon (TIC) in Soil									
Total Inorganic Carbon	----	0.02	%		4.21	4.26	11.6	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions									
>C10 - C16 Fraction	----	3	mg/kg		3	6	<3	----	----
>C16 - C34 Fraction	----	3	mg/kg		28	36	9	----	----
>C34 - C40 Fraction	----	5	mg/kg		16	21	<5	----	----
>C10 - C40 Fraction (sum)	----	3	mg/kg		47	63	9	----	----
>C10 - C16 Fraction minus Naphthalene (F2)	----	3	mg/kg		3	6	<3	----	----
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	----	3	mg/kg		<3	<3	<3	----	----
C10 - C14 Fraction	----	3	mg/kg		<3	4	<3	----	----
C15 - C28 Fraction	----	3	mg/kg		17	23	7	----	----
C29 - C36 Fraction	----	5	mg/kg		20	24	<5	----	----
^ C10 - C36 Fraction (sum)	----	3	mg/kg		37	51	7	----	----
EP080-SD / EP071-SD: Total Recoverable Hydrocarbons									
C6 - C10 Fraction	C6_C10	3	mg/kg		<3	<3	<3	----	----
C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	3.0	mg/kg		<3.0	<3.0	<3.0	----	----
EP080-SD: BTEXN									
Benzene	71-43-2	0.2	mg/kg		<0.2	<0.2	<0.2	----	----
Toluene	108-88-3	0.2	mg/kg		<0.2	<0.2	<0.2	----	----
Ethylbenzene	100-41-4	0.2	mg/kg		<0.2	<0.2	<0.2	----	----
meta- & para-Xylene	108-38-3 106-42-3	0.2	mg/kg		<0.2	<0.2	<0.2	----	----
ortho-Xylene	95-47-6	0.2	mg/kg		<0.2	<0.2	<0.2	----	----
^ Total Xylenes	----	0.5	mg/kg		<0.5	<0.5	<0.5	----	----
^ Sum of BTEX	----	0.2	mg/kg		<0.2	<0.2	<0.2	----	----
Naphthalene	91-20-3	0.2	mg/kg		<0.2	<0.2	<0.2	----	----
EP131A: Organochlorine Pesticides									
Aldrin	309-00-2	0.50	µg/kg		<0.50	<0.50	<0.50	----	----
alpha-BHC	319-84-6	0.50	µg/kg		<0.50	<0.50	<0.50	----	----
beta-BHC	319-85-7	0.50	µg/kg		<0.50	<0.50	<0.50	----	----
delta-BHC	319-86-8	0.50	µg/kg		<0.50	<0.50	<0.50	----	----
4,4`-DDD	72-54-8	0.50	µg/kg		<0.50	<0.50	<0.50	----	----
4,4`-DDE	72-55-9	0.50	µg/kg		<0.50	<0.50	<0.50	----	----



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	SED 14	SED 26	SED 15	----	----
Client sampling date / time					06-Apr-2019 00:00	06-Apr-2019 00:00	08-Apr-2019 00:00	----	----
Compound	CAS Number	LOR	Unit		EB1909792-001	EB1909792-002	EB1909792-003	-----	-----
					Result	Result	Result	----	----
EP131A: Organochlorine Pesticides - Continued									
4,4'-DDT	50-29-3	0.50	µg/kg		<0.50	<0.50	<0.50	----	----
^ Sum of DDD + DDE + DDT	72-54-8/72-55-9/5 0-2	0.50	µg/kg		<0.50	<0.50	<0.50	----	----
Dieldrin	60-57-1	0.50	µg/kg		<0.50	<0.50	<0.50	----	----
alpha-Endosulfan	959-98-8	0.50	µg/kg		<0.50	<0.50	<0.50	----	----
beta-Endosulfan	33213-65-9	0.50	µg/kg		<0.50	<0.50	<0.50	----	----
Endosulfan sulfate	1031-07-8	0.50	µg/kg		<0.50	<0.50	<0.50	----	----
^ Endosulfan (sum)	115-29-7	0.50	µg/kg		<0.50	<0.50	<0.50	----	----
Endrin	72-20-8	0.50	µg/kg		<0.50	<0.50	<0.50	----	----
Endrin aldehyde	7421-93-4	0.50	µg/kg		<0.50	<0.50	<0.50	----	----
Endrin ketone	53494-70-5	0.50	µg/kg		<0.50	<0.50	<0.50	----	----
Heptachlor	76-44-8	0.50	µg/kg		<0.50	<0.50	<0.50	----	----
Heptachlor epoxide	1024-57-3	0.50	µg/kg		<0.50	<0.50	<0.50	----	----
Hexachlorobenzene (HCB)	118-74-1	0.50	µg/kg		<0.50	<0.50	<0.50	----	----
gamma-BHC	58-89-9	0.25	µg/kg		<0.25	<0.25	<0.25	----	----
Methoxychlor	72-43-5	0.50	µg/kg		<0.50	<0.50	<0.50	----	----
cis-Chlordane	5103-71-9	0.50	µg/kg		<0.50	<0.50	<0.50	----	----
trans-Chlordane	5103-74-2	0.50	µg/kg		<0.50	<0.50	<0.50	----	----
^ Total Chlordane (sum)	-----	0.50	µg/kg		<0.50	<0.50	<0.50	----	----
Oxychlordane	27304-13-8	0.50	µg/kg		<0.50	<0.50	<0.50	----	----
^ Sum of Aldrin + Dieldrin	309-00-2/60-57-1	0.50	µg/kg		<0.50	<0.50	<0.50	----	----
EP131B: Polychlorinated Biphenyls (as Aroclors)									
^ Total Polychlorinated biphenyls	-----	5.0	µg/kg		<6.2	<6.2	<5.0	----	----
Aroclor 1016	12674-11-2	5.0	µg/kg		<6.2	<6.2	<5.0	----	----
Aroclor 1221	11104-28-2	5.0	µg/kg		<6.2	<6.2	<5.0	----	----
Aroclor 1232	11141-16-5	5.0	µg/kg		<6.2	<6.2	<5.0	----	----
Aroclor 1242	53469-21-9	5.0	µg/kg		<6.2	<6.2	<5.0	----	----
Aroclor 1248	12672-29-6	5.0	µg/kg		<6.2	<6.2	<5.0	----	----
Aroclor 1254	11097-69-1	5.0	µg/kg		<6.2	<6.2	<5.0	----	----
Aroclor 1260	11096-82-5	5.0	µg/kg		<6.2	<6.2	<5.0	----	----
EP202A: Phenoxyacetic Acid Herbicides by LCMS									
4-Chlorophenoxy acetic acid	122-88-3	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
2,4-DB	94-82-6	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
Dicamba	1918-00-9	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
Mecoprop	93-65-2	0.02	mg/kg		<0.02	<0.02	<0.02	----	----



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	SED 14	SED 26	SED 15	----	----
Client sampling date / time					06-Apr-2019 00:00	06-Apr-2019 00:00	08-Apr-2019 00:00	----	----
Compound	CAS Number	LOR	Unit		EB1909792-001	EB1909792-002	EB1909792-003	-----	-----
					Result	Result	Result	----	----
EP202A: Phenoxyacetic Acid Herbicides by LCMS - Continued									
MCPA	94-74-6	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
2,4-DP	120-36-5	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
2,4-D	94-75-7	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
Triclopyr	55335-06-3	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
2,4,5-TP (Silvex)	93-72-1	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
2,4,5-T	93-76-5	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
MCPB	94-81-5	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
Picloram	1918-02-1	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
Clpyralid	1702-17-6	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
Fluroxypyr	69377-81-7	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
EP080-SD: TPH(V)/BTEX Surrogates									
1,2-Dichloroethane-D4	17060-07-0	0.2	%		86.2	79.6	89.1	----	----
Toluene-D8	2037-26-5	0.2	%		94.1	83.5	99.6	----	----
4-Bromofluorobenzene	460-00-4	0.2	%		93.0	86.2	100	----	----
EP131S: OC Pesticide Surrogate									
Dibromo-DDE	21655-73-2	0.50	%		66.5	63.0	87.8	----	----
EP131T: PCB Surrogate									
Decachlorobiphenyl	2051-24-3	0.5	%		75.0	75.0	87.5	----	----
EP202S: Phenoxyacetic Acid Herbicide Surrogate									
2,4-Dichlorophenyl Acetic Acid	19719-28-9	0.02	%		65.3	53.6	62.5	----	----



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				TSS_08 DEEP	TSS_02	TSS_02 DEEP	TSS_08	TSS_43 DEEP
Client sampling date / time				06-Apr-2019 00:00	06-Apr-2019 00:00	06-Apr-2019 00:00	06-Apr-2019 00:00	07-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1909792-004	EB1909792-005	EB1909792-006	EB1909792-007	EB1909792-008
				Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	1	mg/L	1	3	4	1	2



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				TSS_43	TSS_05 DEEP	TSS_05	TSS_09	TSS_09 DEEP
Client sampling date / time				07-Apr-2019 00:00	06-Apr-2019 00:00	06-Apr-2019 00:00	07-Apr-2019 00:00	07-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1909792-009	EB1909792-010	EB1909792-011	EB1909792-012	EB1909792-013
				Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	1	mg/L	2	1	1	<1	1



Surrogate Control Limits

Sub-Matrix: SOIL		Recovery Limits (%)	
Compound	CAS Number	Low	High
EP080-SD: TPH(V)/BTEX Surrogates			
1,2-Dichloroethane-D4	17060-07-0	67	137
Toluene-D8	2037-26-5	74	134
4-Bromofluorobenzene	460-00-4	73	137
EP131S: OC Pesticide Surrogate			
Dibromo-DDE	21655-73-2	10	119
EP131T: PCB Surrogate			
Decachlorobiphenyl	2051-24-3	10	106
EP202S: Phenoxyacetic Acid Herbicide Surrogate			
2,4-Dichlorophenyl Acetic Acid	19719-28-9	45	139

CERTIFICATE OF ANALYSIS

Work Order	: EB1909792	Page	: 1 of 6
Amendment	: 3		
Client	: COFFEY ENVIRONMENTS PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: ERICA COLLEY	Contact	: Andrew Epps
Address	: LEVEL WORKPLES BUILDING SAVANNAH HEIGHTS SECTION 531, LOT 12 WAIGANI DRIVE HOHOLA, NCD PNG	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: 64277004057	Telephone	: +61 7 3552 8639
Project	: 754-MELEN224697 JDD PROJECT	Date Samples Received	: 15-Apr-2019 12:25
Order number	: BN/065/19	Date Analysis Commenced	: 15-Apr-2019
C-O-C number	: ----	Issue Date	: 31-Mar-2020 16:24
Sampler	: ERICA COLLEY		
Site	:		
Quote number	: EN/222		
No. of samples received	: 13		
No. of samples analysed	: 4		



Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

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- Analytical Results
- Surrogate Control Limits

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Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics, Smithfield, NSW
Franco Lentini	LCMS Coordinator	Sydney Organics, Smithfield, NSW
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

Ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- **Amendment 1 (31/03/2020): This report has been amended and re-released to change the reporting of additional analytical data.**
- EP131B : LOR is raised due to high amount of moistures is present.
- **pH, Total Nitrogen and Organics analysis will be conducted by ALS Environmental, Sydney, NATA accreditation no. 825, Site No. 10911 (Micro site no. 14913).**
- Amendment (29/05/2019): This report has been amended as a result of a request to change sample identification numbers (IDs) received by ALS from E.Colley on 27/05/2019. All analysis results are as per the previous report.
- EK061G: Poor matrix spike recovery due to sample heterogeneity. Confirmed by re-digestion and re-analysis.
- Amendment (5/12/2019): This report has been amended following the removal of data from reports as per request by Erica Colley on the 5/12/2019.



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	SED 14	SED 26	SED 15	----	----
Client sampling date / time					06-Apr-2019 00:00	06-Apr-2019 00:00	08-Apr-2019 00:00	----	----
Compound	CAS Number	LOR	Unit		EB1909792-001	EB1909792-002	EB1909792-003	-----	-----
				Result	Result	Result	Result	----	----
EA002: pH 1:5 (Soils)									
pH Value	----	0.1	pH Unit		8.5	8.5	9.0	----	----
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%		51.9	53.6	21.7	----	----
EA150: Particle Sizing									
+75µm	----	1	%		22	24	86	----	----
+150µm	----	1	%		5	4	85	----	----
+300µm	----	1	%		1	<1	76	----	----
+425µm	----	1	%		<1	<1	59	----	----
+600µm	----	1	%		<1	<1	43	----	----
+1180µm	----	1	%		<1	<1	22	----	----
+2.36mm	----	1	%		<1	<1	11	----	----
+4.75mm	----	1	%		<1	<1	5	----	----
+9.5mm	----	1	%		<1	<1	<1	----	----
+19.0mm	----	1	%		<1	<1	<1	----	----
+37.5mm	----	1	%		<1	<1	<1	----	----
+75.0mm	----	1	%		<1	<1	<1	----	----
EA150: Soil Classification based on Particle Size									
Clay (<2 µm)	----	1	%		36	33	14	----	----
Silt (2-60 µm)	----	1	%		40	42	<1	----	----
Sand (0.06-2.00 mm)	----	1	%		24	25	72	----	----
Gravel (>2mm)	----	1	%		<1	<1	14	----	----
Cobbles (>6cm)	----	1	%		<1	<1	<1	----	----
EA152: Soil Particle Density									
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3		2.30	2.42	2.74	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg		0.2	0.4	<0.1	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg		1320	1330	130	----	----
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg		1320	1330	130	----	----
EP003: Total Organic Carbon (TOC) in Soil									
Total Organic Carbon	----	0.02	%		0.93	0.96	0.10	----	----
EP003TC: Total Carbon (TC) in Soil									
Total Carbon	TC	0.02	%		5.14	5.22	11.7	----	----



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	SED 14	SED 26	SED 15	----	----
Client sampling date / time					06-Apr-2019 00:00	06-Apr-2019 00:00	08-Apr-2019 00:00	----	----
Compound	CAS Number	LOR	Unit		EB1909792-001	EB1909792-002	EB1909792-003	-----	-----
					Result	Result	Result	----	----
EP003TIC: Total inorganic Carbon (TIC) in Soil									
Total Inorganic Carbon	----	0.02	%		4.21	4.26	11.6	----	----
EP202A: Phenoxyacetic Acid Herbicides by LCMS									
4-Chlorophenoxy acetic acid	122-88-3	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
2,4-DB	94-82-6	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
Dicamba	1918-00-9	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
Mecoprop	93-65-2	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
MCPA	94-74-6	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
2,4-DP	120-36-5	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
2,4-D	94-75-7	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
Triclopyr	55335-06-3	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
2,4,5-TP (Silvex)	93-72-1	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
2,4,5-T	93-76-5	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
MCPB	94-81-5	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
Picloram	1918-02-1	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
Clopyralid	1702-17-6	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
Fluroxypyr	69377-81-7	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
EP202S: Phenoxyacetic Acid Herbicide Surrogate									
2,4-Dichlorophenyl Acetic Acid	19719-28-9	0.02	%		65.3	53.6	62.5	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	TSS_43	----	----	----	----
			Client sampling date / time	07-Apr-2019 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1909792-009	-----	-----	-----	-----
				Result	----	----	----	----
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	1	mg/L	2	----	----	----	----

Page : 6 of 6
Work Order : EB1909792 Amendment 3
Client : COFFEY ENVIRONMENTS PTY LTD
Project : 754-MELEN224697 JDD PROJECT



Surrogate Control Limits

Sub-Matrix: SOIL		Recovery Limits (%)	
Compound	CAS Number	Low	High
EP202S: Phenoxyacetic Acid Herbicide Surrogate			
2,4-Dichlorophenyl Acetic Acid	19719-28-9	45	139

Certificate of Analysis

ALS Laboratory Group Pty Ltd
2 Byth Street, Stafford, QLD 4053
pH 07 3552 8678
fax 07 3352 3662
samples.brisbane@alsenviro.com

ALS Environmental
Brisbane, QLD



CLIENT:

ERICA COLLEY

DATE REPORTED: 10-May-2019

COMPANY:

COFFEY ENVIRONMENTS PTY LTD **DATE RECEIVED:** 15-Apr-2019

ADDRESS:

LEVEL WORKPLES BUILDING
Savannah Heights Section 531, Lot 12
WAIGANI DRIVE HOHOLA, NCD PNG

REPORT NO:

EB1909792-001 / PSD

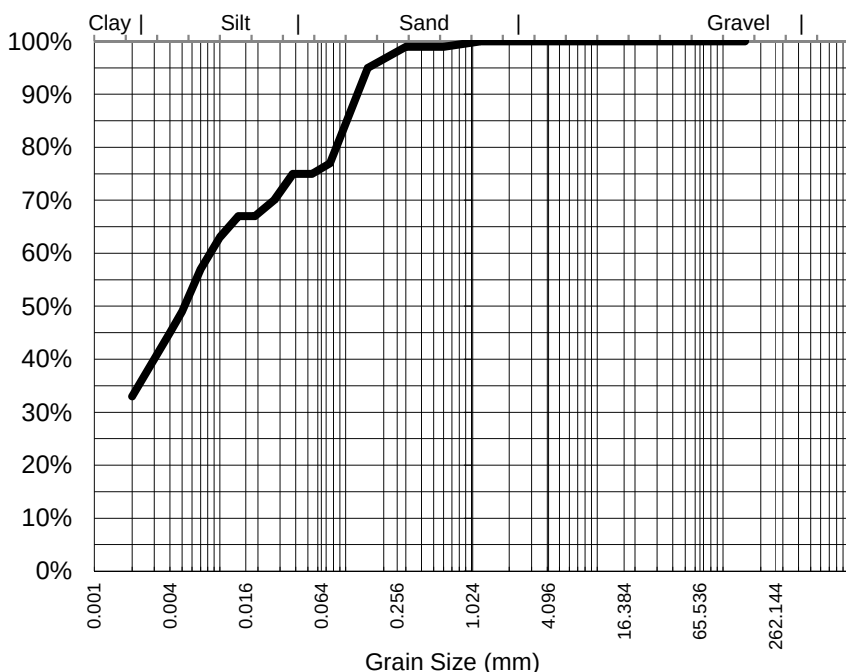
PROJECT:

754-Melen224697 Jdd Project

SAMPLE ID:

SED 14

Particle Size Distribution



Particle Size (mm)	Percent Passing
1.18	100%
0.600	99%
0.425	99%
0.300	99%
0.150	95%
0.075	77%
Particle Size (microns)	
75	77%
54	75%
38	75%
19	67%
10	63%
5	49%
2	33%

Samples analysed as received.

* Soil Particle Density results fell outside the scope of AS 1289.3.6.3. Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Loss on Pretreatment NA

Sample Description:

Test Method: AS1289.3.6.3 2003

Soil Particle Density (<2.36mm) 2.3 (2.45)* g/cm3

NATA Accreditation: 825 Site: Newcastle
This document is issued in accordance with NATA's accreditation requirements. Accredited for compliance with ISO/IEC 17025. This document shall not be reproduced, except in full.



Analysed:

4-May-19

Limit of Reporting: 1%

Dispersion Method Shaker

Hydrometer Type ASTM E100

Satish Trivedi

Soil Chemist

Authorised Signatory

Certificate of Analysis

ALS Laboratory Group Pty Ltd
2 Byth Street, Stafford, QLD 4053
pH 07 3552 8678
fax 07 3352 3662
samples.brisbane@alsenviro.com

ALS Environmental
Brisbane, QLD



CLIENT:

ERICA COLLEY

DATE REPORTED: 10-May-2019

COMPANY:

COFFEY ENVIRONMENTS PTY LTD **DATE RECEIVED:** 15-Apr-2019

ADDRESS:

LEVEL WORKPLES BUILDING
Savannah Heights Section 531, Lot 12
WAIGANI DRIVE HOHOLA, NCD PNG

REPORT NO:

EB1909792-002 / PSD

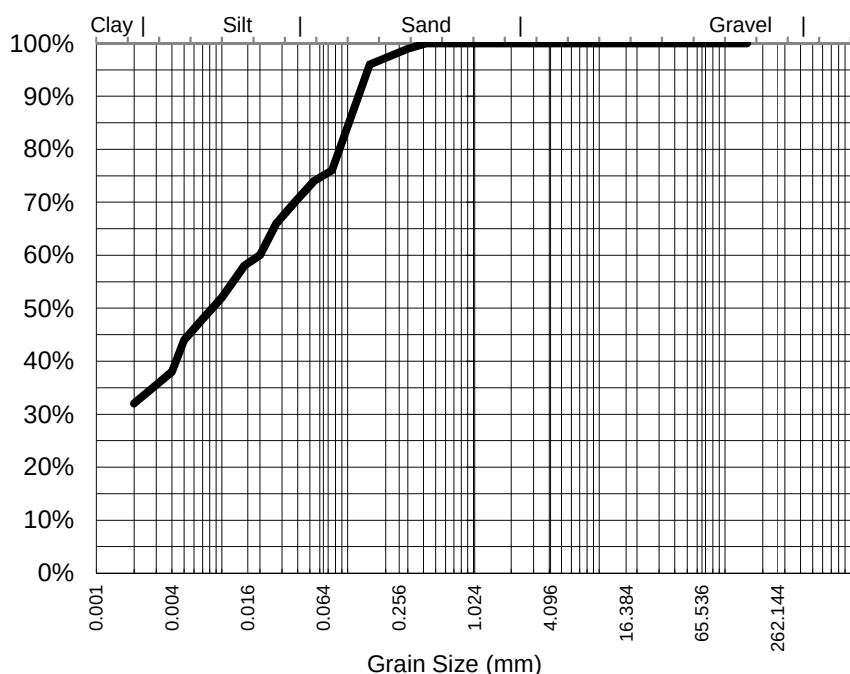
PROJECT:

754-Melen224697 Jdd Project

SAMPLE ID:

SED 23

Particle Size Distribution



Particle Size (mm)	Percent Passing
0.425	100%
0.300	99%
0.150	96%
0.075	76%
Particle Size (microns)	
75	76%
54	74%
38	70%
20	60%
10	52%
5	44%
2	32%

Samples analysed as received.

* Soil Particle Density results fell outside the scope of AS 1289.3.6.3. Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Loss on Pretreatment NA

Sample Description:

Test Method: AS1289.3.6.3 2003

Soil Particle Density (<2.36mm) 2.42 (2.45)* g/cm3

NATA Accreditation: 825 Site: Newcastle
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Analysed:

4-May-19

Limit of Reporting: 1%

Dispersion Method Shaker

Hydrometer Type ASTM E100

Satish Trivedi

Soil Chemist

Authorised Signatory

Certificate of Analysis

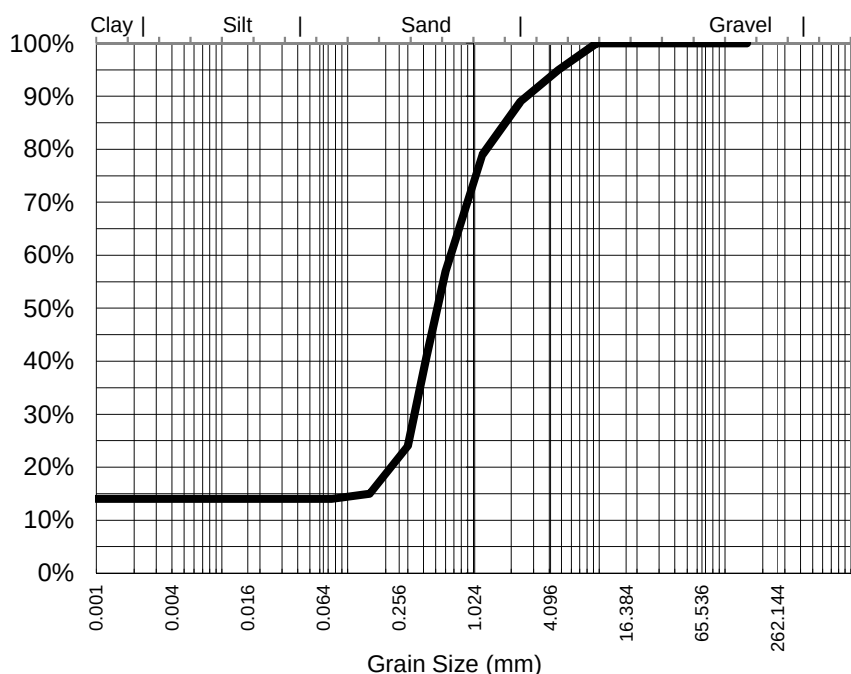
ALS Laboratory Group Pty Ltd
2 Byth Street, Stafford, QLD 4053
pH 07 3552 8678
fax 07 3352 3662
samples.brisbane@alsenviro.com

ALS Environmental
Brisbane, QLD



CLIENT: ERICA COLLEY **DATE REPORTED:** 10-May-2019
COMPANY: COFFEY ENVIRONMENTS PTY LTD **DATE RECEIVED:** 15-Apr-2019
ADDRESS: LEVEL WORKPLES BUILDING **REPORT NO:** EB1909792-003 / PSD
Savannah Heights Section 531, Lot 12
WAIGANI DRIVE HOHOLA, NCD PNG
PROJECT: 754-Melen224697 Jdd Project **SAMPLE ID:** SED 15

Particle Size Distribution



Particle Size (mm)	Percent Passing
9.50	100%
4.75	95%
2.36	89%
1.18	79%
0.600	57%
0.425	41%
0.300	24%
0.150	15%
0.075	14%
Particle Size (microns)	
75	14%
54	14%
38	14%
19	14%
10	14%
5	14%
1	14%

Median Particle Size (mm)*	0.523
----------------------------	-------

Samples analysed as received.

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Loss on Pretreatment NA

Sample Description:

Test Method: AS1289.3.6.3 2003

Soil Particle Density (<2.36mm) 2.74 g/cm3

NATA Accreditation: 825 Site: Newcastle
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Analysed: 4-May-19

Limit of Reporting: 1%

Dispersion Method Shaker

Hydrometer Type ASTM E100

Satish Trivedi
Soil Chemist
Authorised Signatory

CERTIFICATE OF ANALYSIS

Work Order	: EB1909784	Page	: 1 of 4
Amendment	: 4		
Client	: COFFEY ENVIRONMENTS PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: ERICA COLLEY	Contact	: Andrew Epps
Address	: LEVEL WORKPLES BUILDING SAVANNAH HEIGHTS SECTION	Address	: 2 Byth Street Stafford QLD Australia 4053
	531, LOT 12 WAIGANI DRIVE		
	HOHOLA, NCD PNG		
Telephone	: 64277004057	Telephone	: +61 7 3552 8639
Project	: 754-MELEN224697 JDD PROJECT	Date Samples Received	: 15-Apr-2019 12:25
Order number	: BN/065/19	Date Analysis Commenced	: 16-Apr-2019
C-O-C number	: ----	Issue Date	: 05-Dec-2019 11:34
Sampler	: ERICA COLLEY		
Site	:		
Quote number	: EN/222		
No. of samples received	: 5		
No. of samples analysed	: 3		



Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Arenie Vijayaratham	Non-metals prep supervisor	Melbourne Inorganics, Springvale, VIC
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

Ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- It is recognised that EG093-T (Total Metals in Saline Water by ORC-ICP-MS) is less than EG093-F (Dissolved Metals in Saline Water by ORC-ICP-MS) for sample EB1909784-002 (WQ-17). However insufficient sample remains to confirm results.
- Benzo(a)pyrene Toxicity Equivalent Quotient (TEQ) per the NEPM (2013) is the sum total of the concentration of the eight carcinogenic PAHs multiplied by their Toxicity Equivalence Factor (TEF) relative to Benzo(a)pyrene. TEF values are provided in brackets as follows: Benz(a)anthracene (0.1), Chrysene (0.01), Benzo(b+j) & Benzo(k)fluoranthene (0.1), Benzo(a)pyrene (1.0), Indeno(1.2.3.cd)pyrene (0.1), Dibenz(a,h)anthracene (1.0), Benzo(g,h,i)perylene (0.01). Less than LOR results for 'TEQ Zero' are treated as zero.
- EP026SP: EB1909784 samples #1-3 required dilution prior to extraction due to matrix interferences. LOR values have been adjusted accordingly.
- Amendment (14/06/2019): This report has been amended and re-released to allow the reporting of additional analytical data.
- Amendment (27/08/2019): This report has been amended and re-released to allow the reporting of additional analytical data.
- Amendment (29/05/2019): This report has been amended as a result of a request to change sample identification numbers (IDs) received by ALS from E.Coley on 27/05/2019. All analysis results are as per the previous report.
- It is recognised that EG093-T (Total Metals in Saline Water by ORC-ICP-MS) is less than EG093-F (Dissolved Metals in Saline Water by ORC-ICP-MS) for some samples. However, the difference is within experimental variation of the methods.
- EK061G (Total Kjeldahl Nitrogen as N) / EK067G (Total Phosphorous as P): Some samples were diluted due to matrix interference. LOR adjusted accordingly.
- Amendment (5/12/2019): This report has been amended following the removal of data from reports as per request by Erica Colley on the 5/12/2019.
- EG093: Samples containing high levels of sulfate may precipitate barium under the acidic conditions of this method and may therefore bias results low.



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				WQ-01	WQ-17	WQ-12	----	----
Client sampling date / time				06-Apr-2019 00:00	06-Apr-2019 00:00	06-Apr-2019 00:00	----	----
Compound	CAS Number	LOR	Unit	EB1909784-001	EB1909784-002	EB1909784-003	-----	-----
				Result	Result	Result	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	2090	2110	2280	----	----
ED093T: Total Major Cations								
Potassium	7440-09-7	1	mg/L	300	307	325	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	----	----
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS								
Aluminium	7429-90-5	5	µg/L	10	100	<5	----	----
Antimony	7440-36-0	0.5	µg/L	<0.5	<0.5	<0.5	----	----
Arsenic	7440-38-2	0.5	µg/L	1.4	1.5	1.3	----	----
Barium	7440-39-3	1	µg/L	10	10	9	----	----
Beryllium	7440-41-7	0.1	µg/L	<0.1	<0.1	<0.1	----	----
Boron	7440-42-8	100	µg/L	3520	3480	3640	----	----
Cadmium	7440-43-9	0.2	µg/L	<0.2	<0.2	<0.2	----	----
Chromium	7440-47-3	0.5	µg/L	<0.5	<0.5	<0.5	----	----
Cobalt	7440-48-4	0.2	µg/L	<0.2	<0.2	<0.2	----	----
Copper	7440-50-8	1	µg/L	<1	<1	<1	----	----
Iron	7439-89-6	5	µg/L	<5	<5	<5	----	----
Lead	7439-92-1	0.2	µg/L	<0.2	<0.2	<0.2	----	----
Manganese	7439-96-5	0.5	µg/L	2.1	1.9	1.0	----	----
Molybdenum	7439-98-7	0.1	µg/L	7.5	7.6	8.0	----	----
Nickel	7440-02-0	0.5	µg/L	<0.5	<0.5	<0.5	----	----
Selenium	7782-49-2	2	µg/L	9	8	10	----	----
Silver	7440-22-4	0.1	µg/L	<0.1	<0.1	<0.1	----	----
Tin	7440-31-5	5	µg/L	<5	<5	<5	----	----
Vanadium	7440-62-2	0.5	µg/L	1.7	1.4	1.3	----	----
Zinc	7440-66-6	5	µg/L	8	6	<5	----	----
EG093T: Total Metals in Saline Water by ORC-ICPMS								
Aluminium	7429-90-5	5	µg/L	39	29	<5	----	----
Antimony	7440-36-0	0.5	µg/L	<0.5	<0.5	<0.5	----	----
Arsenic	7440-38-2	0.5	µg/L	1.2	1.3	1.2	----	----
Barium	7440-39-3	1	µg/L	11	10	9	----	----
Beryllium	7440-41-7	0.1	µg/L	<0.1	<0.1	<0.1	----	----



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				WQ-01	WQ-17	WQ-12	----	----
Client sampling date / time				06-Apr-2019 00:00	06-Apr-2019 00:00	06-Apr-2019 00:00	----	----
Compound	CAS Number	LOR	Unit	EB1909784-001	EB1909784-002	EB1909784-003	-----	-----
				Result	Result	Result	----	----
EG093T: Total Metals in Saline Water by ORC-ICPMS - Continued								
Boron	7440-42-8	100	µg/L	3570	3290	3570	----	----
Cadmium	7440-43-9	0.2	µg/L	<0.2	<0.2	<0.2	----	----
Chromium	7440-47-3	0.5	µg/L	0.8	0.6	<0.5	----	----
Cobalt	7440-48-4	0.2	µg/L	<0.2	<0.2	<0.2	----	----
Copper	7440-50-8	1	µg/L	<1	<1	<1	----	----
Iron	7439-89-6	5	µg/L	64	54	6	----	----
Lead	7439-92-1	0.2	µg/L	<0.2	<0.2	<0.2	----	----
Manganese	7439-96-5	0.5	µg/L	4.1	3.8	1.3	----	----
Molybdenum	7439-98-7	0.1	µg/L	7.8	7.4	8.5	----	----
Nickel	7440-02-0	0.5	µg/L	<0.5	<0.5	<0.5	----	----
Selenium	7782-49-2	2	µg/L	8	8	9	----	----
Silver	7440-22-4	0.1	µg/L	<0.1	<0.1	<0.1	----	----
Tin	7440-31-5	5	µg/L	<5	<5	<5	----	----
Vanadium	7440-62-2	0.5	µg/L	1.7	1.6	1.6	----	----
Zinc	7440-66-6	5	µg/L	<5	<5	<5	----	----
EK026SF: Total CN by Segmented Flow Analyser								
Total Cyanide	57-12-5	0.004	mg/L	<0.004	<0.004	<0.004	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	0.8	0.8	0.8	----	----
EP026SP: Chemical Oxygen Demand (Spectrophotometric)								
Chemical Oxygen Demand	----	10	mg/L	<100	<100	<100	----	----

CERTIFICATE OF ANALYSIS

Work Order	: EB1910136	Page	: 1 of 27
Amendment	: 3		
Client	: COFFEY ENVIRONMENTS PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MS ERICA COLLEY	Contact	: Andrew Epps
Address	: Level 5 12 Creek St Brisbane QLD, AUSTRALIA 4000	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3608 2500	Telephone	: +61 7 3552 8639
Project	: 754-MELEN224697 JDD PROJECT	Date Samples Received	: 17-Apr-2019 12:20
Order number	: BN/065/19	Date Analysis Commenced	: 18-Apr-2019
C-O-C number	: ----	Issue Date	: 05-Dec-2019 11:37
Sampler	: E COLLEY		
Site	: ----		
Quote number	: BN/065/19 V2		
No. of samples received	: 45		
No. of samples analysed	: 45		



Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Santusha Pandra	Senior Chemist	Brisbane Organics, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

Ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- EK061G (Total Kjeldahl Nitrogen as N) / EK067G (Total Phosphorus as P): Some samples were diluted due to matrix interference. LOR adjusted accordingly.
- Benzo(a)pyrene Toxicity Equivalent Quotient (TEQ) per the NEPM (2013) is the sum total of the concentration of the eight carcinogenic PAHs multiplied by their Toxicity Equivalence Factor (TEF) relative to Benzo(a)pyrene. TEF values are provided in brackets as follows: Benz(a)anthracene (0.1), Chrysene (0.01), Benzo(b+j) & Benzo(k)fluoranthene (0.1), Benzo(a)pyrene (1.0), Indeno(1.2.3.cd)pyrene (0.1), Dibenzo(a,h)anthracene (1.0), Benzo(g,h,i)perylene (0.01). Less than LOR results for 'TEQ Zero' are treated as zero.
- EK026SF (Total Cyanide by SFA): Samples were passed through a 0.45µm filter prior to analysis due to suspended particulate matter as per ISO 14403.
- Amendment (14/06/2019): This report has been amended and re-released to allow the reporting of additional analytical data.
- Amendment (27/08/2019): This report has been amended and re-released to allow the reporting of additional analytical data.
- It is recognised that EG093-T (Total Metals in Saline Water by ORC-ICP-MS) is less than EG093-F (Dissolved Metals in Saline Water by ORC-ICP-MS) for some samples. However, the difference is within experimental variation of the methods.
- EG035T (Total Mercury): Sample EB1910136-004(WQ_03) diluted due to matrix interference. LOR adjusted accordingly
- EG035F (Dissolved Mercury): Sample EB1910136-004(WQ_03) diluted due to matrix interference. LOR adjusted accordingly.
- Amendment (5/12/2019): This report has been amended following the removal of data from reports as per request by Erica Colley on the 5/12/2019.
- EG093: Samples containing high levels of sulfate may precipitate barium under the acidic conditions of this method and may therefore bias results low.



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				TSS_16 Deep	WQ_16	WQ_16	WQ_03	TSS_06
Client sampling date / time				12-Apr-2019 00:00	13-Apr-2019 00:00	13-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910136-001	EB1910136-002	EB1910136-003	EB1910136-004	EB1910136-005
				Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	1	mg/L	<1	<1	<1	----	<1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	----	2480	----	2460	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	----	<0.0001	----	<0.0005	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	----	<0.0001	----	<0.0005	----
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS								
Aluminium	7429-90-5	5	µg/L	----	<5	----	<5	----
Antimony	7440-36-0	0.5	µg/L	----	<0.5	----	<0.5	----
Arsenic	7440-38-2	0.5	µg/L	----	1.9	----	1.5	----
Barium	7440-39-3	1	µg/L	----	4	----	4	----
Beryllium	7440-41-7	0.1	µg/L	----	<0.1	----	<0.1	----
Boron	7440-42-8	100	µg/L	----	4450	----	4580	----
Cadmium	7440-43-9	0.1	µg/L	----	<0.1	----	<0.1	----
Chromium	7440-47-3	0.5	µg/L	----	<0.5	----	79.4	----
Cobalt	7440-48-4	0.2	µg/L	----	<0.2	----	<0.2	----
Copper	7440-50-8	1	µg/L	----	<1	----	<1	----
Iron	7439-89-6	5	µg/L	----	<5	----	<5	----
Lead	7439-92-1	0.2	µg/L	----	<0.2	----	<0.2	----
Manganese	7439-96-5	0.5	µg/L	----	0.5	----	<0.5	----
Molybdenum	7439-98-7	0.1	µg/L	----	10.1	----	10.4	----
Nickel	7440-02-0	0.5	µg/L	----	<0.5	----	<0.5	----
Selenium	7782-49-2	2	µg/L	----	10	----	10	----
Silver	7440-22-4	0.1	µg/L	----	<0.1	----	0.4	----
Tin	7440-31-5	5	µg/L	----	<5	----	<5	----
Vanadium	7440-62-2	0.5	µg/L	----	2.0	----	1.4	----
Zinc	7440-66-6	5	µg/L	----	<5	----	<5	----
EG093T: Total Metals in Saline Water by ORC-ICPMS								
Antimony	7440-36-0	0.5	µg/L	----	<0.5	----	<0.5	----
Arsenic	7440-38-2	0.5	µg/L	----	1.5	----	1.5	----
Barium	7440-39-3	1	µg/L	----	4	----	4	----
Beryllium	7440-41-7	0.1	µg/L	----	<0.1	----	<0.1	----
Boron	7440-42-8	100	µg/L	----	4330	----	3860	----



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				TSS_16 Deep	WQ_16	WQ_16	WQ_03	TSS_06
Client sampling date / time				12-Apr-2019 00:00	13-Apr-2019 00:00	13-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910136-001	EB1910136-002	EB1910136-003	EB1910136-004	EB1910136-005
				Result	Result	Result	Result	Result
EG093T: Total Metals in Saline Water by ORC-ICPMS - Continued								
Cadmium	7440-43-9	0.2	µg/L	----	<0.2	----	<0.2	----
Chromium	7440-47-3	0.5	µg/L	----	<0.5	----	76.9	----
Cobalt	7440-48-4	0.2	µg/L	----	<0.2	----	<0.2	----
Copper	7440-50-8	1	µg/L	----	<1	----	<1	----
Iron	7439-89-6	5	µg/L	----	8	----	7	----
Lead	7439-92-1	0.2	µg/L	----	<0.2	----	<0.2	----
Manganese	7439-96-5	0.5	µg/L	----	0.9	----	0.9	----
Molybdenum	7439-98-7	0.1	µg/L	----	10.6	----	10.2	----
Nickel	7440-02-0	0.5	µg/L	----	<0.5	----	<0.5	----
Selenium	7782-49-2	2	µg/L	----	5	----	4	----
Silver	7440-22-4	0.1	µg/L	----	<0.1	----	3.5	----
Tin	7440-31-5	5	µg/L	----	<5	----	<5	----
Vanadium	7440-62-2	0.5	µg/L	----	1.7	----	1.7	----
Zinc	7440-66-6	5	µg/L	----	<5	----	<5	----
EK026SF: Total CN by Segmented Flow Analyser								
Total Cyanide	57-12-5	0.004	mg/L	----	<0.004	----	<0.004	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	----	1.1	----	0.9	----
EK085M: Sulfide as S2-								
Sulfide as S2-	18496-25-8	0.1	mg/L	----	<0.1	----	<0.1	----
EP075(SIM)A: Phenolic Compounds								
Phenol	108-95-2	1.0	µg/L	----	<1.0	----	<1.0	----
2-Chlorophenol	95-57-8	1.0	µg/L	----	<1.0	----	<1.0	----
2-Methylphenol	95-48-7	1.0	µg/L	----	<1.0	----	<1.0	----
3- & 4-Methylphenol	1319-77-3	2.0	µg/L	----	<2.0	----	<2.0	----
2-Nitrophenol	88-75-5	1.0	µg/L	----	<1.0	----	<1.0	----
2,4-Dimethylphenol	105-67-9	1.0	µg/L	----	<1.0	----	<1.0	----
2,4-Dichlorophenol	120-83-2	1.0	µg/L	----	<1.0	----	<1.0	----
2,6-Dichlorophenol	87-65-0	1.0	µg/L	----	<1.0	----	<1.0	----
4-Chloro-3-methylphenol	59-50-7	1.0	µg/L	----	<1.0	----	<1.0	----
2,4,6-Trichlorophenol	88-06-2	1.0	µg/L	----	<1.0	----	<1.0	----
2,4,5-Trichlorophenol	95-95-4	1.0	µg/L	----	<1.0	----	<1.0	----
Pentachlorophenol	87-86-5	2.0	µg/L	----	<2.0	----	<2.0	----
2,3,4,6-Tetrachlorophenol	58-90-2	1.0	µg/L	----	<1.0	----	<1.0	----



Analytical Results

Sub-Matrix: WATER
 (Matrix: WATER)

Client sample ID

				TSS_16 Deep	WQ_16	WQ_16	WQ_03	TSS_06
Client sampling date / time				12-Apr-2019 00:00	13-Apr-2019 00:00	13-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910136-001	EB1910136-002	EB1910136-003	EB1910136-004	EB1910136-005
				Result	Result	Result	Result	Result
EP075(SIM)A: Phenolic Compounds - Continued								
^ Total Cresol	----	1.0	µg/L	----	<1.0	----	<1.0	----
^ Sum of Phenols	----	1.0	µg/L	----	<1.0	----	<1.0	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	1.0	µg/L	----	<1.0	----	<1.0	----
Acenaphthylene	208-96-8	1.0	µg/L	----	<1.0	----	<1.0	----
Acenaphthene	83-32-9	1.0	µg/L	----	<1.0	----	<1.0	----
Fluorene	86-73-7	1.0	µg/L	----	<1.0	----	<1.0	----
Phenanthrene	85-01-8	1.0	µg/L	----	<1.0	----	<1.0	----
Anthracene	120-12-7	1.0	µg/L	----	<1.0	----	<1.0	----
Fluoranthene	206-44-0	1.0	µg/L	----	<1.0	----	<1.0	----
Pyrene	129-00-0	1.0	µg/L	----	<1.0	----	<1.0	----
Benz(a)anthracene	56-55-3	1.0	µg/L	----	<1.0	----	<1.0	----
Chrysene	218-01-9	1.0	µg/L	----	<1.0	----	<1.0	----
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L	----	<1.0	----	<1.0	----
Benzo(k)fluoranthene	207-08-9	1.0	µg/L	----	<1.0	----	<1.0	----
Benzo(a)pyrene	50-32-8	0.5	µg/L	----	<0.5	----	<0.5	----
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L	----	<1.0	----	<1.0	----
Dibenz(a.h)anthracene	53-70-3	1.0	µg/L	----	<1.0	----	<1.0	----
Benzo(g.h.i)perylene	191-24-2	1.0	µg/L	----	<1.0	----	<1.0	----
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L	----	<0.5	----	<0.5	----
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L	----	<0.5	----	<0.5	----
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	----	<20	----	<20	----
C10 - C14 Fraction	----	50	µg/L	----	<50	----	<50	----
C15 - C28 Fraction	----	100	µg/L	----	<100	----	<100	----
C29 - C36 Fraction	----	50	µg/L	----	<50	----	<50	----
^ C10 - C36 Fraction (sum)	----	50	µg/L	----	<50	----	<50	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	----	<20	----	<20	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	----	<20	----	<20	----
>C10 - C16 Fraction	----	100	µg/L	----	<100	----	<100	----
>C16 - C34 Fraction	----	100	µg/L	----	<100	----	<100	----
>C34 - C40 Fraction	----	100	µg/L	----	<100	----	<100	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	TSS_16 Deep	WQ_16	WQ_16	WQ_03	TSS_06
Client sampling date / time					12-Apr-2019 00:00	13-Apr-2019 00:00	13-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00
Compound	CAS Number	LOR	Unit		EB1910136-001	EB1910136-002	EB1910136-003	EB1910136-004	EB1910136-005
					Result	Result	Result	Result	Result
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued									
^ >C10 - C40 Fraction (sum)	----	100	µg/L		----	<100	----	<100	----
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L		----	<100	----	<100	----
EP080: BTEXN									
Benzene	71-43-2	1	µg/L		----	<1	----	<1	----
Toluene	108-88-3	2	µg/L		----	<2	----	<2	----
Ethylbenzene	100-41-4	2	µg/L		----	<2	----	<2	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L		----	<2	----	<2	----
ortho-Xylene	95-47-6	2	µg/L		----	<2	----	<2	----
^ Total Xylenes	----	2	µg/L		----	<2	----	<2	----
^ Sum of BTEX	----	1	µg/L		----	<1	----	<1	----
Naphthalene	91-20-3	5	µg/L		----	<5	----	<5	----
EP075(SIM)S: Phenolic Compound Surrogates									
Phenol-d6	13127-88-3	1.0	%		----	34.1	----	32.6	----
2-Chlorophenol-D4	93951-73-6	1.0	%		----	71.1	----	66.3	----
2,4,6-Tribromophenol	118-79-6	1.0	%		----	59.9	----	48.3	----
EP075(SIM)T: PAH Surrogates									
2-Fluorobiphenyl	321-60-8	1.0	%		----	79.5	----	74.3	----
Anthracene-d10	1719-06-8	1.0	%		----	71.8	----	77.9	----
4-Terphenyl-d14	1718-51-0	1.0	%		----	73.1	----	76.8	----
EP080S: TPH(V)/BTEX Surrogates									
1,2-Dichloroethane-D4	17060-07-0	2	%		----	106	----	103	----
Toluene-D8	2037-26-5	2	%		----	98.3	----	96.8	----
4-Bromofluorobenzene	460-00-4	2	%		----	102	----	98.0	----



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				TSS_06 Deep	WQ_10	TSS_21	TSS_35 Deep	TSS_35
Client sampling date / time				12-Apr-2019 00:00	14-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910136-006	EB1910136-007	EB1910136-008	EB1910136-009	EB1910136-010
				Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	1	mg/L	1	1	1	<1	<1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	----	2400	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	----	<0.0001	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	----	<0.0001	----	----	----
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS								
Aluminium	7429-90-5	5	µg/L	----	<5	----	----	----
Antimony	7440-36-0	0.5	µg/L	----	<0.5	----	----	----
Arsenic	7440-38-2	0.5	µg/L	----	1.4	----	----	----
Barium	7440-39-3	1	µg/L	----	6	----	----	----
Beryllium	7440-41-7	0.1	µg/L	----	<0.1	----	----	----
Boron	7440-42-8	100	µg/L	----	4200	----	----	----
Cadmium	7440-43-9	0.1	µg/L	----	<0.1	----	----	----
Chromium	7440-47-3	0.5	µg/L	----	<0.5	----	----	----
Cobalt	7440-48-4	0.2	µg/L	----	<0.2	----	----	----
Copper	7440-50-8	1	µg/L	----	<1	----	----	----
Iron	7439-89-6	5	µg/L	----	<5	----	----	----
Lead	7439-92-1	0.2	µg/L	----	<0.2	----	----	----
Manganese	7439-96-5	0.5	µg/L	----	<0.5	----	----	----
Molybdenum	7439-98-7	0.1	µg/L	----	9.4	----	----	----
Nickel	7440-02-0	0.5	µg/L	----	<0.5	----	----	----
Selenium	7782-49-2	2	µg/L	----	10	----	----	----
Silver	7440-22-4	0.1	µg/L	----	0.2	----	----	----
Tin	7440-31-5	5	µg/L	----	<5	----	----	----
Vanadium	7440-62-2	0.5	µg/L	----	2.0	----	----	----
Zinc	7440-66-6	5	µg/L	----	<5	----	----	----
EG093T: Total Metals in Saline Water by ORC-ICPMS								
Antimony	7440-36-0	0.5	µg/L	----	<0.5	----	----	----
Arsenic	7440-38-2	0.5	µg/L	----	1.6	----	----	----
Barium	7440-39-3	1	µg/L	----	6	----	----	----
Beryllium	7440-41-7	0.1	µg/L	----	<0.1	----	----	----
Boron	7440-42-8	100	µg/L	----	3780	----	----	----



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				TSS_06 Deep	WQ_10	TSS_21	TSS_35 Deep	TSS_35
Client sampling date / time				12-Apr-2019 00:00	14-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910136-006	EB1910136-007	EB1910136-008	EB1910136-009	EB1910136-010
				Result	Result	Result	Result	Result
EG093T: Total Metals in Saline Water by ORC-ICPMS - Continued								
Cadmium	7440-43-9	0.2	µg/L	----	<0.2	----	----	----
Chromium	7440-47-3	0.5	µg/L	----	<0.5	----	----	----
Cobalt	7440-48-4	0.2	µg/L	----	<0.2	----	----	----
Copper	7440-50-8	1	µg/L	----	<1	----	----	----
Iron	7439-89-6	5	µg/L	----	<5	----	----	----
Lead	7439-92-1	0.2	µg/L	----	<0.2	----	----	----
Manganese	7439-96-5	0.5	µg/L	----	0.7	----	----	----
Molybdenum	7439-98-7	0.1	µg/L	----	11.0	----	----	----
Nickel	7440-02-0	0.5	µg/L	----	<0.5	----	----	----
Selenium	7782-49-2	2	µg/L	----	4	----	----	----
Silver	7440-22-4	0.1	µg/L	----	<0.1	----	----	----
Tin	7440-31-5	5	µg/L	----	<5	----	----	----
Vanadium	7440-62-2	0.5	µg/L	----	1.6	----	----	----
Zinc	7440-66-6	5	µg/L	----	<5	----	----	----
EK026SF: Total CN by Segmented Flow Analyser								
Total Cyanide	57-12-5	0.004	mg/L	----	<0.004	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	----	0.9	----	----	----
EK085M: Sulfide as S2-								
Sulfide as S2-	18496-25-8	0.1	mg/L	----	<0.1	----	----	----
EP075(SIM)A: Phenolic Compounds								
Phenol	108-95-2	1.0	µg/L	----	<1.0	----	----	----
2-Chlorophenol	95-57-8	1.0	µg/L	----	<1.0	----	----	----
2-Methylphenol	95-48-7	1.0	µg/L	----	<1.0	----	----	----
3- & 4-Methylphenol	1319-77-3	2.0	µg/L	----	<2.0	----	----	----
2-Nitrophenol	88-75-5	1.0	µg/L	----	<1.0	----	----	----
2,4-Dimethylphenol	105-67-9	1.0	µg/L	----	<1.0	----	----	----
2,4-Dichlorophenol	120-83-2	1.0	µg/L	----	<1.0	----	----	----
2,6-Dichlorophenol	87-65-0	1.0	µg/L	----	<1.0	----	----	----
4-Chloro-3-methylphenol	59-50-7	1.0	µg/L	----	<1.0	----	----	----
2,4,6-Trichlorophenol	88-06-2	1.0	µg/L	----	<1.0	----	----	----
2,4,5-Trichlorophenol	95-95-4	1.0	µg/L	----	<1.0	----	----	----
Pentachlorophenol	87-86-5	2.0	µg/L	----	<2.0	----	----	----
2,3,4,6-Tetrachlorophenol	58-90-2	1.0	µg/L	----	<1.0	----	----	----



Analytical Results

Sub-Matrix: WATER
 (Matrix: WATER)

Client sample ID

				TSS_06 Deep	WQ_10	TSS_21	TSS_35 Deep	TSS_35
Client sampling date / time				12-Apr-2019 00:00	14-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910136-006	EB1910136-007	EB1910136-008	EB1910136-009	EB1910136-010
				Result	Result	Result	Result	Result
EP075(SIM)A: Phenolic Compounds - Continued								
^ Total Cresol	----	1.0	µg/L	----	<1.0	----	----	----
^ Sum of Phenols	----	1.0	µg/L	----	<1.0	----	----	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	1.0	µg/L	----	<1.0	----	----	----
Acenaphthylene	208-96-8	1.0	µg/L	----	<1.0	----	----	----
Acenaphthene	83-32-9	1.0	µg/L	----	<1.0	----	----	----
Fluorene	86-73-7	1.0	µg/L	----	<1.0	----	----	----
Phenanthrene	85-01-8	1.0	µg/L	----	<1.0	----	----	----
Anthracene	120-12-7	1.0	µg/L	----	<1.0	----	----	----
Fluoranthene	206-44-0	1.0	µg/L	----	<1.0	----	----	----
Pyrene	129-00-0	1.0	µg/L	----	<1.0	----	----	----
Benz(a)anthracene	56-55-3	1.0	µg/L	----	<1.0	----	----	----
Chrysene	218-01-9	1.0	µg/L	----	<1.0	----	----	----
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L	----	<1.0	----	----	----
Benzo(k)fluoranthene	207-08-9	1.0	µg/L	----	<1.0	----	----	----
Benzo(a)pyrene	50-32-8	0.5	µg/L	----	<0.5	----	----	----
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L	----	<1.0	----	----	----
Dibenz(a.h)anthracene	53-70-3	1.0	µg/L	----	<1.0	----	----	----
Benzo(g.h.i)perylene	191-24-2	1.0	µg/L	----	<1.0	----	----	----
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L	----	<0.5	----	----	----
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L	----	<0.5	----	----	----
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	----	<20	----	----	----
C10 - C14 Fraction	----	50	µg/L	----	<50	----	----	----
C15 - C28 Fraction	----	100	µg/L	----	<100	----	----	----
C29 - C36 Fraction	----	50	µg/L	----	<50	----	----	----
^ C10 - C36 Fraction (sum)	----	50	µg/L	----	<50	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	----	<20	----	----	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	----	<20	----	----	----
>C10 - C16 Fraction	----	100	µg/L	----	<100	----	----	----
>C16 - C34 Fraction	----	100	µg/L	----	<100	----	----	----
>C34 - C40 Fraction	----	100	µg/L	----	<100	----	----	----



Analytical Results

Sub-Matrix: WATER
 (Matrix: WATER)

Client sample ID

				TSS_06 Deep	WQ_10	TSS_21	TSS_35 Deep	TSS_35
Client sampling date / time				12-Apr-2019 00:00	14-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910136-006	EB1910136-007	EB1910136-008	EB1910136-009	EB1910136-010
				Result	Result	Result	Result	Result
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued								
^ >C10 - C40 Fraction (sum)	----	100	µg/L	----	<100	----	----	----
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	----	<100	----	----	----
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	----	<1	----	----	----
Toluene	108-88-3	2	µg/L	----	<2	----	----	----
Ethylbenzene	100-41-4	2	µg/L	----	<2	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	----	<2	----	----	----
ortho-Xylene	95-47-6	2	µg/L	----	<2	----	----	----
^ Total Xylenes	----	2	µg/L	----	<2	----	----	----
^ Sum of BTEX	----	1	µg/L	----	<1	----	----	----
Naphthalene	91-20-3	5	µg/L	----	<5	----	----	----
EP075(SIM)S: Phenolic Compound Surrogates								
Phenol-d6	13127-88-3	1.0	%	----	35.6	----	----	----
2-Chlorophenol-D4	93951-73-6	1.0	%	----	74.3	----	----	----
2,4,6-Tribromophenol	118-79-6	1.0	%	----	52.0	----	----	----
EP075(SIM)T: PAH Surrogates								
2-Fluorobiphenyl	321-60-8	1.0	%	----	84.3	----	----	----
Anthracene-d10	1719-06-8	1.0	%	----	89.0	----	----	----
4-Terphenyl-d14	1718-51-0	1.0	%	----	89.7	----	----	----
EP080S: TPH(V)/BTEX Surrogates								
1,2-Dichloroethane-D4	17060-07-0	2	%	----	104	----	----	----
Toluene-D8	2037-26-5	2	%	----	101	----	----	----
4-Bromofluorobenzene	460-00-4	2	%	----	104	----	----	----



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				TSS_36	TSS_36 Deep	WQ_09	WQ_15	WQ_05
Client sampling date / time				12-Apr-2019 00:00	12-Apr-2019 00:00	14-Apr-2019 00:00	13-Apr-2019 00:00	13-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910136-011	EB1910136-012	EB1910136-013	EB1910136-014	EB1910136-015
				Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	1	mg/L	<1	2	6	<1	<1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	----	----	2450	2550	2410
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	----	----	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	----	----	<0.0001	<0.0001	<0.0001
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS								
Aluminium	7429-90-5	5	µg/L	----	----	<5	<5	<5
Antimony	7440-36-0	0.5	µg/L	----	----	<0.5	<0.5	<0.5
Arsenic	7440-38-2	0.5	µg/L	----	----	1.6	1.7	1.5
Barium	7440-39-3	1	µg/L	----	----	10	4	5
Beryllium	7440-41-7	0.1	µg/L	----	----	<0.1	<0.1	<0.1
Boron	7440-42-8	100	µg/L	----	----	4300	4450	4340
Cadmium	7440-43-9	0.1	µg/L	----	----	<0.1	<0.1	<0.1
Chromium	7440-47-3	0.5	µg/L	----	----	0.7	<0.5	<0.5
Cobalt	7440-48-4	0.2	µg/L	----	----	<0.2	<0.2	<0.2
Copper	7440-50-8	1	µg/L	----	----	<1	<1	1
Iron	7439-89-6	5	µg/L	----	----	6	<5	5
Lead	7439-92-1	0.2	µg/L	----	----	<0.2	<0.2	<0.2
Manganese	7439-96-5	0.5	µg/L	----	----	19.6	0.6	1.1
Molybdenum	7439-98-7	0.1	µg/L	----	----	9.3	9.8	9.6
Nickel	7440-02-0	0.5	µg/L	----	----	0.6	<0.5	0.5
Selenium	7782-49-2	2	µg/L	----	----	10	8	10
Silver	7440-22-4	0.1	µg/L	----	----	<0.1	<0.1	<0.1
Tin	7440-31-5	5	µg/L	----	----	<5	<5	<5
Vanadium	7440-62-2	0.5	µg/L	----	----	2.8	1.9	1.8
Zinc	7440-66-6	5	µg/L	----	----	<5	<5	<5
EG093T: Total Metals in Saline Water by ORC-ICPMS								
Antimony	7440-36-0	0.5	µg/L	----	----	<0.5	<0.5	<0.5
Arsenic	7440-38-2	0.5	µg/L	----	----	1.6	1.4	1.5
Barium	7440-39-3	1	µg/L	----	----	11	5	6
Beryllium	7440-41-7	0.1	µg/L	----	----	<0.1	<0.1	<0.1
Boron	7440-42-8	100	µg/L	----	----	3730	3730	3670



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				TSS_36	TSS_36 Deep	WQ_09	WQ_15	WQ_05
Client sampling date / time				12-Apr-2019 00:00	12-Apr-2019 00:00	14-Apr-2019 00:00	13-Apr-2019 00:00	13-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910136-011	EB1910136-012	EB1910136-013	EB1910136-014	EB1910136-015
				Result	Result	Result	Result	Result
EG093T: Total Metals in Saline Water by ORC-ICPMS - Continued								
Cadmium	7440-43-9	0.2	µg/L	----	----	<0.2	<0.2	<0.2
Chromium	7440-47-3	0.5	µg/L	----	----	<0.5	<0.5	0.7
Cobalt	7440-48-4	0.2	µg/L	----	----	0.2	<0.2	<0.2
Copper	7440-50-8	1	µg/L	----	----	<1	<1	<1
Iron	7439-89-6	5	µg/L	----	----	232	5	21
Lead	7439-92-1	0.2	µg/L	----	----	<0.2	<0.2	<0.2
Manganese	7439-96-5	0.5	µg/L	----	----	23.2	0.8	1.8
Molybdenum	7439-98-7	0.1	µg/L	----	----	10.2	10.6	10.2
Nickel	7440-02-0	0.5	µg/L	----	----	0.6	<0.5	<0.5
Selenium	7782-49-2	2	µg/L	----	----	4	4	4
Silver	7440-22-4	0.1	µg/L	----	----	<0.1	<0.1	<0.1
Tin	7440-31-5	5	µg/L	----	----	<5	<5	<5
Vanadium	7440-62-2	0.5	µg/L	----	----	2.8	1.7	1.9
Zinc	7440-66-6	5	µg/L	----	----	<5	<5	<5
EK026SF: Total CN by Segmented Flow Analyser								
Total Cyanide	57-12-5	0.004	mg/L	----	----	<0.004	<0.004	<0.004
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	----	----	0.9	0.9	0.8
EK085M: Sulfide as S2-								
Sulfide as S2-	18496-25-8	0.1	mg/L	----	----	<0.1	<0.1	<0.1
EP075(SIM)A: Phenolic Compounds								
Phenol	108-95-2	1.0	µg/L	----	----	<1.0	<1.0	<1.0
2-Chlorophenol	95-57-8	1.0	µg/L	----	----	<1.0	<1.0	<1.0
2-Methylphenol	95-48-7	1.0	µg/L	----	----	<1.0	<1.0	<1.0
3- & 4-Methylphenol	1319-77-3	2.0	µg/L	----	----	<2.0	<2.0	<2.0
2-Nitrophenol	88-75-5	1.0	µg/L	----	----	<1.0	<1.0	<1.0
2,4-Dimethylphenol	105-67-9	1.0	µg/L	----	----	<1.0	<1.0	<1.0
2,4-Dichlorophenol	120-83-2	1.0	µg/L	----	----	<1.0	<1.0	<1.0
2,6-Dichlorophenol	87-65-0	1.0	µg/L	----	----	<1.0	<1.0	<1.0
4-Chloro-3-methylphenol	59-50-7	1.0	µg/L	----	----	<1.0	<1.0	<1.0
2,4,6-Trichlorophenol	88-06-2	1.0	µg/L	----	----	<1.0	<1.0	<1.0
2,4,5-Trichlorophenol	95-95-4	1.0	µg/L	----	----	<1.0	<1.0	<1.0
Pentachlorophenol	87-86-5	2.0	µg/L	----	----	<2.0	<2.0	<2.0
2,3,4,6-Tetrachlorophenol	58-90-2	1.0	µg/L	----	----	<1.0	<1.0	<1.0



Analytical Results

Sub-Matrix: WATER
 (Matrix: WATER)

Client sample ID

				TSS_36	TSS_36 Deep	WQ_09	WQ_15	WQ_05
Client sampling date / time				12-Apr-2019 00:00	12-Apr-2019 00:00	14-Apr-2019 00:00	13-Apr-2019 00:00	13-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910136-011	EB1910136-012	EB1910136-013	EB1910136-014	EB1910136-015
				Result	Result	Result	Result	Result
EP075(SIM)A: Phenolic Compounds - Continued								
^ Total Cresol	----	1.0	µg/L	----	----	<1.0	<1.0	<1.0
^ Sum of Phenols	----	1.0	µg/L	----	----	<1.0	<1.0	<1.0
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	1.0	µg/L	----	----	<1.0	<1.0	<1.0
Acenaphthylene	208-96-8	1.0	µg/L	----	----	<1.0	<1.0	<1.0
Acenaphthene	83-32-9	1.0	µg/L	----	----	<1.0	<1.0	<1.0
Fluorene	86-73-7	1.0	µg/L	----	----	<1.0	<1.0	<1.0
Phenanthrene	85-01-8	1.0	µg/L	----	----	<1.0	<1.0	<1.0
Anthracene	120-12-7	1.0	µg/L	----	----	<1.0	<1.0	<1.0
Fluoranthene	206-44-0	1.0	µg/L	----	----	<1.0	<1.0	<1.0
Pyrene	129-00-0	1.0	µg/L	----	----	<1.0	<1.0	<1.0
Benz(a)anthracene	56-55-3	1.0	µg/L	----	----	<1.0	<1.0	<1.0
Chrysene	218-01-9	1.0	µg/L	----	----	<1.0	<1.0	<1.0
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L	----	----	<1.0	<1.0	<1.0
Benzo(k)fluoranthene	207-08-9	1.0	µg/L	----	----	<1.0	<1.0	<1.0
Benzo(a)pyrene	50-32-8	0.5	µg/L	----	----	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L	----	----	<1.0	<1.0	<1.0
Dibenz(a.h)anthracene	53-70-3	1.0	µg/L	----	----	<1.0	<1.0	<1.0
Benzo(g.h.i)perylene	191-24-2	1.0	µg/L	----	----	<1.0	<1.0	<1.0
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L	----	----	<0.5	<0.5	<0.5
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L	----	----	<0.5	<0.5	<0.5
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	----	----	<20	<20	<20
C10 - C14 Fraction	----	50	µg/L	----	----	<50	<50	<50
C15 - C28 Fraction	----	100	µg/L	----	----	<100	<100	<100
C29 - C36 Fraction	----	50	µg/L	----	----	<50	<50	<50
^ C10 - C36 Fraction (sum)	----	50	µg/L	----	----	<50	<50	<50
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	----	----	<20	<20	<20
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	----	----	<20	<20	<20
>C10 - C16 Fraction	----	100	µg/L	----	----	<100	<100	<100
>C16 - C34 Fraction	----	100	µg/L	----	----	<100	<100	<100
>C34 - C40 Fraction	----	100	µg/L	----	----	<100	<100	<100



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				TSS_36	TSS_36 Deep	WQ_09	WQ_15	WQ_05
Client sampling date / time				12-Apr-2019 00:00	12-Apr-2019 00:00	14-Apr-2019 00:00	13-Apr-2019 00:00	13-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910136-011	EB1910136-012	EB1910136-013	EB1910136-014	EB1910136-015
				Result	Result	Result	Result	Result
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued								
^ >C10 - C40 Fraction (sum)	----	100	µg/L	----	----	<100	<100	<100
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	----	----	<100	<100	<100
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	----	----	<1	<1	<1
Toluene	108-88-3	2	µg/L	----	----	<2	<2	<2
Ethylbenzene	100-41-4	2	µg/L	----	----	<2	<2	<2
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	----	----	<2	<2	<2
ortho-Xylene	95-47-6	2	µg/L	----	----	<2	<2	<2
^ Total Xylenes	----	2	µg/L	----	----	<2	<2	<2
^ Sum of BTEX	----	1	µg/L	----	----	<1	<1	<1
Naphthalene	91-20-3	5	µg/L	----	----	<5	<5	<5
EP075(SIM)S: Phenolic Compound Surrogates								
Phenol-d6	13127-88-3	1.0	%	----	----	35.9	35.7	33.4
2-Chlorophenol-D4	93951-73-6	1.0	%	----	----	75.9	72.5	71.2
2,4,6-Tribromophenol	118-79-6	1.0	%	----	----	57.9	54.3	52.4
EP075(SIM)T: PAH Surrogates								
2-Fluorobiphenyl	321-60-8	1.0	%	----	----	86.5	82.0	82.2
Anthracene-d10	1719-06-8	1.0	%	----	----	81.8	74.7	75.3
4-Terphenyl-d14	1718-51-0	1.0	%	----	----	85.6	76.5	79.1
EP080S: TPH(V)/BTEX Surrogates								
1,2-Dichloroethane-D4	17060-07-0	2	%	----	----	105	100	106
Toluene-D8	2037-26-5	2	%	----	----	98.0	100	99.9
4-Bromofluorobenzene	460-00-4	2	%	----	----	100	101	103



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				WQ_04	WQ_08	WQ_11	WQ_14	WQ_06
Client sampling date / time				14-Apr-2019 00:00	13-Apr-2019 00:00	14-Apr-2019 00:00	14-Apr-2019 00:00	12-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910136-016	EB1910136-017	EB1910136-018	EB1910136-019	EB1910136-020
				Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	1	mg/L	1	3	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	2300	2470	2400	2360	2450
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS								
Aluminium	7429-90-5	5	µg/L	<5	<5	<5	<5	<5
Antimony	7440-36-0	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Arsenic	7440-38-2	0.5	µg/L	1.6	1.8	1.5	1.5	1.8
Barium	7440-39-3	1	µg/L	6	5	6	6	4
Beryllium	7440-41-7	0.1	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Boron	7440-42-8	100	µg/L	4230	4460	4270	4170	4470
Cadmium	7440-43-9	0.1	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	7440-47-3	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Cobalt	7440-48-4	0.2	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Copper	7440-50-8	1	µg/L	1	1	1	1	1
Iron	7439-89-6	5	µg/L	<5	<5	<5	<5	<5
Lead	7439-92-1	0.2	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Manganese	7439-96-5	0.5	µg/L	<0.5	1.8	1.3	<0.5	1.0
Molybdenum	7439-98-7	0.1	µg/L	9.1	9.5	8.9	9.4	9.6
Nickel	7440-02-0	0.5	µg/L	<0.5	0.9	<0.5	<0.5	<0.5
Selenium	7782-49-2	2	µg/L	10	10	9	10	10
Silver	7440-22-4	0.1	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Tin	7440-31-5	5	µg/L	<5	<5	<5	<5	<5
Vanadium	7440-62-2	0.5	µg/L	1.9	1.9	2.1	1.9	1.9
Zinc	7440-66-6	5	µg/L	<5	<5	<5	<5	7
EG093T: Total Metals in Saline Water by ORC-ICPMS								
Antimony	7440-36-0	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	0.5
Arsenic	7440-38-2	0.5	µg/L	1.4	1.4	1.4	1.3	1.5
Barium	7440-39-3	1	µg/L	6	5	7	6	5
Beryllium	7440-41-7	0.1	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Boron	7440-42-8	100	µg/L	3680	4220	4100	3500	3840



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				WQ_04	WQ_08	WQ_11	WQ_14	WQ_06
Client sampling date / time				14-Apr-2019 00:00	13-Apr-2019 00:00	14-Apr-2019 00:00	14-Apr-2019 00:00	12-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910136-016	EB1910136-017	EB1910136-018	EB1910136-019	EB1910136-020
				Result	Result	Result	Result	Result
EG093T: Total Metals in Saline Water by ORC-ICPMS - Continued								
Cadmium	7440-43-9	0.2	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Chromium	7440-47-3	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Cobalt	7440-48-4	0.2	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Copper	7440-50-8	1	µg/L	<1	<1	<1	<1	<1
Iron	7439-89-6	5	µg/L	5	14	7	<5	15
Lead	7439-92-1	0.2	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Manganese	7439-96-5	0.5	µg/L	<0.5	2.2	1.4	<0.5	1.4
Molybdenum	7439-98-7	0.1	µg/L	10.4	10.0	9.9	9.8	10.9
Nickel	7440-02-0	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Selenium	7782-49-2	2	µg/L	4	4	4	4	4
Silver	7440-22-4	0.1	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Tin	7440-31-5	5	µg/L	<5	<5	<5	<5	<5
Vanadium	7440-62-2	0.5	µg/L	1.7	1.7	1.7	1.6	1.7
Zinc	7440-66-6	5	µg/L	<5	<5	<5	<5	<5
EK026SF: Total CN by Segmented Flow Analyser								
Total Cyanide	57-12-5	0.004	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	0.8	0.9	0.8	0.9	0.9
EK085M: Sulfide as S2-								
Sulfide as S2-	18496-25-8	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	----
EP075(SIM)A: Phenolic Compounds								
Phenol	108-95-2	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
2-Chlorophenol	95-57-8	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
2-Methylphenol	95-48-7	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
3- & 4-Methylphenol	1319-77-3	2.0	µg/L	<2.0	<2.0	<2.0	<2.0	<2.0
2-Nitrophenol	88-75-5	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
2,4-Dimethylphenol	105-67-9	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
2,4-Dichlorophenol	120-83-2	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
2,6-Dichlorophenol	87-65-0	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
4-Chloro-3-methylphenol	59-50-7	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
2,4,6-Trichlorophenol	88-06-2	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
2,4,5-Trichlorophenol	95-95-4	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Pentachlorophenol	87-86-5	2.0	µg/L	<2.0	<2.0	<2.0	<2.0	<2.0
2,3,4,6-Tetrachlorophenol	58-90-2	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0



Analytical Results

Sub-Matrix: WATER
 (Matrix: WATER)

Client sample ID

				WQ_04	WQ_08	WQ_11	WQ_14	WQ_06
Client sampling date / time				14-Apr-2019 00:00	13-Apr-2019 00:00	14-Apr-2019 00:00	14-Apr-2019 00:00	12-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910136-016	EB1910136-017	EB1910136-018	EB1910136-019	EB1910136-020
				Result	Result	Result	Result	Result
EP075(SIM)A: Phenolic Compounds - Continued								
^ Total Cresol	----	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
^ Sum of Phenols	----	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthylene	208-96-8	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthene	83-32-9	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Fluorene	86-73-7	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Phenanthrene	85-01-8	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Anthracene	120-12-7	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Fluoranthene	206-44-0	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Pyrene	129-00-0	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benz(a)anthracene	56-55-3	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Chrysene	218-01-9	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(k)fluoranthene	207-08-9	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(a)pyrene	50-32-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Dibenz(a.h)anthracene	53-70-3	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(g,h,i)perylene	191-24-2	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	<20	<20	<20	<20
C10 - C14 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
C15 - C28 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
C29 - C36 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	<50	<50	<50	<50
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	<20	<20	<20
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	<20	<20	<20	<20
>C10 - C16 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C16 - C34 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C34 - C40 Fraction	----	100	µg/L	<100	<100	<100	<100	<100



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	WQ_04	WQ_08	WQ_11	WQ_14	WQ_06
Client sampling date / time					14-Apr-2019 00:00	13-Apr-2019 00:00	14-Apr-2019 00:00	14-Apr-2019 00:00	12-Apr-2019 00:00
Compound	CAS Number	LOR	Unit		EB1910136-016	EB1910136-017	EB1910136-018	EB1910136-019	EB1910136-020
					Result	Result	Result	Result	Result
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued									
^ >C10 - C40 Fraction (sum)	----	100	µg/L		<100	<100	<100	<100	<100
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L		<100	<100	<100	<100	<100
EP080: BTEXN									
Benzene	71-43-2	1	µg/L		<1	<1	<1	<1	<1
Toluene	108-88-3	2	µg/L		<2	<2	<2	<2	<2
Ethylbenzene	100-41-4	2	µg/L		<2	<2	<2	<2	<2
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L		<2	<2	<2	<2	<2
ortho-Xylene	95-47-6	2	µg/L		<2	<2	<2	<2	<2
^ Total Xylenes	----	2	µg/L		<2	<2	<2	<2	<2
^ Sum of BTEX	----	1	µg/L		<1	<1	<1	<1	<1
Naphthalene	91-20-3	5	µg/L		<5	<5	<5	<5	<5
EP075(SIM)S: Phenolic Compound Surrogates									
Phenol-d6	13127-88-3	1.0	%		35.4	27.9	31.0	35.4	33.0
2-Chlorophenol-D4	93951-73-6	1.0	%		71.8	59.9	64.2	70.7	68.8
2,4,6-Tribromophenol	118-79-6	1.0	%		44.9	35.3	36.8	41.8	43.0
EP075(SIM)T: PAH Surrogates									
2-Fluorobiphenyl	321-60-8	1.0	%		81.4	72.1	75.8	81.2	83.8
Anthracene-d10	1719-06-8	1.0	%		74.1	78.3	75.5	79.2	80.7
4-Terphenyl-d14	1718-51-0	1.0	%		81.2	80.4	82.1	83.3	86.1
EP080S: TPH(V)/BTEX Surrogates									
1,2-Dichloroethane-D4	17060-07-0	2	%		106	107	105	103	102
Toluene-D8	2037-26-5	2	%		97.0	98.6	97.1	95.4	96.7
4-Bromofluorobenzene	460-00-4	2	%		102	101	100	98.7	99.0



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				WQ_07	WQ_02	WQ_18	WQ_13	TSS_25 Deep
Client sampling date / time				12-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910136-021	EB1910136-022	EB1910136-023	EB1910136-024	EB1910136-025
				Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	1	mg/L	<1	<1	----	----	1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	2430	2370	2350	2360	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	----
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS								
Aluminium	7429-90-5	5	µg/L	<5	<5	<5	<5	----
Antimony	7440-36-0	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	----
Arsenic	7440-38-2	0.5	µg/L	1.8	1.7	1.5	1.5	----
Barium	7440-39-3	1	µg/L	5	5	6	6	----
Beryllium	7440-41-7	0.1	µg/L	<0.1	<0.1	<0.1	<0.1	----
Boron	7440-42-8	100	µg/L	4420	4290	4190	4140	----
Cadmium	7440-43-9	0.1	µg/L	<0.1	<0.1	<0.1	<0.1	----
Chromium	7440-47-3	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	----
Cobalt	7440-48-4	0.2	µg/L	<0.2	<0.2	<0.2	<0.2	----
Copper	7440-50-8	1	µg/L	1	1	1	3	----
Iron	7439-89-6	5	µg/L	<5	5	<5	<5	----
Lead	7439-92-1	0.2	µg/L	<0.2	<0.2	<0.2	<0.2	----
Manganese	7439-96-5	0.5	µg/L	0.9	0.7	<0.5	<0.5	----
Molybdenum	7439-98-7	0.1	µg/L	9.6	9.5	9.0	9.0	----
Nickel	7440-02-0	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	----
Selenium	7782-49-2	2	µg/L	9	9	9	9	----
Silver	7440-22-4	0.1	µg/L	<0.1	<0.1	<0.1	<0.1	----
Tin	7440-31-5	5	µg/L	<5	<5	<5	<5	----
Vanadium	7440-62-2	0.5	µg/L	1.8	1.7	1.9	2.0	----
Zinc	7440-66-6	5	µg/L	<5	<5	<5	<5	----
EG093T: Total Metals in Saline Water by ORC-ICPMS								
Antimony	7440-36-0	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	----
Arsenic	7440-38-2	0.5	µg/L	1.4	1.3	1.3	1.4	----
Barium	7440-39-3	1	µg/L	5	5	6	6	----
Beryllium	7440-41-7	0.1	µg/L	<0.1	<0.1	<0.1	<0.1	----
Boron	7440-42-8	100	µg/L	4350	4140	4250	4170	----



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				WQ_07	WQ_02	WQ_18	WQ_13	TSS_25 Deep
Client sampling date / time				12-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910136-021	EB1910136-022	EB1910136-023	EB1910136-024	EB1910136-025
				Result	Result	Result	Result	Result
EG093T: Total Metals in Saline Water by ORC-ICPMS - Continued								
Cadmium	7440-43-9	0.2	µg/L	<0.2	<0.2	<0.2	<0.2	----
Chromium	7440-47-3	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	----
Cobalt	7440-48-4	0.2	µg/L	<0.2	<0.2	<0.2	<0.2	----
Copper	7440-50-8	1	µg/L	<1	<1	<1	<1	----
Iron	7439-89-6	5	µg/L	10	6	<5	<5	----
Lead	7439-92-1	0.2	µg/L	<0.2	<0.2	<0.2	<0.2	----
Manganese	7439-96-5	0.5	µg/L	1.3	1.0	<0.5	<0.5	----
Molybdenum	7439-98-7	0.1	µg/L	10.0	10.0	9.4	9.8	----
Nickel	7440-02-0	0.5	µg/L	8.0	<0.5	<0.5	<0.5	----
Selenium	7782-49-2	2	µg/L	4	4	4	4	----
Silver	7440-22-4	0.1	µg/L	<0.1	<0.1	<0.1	<0.1	----
Tin	7440-31-5	5	µg/L	<5	<5	<5	<5	----
Vanadium	7440-62-2	0.5	µg/L	1.7	1.7	1.6	1.6	----
Zinc	7440-66-6	5	µg/L	<5	<5	<5	<5	----
EK026SF: Total CN by Segmented Flow Analyser								
Total Cyanide	57-12-5	0.004	mg/L	<0.004	<0.004	<0.004	<0.004	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	0.8	0.9	0.8	0.8	----
EK085M: Sulfide as S2-								
Sulfide as S2-	18496-25-8	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	----
EP075(SIM)A: Phenolic Compounds								
Phenol	108-95-2	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	----
2-Chlorophenol	95-57-8	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	----
2-Methylphenol	95-48-7	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	----
3- & 4-Methylphenol	1319-77-3	2.0	µg/L	<2.0	<2.0	<2.0	<2.0	----
2-Nitrophenol	88-75-5	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	----
2,4-Dimethylphenol	105-67-9	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	----
2,4-Dichlorophenol	120-83-2	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	----
2,6-Dichlorophenol	87-65-0	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	----
4-Chloro-3-methylphenol	59-50-7	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	----
2,4,6-Trichlorophenol	88-06-2	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	----
2,4,5-Trichlorophenol	95-95-4	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	----
Pentachlorophenol	87-86-5	2.0	µg/L	<2.0	<2.0	<2.0	<2.0	----
2,3,4,6-Tetrachlorophenol	58-90-2	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	----



Analytical Results

Sub-Matrix: WATER
 (Matrix: WATER)

Client sample ID

				WQ_07	WQ_02	WQ_18	WQ_13	TSS_25 Deep
Client sampling date / time				12-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910136-021	EB1910136-022	EB1910136-023	EB1910136-024	EB1910136-025
				Result	Result	Result	Result	Result
EP075(SIM)A: Phenolic Compounds - Continued								
^ Total Cresol	----	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	----
^ Sum of Phenols	----	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	----
Acenaphthylene	208-96-8	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	----
Acenaphthene	83-32-9	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	----
Fluorene	86-73-7	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	----
Phenanthrene	85-01-8	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	----
Anthracene	120-12-7	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	----
Fluoranthene	206-44-0	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	----
Pyrene	129-00-0	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	----
Benz(a)anthracene	56-55-3	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	----
Chrysene	218-01-9	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	----
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	----
Benzo(k)fluoranthene	207-08-9	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	----
Benzo(a)pyrene	50-32-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	----
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	----
Dibenz(a.h)anthracene	53-70-3	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	----
Benzo(g.h.i)perylene	191-24-2	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	----
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	----
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	----
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	<20	<20	<20	----
C10 - C14 Fraction	----	50	µg/L	<50	<50	<50	<50	----
C15 - C28 Fraction	----	100	µg/L	<100	<100	<100	<100	----
C29 - C36 Fraction	----	50	µg/L	<50	<50	<50	<50	----
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	<50	<50	<50	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	<20	<20	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	<20	<20	<20	----
>C10 - C16 Fraction	----	100	µg/L	<100	<100	<100	<100	----
>C16 - C34 Fraction	----	100	µg/L	<100	<100	<100	<100	----
>C34 - C40 Fraction	----	100	µg/L	<100	<100	<100	<100	----



Analytical Results

Sub-Matrix: WATER
 (Matrix: WATER)

Client sample ID

				WQ_07	WQ_02	WQ_18	WQ_13	TSS_25 Deep
Client sampling date / time				12-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910136-021	EB1910136-022	EB1910136-023	EB1910136-024	EB1910136-025
				Result	Result	Result	Result	Result
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued								
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	<100	<100	<100	----
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	<100	<100	<100	----
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	<1	<1	<1	----
Toluene	108-88-3	2	µg/L	<2	<2	<2	<2	----
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	<2	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	<2	----
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	<2	----
^ Total Xylenes	----	2	µg/L	<2	<2	<2	<2	----
^ Sum of BTEX	----	1	µg/L	<1	<1	<1	<1	----
Naphthalene	91-20-3	5	µg/L	<5	<5	<5	<5	----
EP075(SIM)S: Phenolic Compound Surrogates								
Phenol-d6	13127-88-3	1.0	%	31.3	31.6	32.8	33.1	----
2-Chlorophenol-D4	93951-73-6	1.0	%	62.3	63.8	65.3	68.7	----
2,4,6-Tribromophenol	118-79-6	1.0	%	32.9	35.3	32.9	32.8	----
EP075(SIM)T: PAH Surrogates								
2-Fluorobiphenyl	321-60-8	1.0	%	77.9	77.2	81.0	83.2	----
Anthracene-d10	1719-06-8	1.0	%	73.6	78.5	74.2	88.0	----
4-Terphenyl-d14	1718-51-0	1.0	%	78.1	80.5	81.4	89.2	----
EP080S: TPH(V)/BTEX Surrogates								
1,2-Dichloroethane-D4	17060-07-0	2	%	102	105	104	102	----
Toluene-D8	2037-26-5	2	%	98.2	99.2	99.2	96.1	----
4-Bromofluorobenzene	460-00-4	2	%	101	102	103	98.2	----



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				TSS_40	TSS_20	TSS_39	TSS_15 Deep	TSS_02
Client sampling date / time				12-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00	14-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910136-026	EB1910136-027	EB1910136-028	EB1910136-029	EB1910136-030
				Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	1	mg/L	2	<1	2	2	<1



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	TSS_19	TSS_38	TSS_11	TSS_23 Deep	TSS_17 Deep
Client sampling date / time					13-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00	13-Apr-2019 00:00	13-Apr-2019 00:00
Compound	CAS Number	LOR	Unit		EB1910136-031	EB1910136-032	EB1910136-033	EB1910136-034	EB1910136-035
					Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	1	mg/L		<1	2	1	2	2

Page : 25 of 27
 Work Order : EB1910136 Amendment 3
 Client : COFFEY ENVIRONMENTS PTY LTD
 Project : 754-MELEN224697 JDD PROJECT



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				TSS_17	TSS_11 Deep	TSS_18	TSS_24	TSS_23
Client sampling date / time				13-Apr-2019 00:00	12-Apr-2019 00:00	13-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910136-036	EB1910136-037	EB1910136-038	EB1910136-039	EB1910136-040
				Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	1	mg/L	<1	<1	<1	<1	1



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	TSS_15	TSS_30	TSS_13	TSS_33	TSS_03
Client sampling date / time					12-Apr-2019 00:00	14-Apr-2019 00:00	13-Apr-2019 00:00	14-Apr-2019 00:00	14-Apr-2019 00:00
Compound	CAS Number	LOR	Unit		EB1910136-041	EB1910136-042	EB1910136-043	EB1910136-044	EB1910136-045
					Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	1	mg/L		<1	1	1	4	1



Surrogate Control Limits

Sub-Matrix: WATER		Recovery Limits (%)	
Compound	CAS Number	Low	High
EP075(SIM)S: Phenolic Compound Surrogates			
Phenol-d6	13127-88-3	10	72
2-Chlorophenol-D4	93951-73-6	27	130
2,4,6-Tribromophenol	118-79-6	19	181
EP075(SIM)T: PAH Surrogates			
2-Fluorobiphenyl	321-60-8	14	146
Anthracene-d10	1719-06-8	35	137
4-Terphenyl-d14	1718-51-0	36	154
EP080S: TPH(V)/BTEX Surrogates			
1,2-Dichloroethane-D4	17060-07-0	66	138
Toluene-D8	2037-26-5	79	120
4-Bromofluorobenzene	460-00-4	74	118

CERTIFICATE OF ANALYSIS

Work Order	: EB1910136	Page	: 1 of 16
Amendment	: 4		
Client	: COFFEY ENVIRONMENTS PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MS ERICA COLLEY	Contact	: Andrew Epps
Address	: Level 5 12 Creek St Brisbane QLD, AUSTRALIA 4000	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3608 2500	Telephone	: +61 7 3552 8639
Project	: 754-MELEN224697 JDD PROJECT	Date Samples Received	: 17-Apr-2019 12:20
Order number	: BN/065/19	Date Analysis Commenced	: 18-Apr-2019
C-O-C number	: ----	Issue Date	: 31-Mar-2020 15:05
Sampler	: E COLLEY		
Site	: ----		
Quote number	: BN/065/19 V2		
No. of samples received	: 45		
No. of samples analysed	: 45		



Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- EK061G (Total Kjeldahl Nitrogen as N) / EK067G (Total Phosphorus as P): Some samples were diluted due to matrix interference. LOR adjusted accordingly.
- Benzo(a)pyrene Toxicity Equivalent Quotient (TEQ) per the NEPM (2013) is the sum total of the concentration of the eight carcinogenic PAHs multiplied by their Toxicity Equivalence Factor (TEF) relative to Benzo(a)pyrene. TEF values are provided in brackets as follows: Benz(a)anthracene (0.1), Chrysene (0.01), Benzo(b+j) & Benzo(k)fluoranthene (0.1), Benzo(a)pyrene (1.0), Indeno(1.2.3.cd)pyrene (0.1), Dibenz(a,h)anthracene (1.0), Benzo(g,h,i)perylene (0.01). Less than LOR results for 'TEQ Zero' are treated as zero.
- **Amendment 1 (31/03/2020): This report has been amended and re-released to change the reporting of additional analytical data.**
- EK026SF (Total Cyanide by SFA): Samples were passed through a 0.45µm filter prior to analysis due to suspended particulate matter as per ISO 14403.
- Amendment (14/06/2019): This report has been amended and re-released to allow the reporting of additional analytical data.
- Amendment (27/08/2019): This report has been amended and re-released to allow the reporting of additional analytical data.
- It is recognised that EG093-T (Total Metals in Saline Water by ORC-ICP-MS) is less than EG093-F (Dissolved Metals in Saline Water by ORC-ICP-MS) for some samples. However, the difference is within experimental variation of the methods.
- EG035T (Total Mercury): Sample EB1910136-004(WQ_03) diluted due to matrix interference. LOR adjusted accordingly
- EG035F (Dissolved Mercury): Sample EB1910136-004(WQ_03) diluted due to matrix interference. LOR adjusted accordingly.
- Amendment (5/12/2019): This report has been amended following the removal of data from reports as per request by Erica Colley on the 5/12/2019.
- EG093: Samples containing high levels of sulfate may precipitate barium under the acidic conditions of this method and may therefore bias results low.



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				TSS_16 Deep	WQ_16	WQ_16	WQ_03	TSS_06
Client sampling date / time				12-Apr-2019 00:00	13-Apr-2019 00:00	13-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910136-001	EB1910136-002	EB1910136-003	EB1910136-004	EB1910136-005
				Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	1	mg/L	<1	<1	<1	----	<1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	----	2480	----	2460	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	----	<0.0001	----	<0.0005	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	----	<0.0001	----	<0.0005	----
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS								
Aluminium	7429-90-5	5	µg/L	----	<5	----	<5	----
Antimony	7440-36-0	0.5	µg/L	----	<0.5	----	<0.5	----
Arsenic	7440-38-2	0.5	µg/L	----	1.9	----	1.5	----
Barium	7440-39-3	1	µg/L	----	4	----	4	----
Beryllium	7440-41-7	0.1	µg/L	----	<0.1	----	<0.1	----
Boron	7440-42-8	100	µg/L	----	4450	----	4580	----
Cadmium	7440-43-9	0.1	µg/L	----	<0.1	----	<0.1	----
Chromium	7440-47-3	0.5	µg/L	----	<0.5	----	79.4	----
Cobalt	7440-48-4	0.2	µg/L	----	<0.2	----	<0.2	----
Copper	7440-50-8	1	µg/L	----	<1	----	<1	----
Iron	7439-89-6	5	µg/L	----	<5	----	<5	----
Lead	7439-92-1	0.2	µg/L	----	<0.2	----	<0.2	----
Manganese	7439-96-5	0.5	µg/L	----	0.5	----	<0.5	----
Molybdenum	7439-98-7	0.1	µg/L	----	10.1	----	10.4	----
Nickel	7440-02-0	0.5	µg/L	----	<0.5	----	<0.5	----
Selenium	7782-49-2	2	µg/L	----	10	----	10	----
Silver	7440-22-4	0.1	µg/L	----	<0.1	----	0.4	----
Tin	7440-31-5	5	µg/L	----	<5	----	<5	----
Vanadium	7440-62-2	0.5	µg/L	----	2.0	----	1.4	----
Zinc	7440-66-6	5	µg/L	----	<5	----	<5	----
EG093T: Total Metals in Saline Water by ORC-ICPMS								
Antimony	7440-36-0	0.5	µg/L	----	<0.5	----	<0.5	----
Arsenic	7440-38-2	0.5	µg/L	----	1.5	----	1.5	----
Barium	7440-39-3	1	µg/L	----	4	----	4	----
Beryllium	7440-41-7	0.1	µg/L	----	<0.1	----	<0.1	----
Boron	7440-42-8	100	µg/L	----	4330	----	3860	----



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				TSS_16 Deep	WQ_16	WQ_16	WQ_03	TSS_06
Client sampling date / time				12-Apr-2019 00:00	13-Apr-2019 00:00	13-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910136-001	EB1910136-002	EB1910136-003	EB1910136-004	EB1910136-005
				Result	Result	Result	Result	Result
EG093T: Total Metals in Saline Water by ORC-ICPMS - Continued								
Cadmium	7440-43-9	0.2	µg/L	----	<0.2	----	<0.2	----
Chromium	7440-47-3	0.5	µg/L	----	<0.5	----	76.9	----
Cobalt	7440-48-4	0.2	µg/L	----	<0.2	----	<0.2	----
Copper	7440-50-8	1	µg/L	----	<1	----	<1	----
Iron	7439-89-6	5	µg/L	----	8	----	7	----
Lead	7439-92-1	0.2	µg/L	----	<0.2	----	<0.2	----
Manganese	7439-96-5	0.5	µg/L	----	0.9	----	0.9	----
Molybdenum	7439-98-7	0.1	µg/L	----	10.6	----	10.2	----
Nickel	7440-02-0	0.5	µg/L	----	<0.5	----	<0.5	----
Selenium	7782-49-2	2	µg/L	----	5	----	4	----
Silver	7440-22-4	0.1	µg/L	----	<0.1	----	3.5	----
Tin	7440-31-5	5	µg/L	----	<5	----	<5	----
Vanadium	7440-62-2	0.5	µg/L	----	1.7	----	1.7	----
Zinc	7440-66-6	5	µg/L	----	<5	----	<5	----
EK026SF: Total CN by Segmented Flow Analyser								
Total Cyanide	57-12-5	0.004	mg/L	----	<0.004	----	<0.004	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	----	1.1	----	0.9	----
EK085M: Sulfide as S2-								
Sulfide as S2-	18496-25-8	0.1	mg/L	----	<0.1	----	<0.1	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	TSS_06 Deep	WQ_10	TSS_21	TSS_35 Deep	TSS_35
Client sampling date / time					12-Apr-2019 00:00	14-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00
Compound	CAS Number	LOR	Unit		EB1910136-006	EB1910136-007	EB1910136-008	EB1910136-009	EB1910136-010
					Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	1	mg/L		1	1	1	<1	<1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		----	2400	----	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		----	<0.0001	----	----	----
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		----	<0.0001	----	----	----
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS									
Aluminium	7429-90-5	5	µg/L		----	<5	----	----	----
Antimony	7440-36-0	0.5	µg/L		----	<0.5	----	----	----
Arsenic	7440-38-2	0.5	µg/L		----	1.4	----	----	----
Barium	7440-39-3	1	µg/L		----	6	----	----	----
Beryllium	7440-41-7	0.1	µg/L		----	<0.1	----	----	----
Boron	7440-42-8	100	µg/L		----	4200	----	----	----
Cadmium	7440-43-9	0.1	µg/L		----	<0.1	----	----	----
Chromium	7440-47-3	0.5	µg/L		----	<0.5	----	----	----
Cobalt	7440-48-4	0.2	µg/L		----	<0.2	----	----	----
Copper	7440-50-8	1	µg/L		----	<1	----	----	----
Iron	7439-89-6	5	µg/L		----	<5	----	----	----
Lead	7439-92-1	0.2	µg/L		----	<0.2	----	----	----
Manganese	7439-96-5	0.5	µg/L		----	<0.5	----	----	----
Molybdenum	7439-98-7	0.1	µg/L		----	9.4	----	----	----
Nickel	7440-02-0	0.5	µg/L		----	<0.5	----	----	----
Selenium	7782-49-2	2	µg/L		----	10	----	----	----
Silver	7440-22-4	0.1	µg/L		----	0.2	----	----	----
Tin	7440-31-5	5	µg/L		----	<5	----	----	----
Vanadium	7440-62-2	0.5	µg/L		----	2.0	----	----	----
Zinc	7440-66-6	5	µg/L		----	<5	----	----	----
EG093T: Total Metals in Saline Water by ORC-ICPMS									
Antimony	7440-36-0	0.5	µg/L		----	<0.5	----	----	----
Arsenic	7440-38-2	0.5	µg/L		----	1.6	----	----	----
Barium	7440-39-3	1	µg/L		----	6	----	----	----
Beryllium	7440-41-7	0.1	µg/L		----	<0.1	----	----	----
Boron	7440-42-8	100	µg/L		----	3780	----	----	----



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				TSS_06 Deep	WQ_10	TSS_21	TSS_35 Deep	TSS_35
Client sampling date / time				12-Apr-2019 00:00	14-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910136-006	EB1910136-007	EB1910136-008	EB1910136-009	EB1910136-010
				Result	Result	Result	Result	Result
EG093T: Total Metals in Saline Water by ORC-ICPMS - Continued								
Cadmium	7440-43-9	0.2	µg/L	----	<0.2	----	----	----
Chromium	7440-47-3	0.5	µg/L	----	<0.5	----	----	----
Cobalt	7440-48-4	0.2	µg/L	----	<0.2	----	----	----
Copper	7440-50-8	1	µg/L	----	<1	----	----	----
Iron	7439-89-6	5	µg/L	----	<5	----	----	----
Lead	7439-92-1	0.2	µg/L	----	<0.2	----	----	----
Manganese	7439-96-5	0.5	µg/L	----	0.7	----	----	----
Molybdenum	7439-98-7	0.1	µg/L	----	11.0	----	----	----
Nickel	7440-02-0	0.5	µg/L	----	<0.5	----	----	----
Selenium	7782-49-2	2	µg/L	----	4	----	----	----
Silver	7440-22-4	0.1	µg/L	----	<0.1	----	----	----
Tin	7440-31-5	5	µg/L	----	<5	----	----	----
Vanadium	7440-62-2	0.5	µg/L	----	1.6	----	----	----
Zinc	7440-66-6	5	µg/L	----	<5	----	----	----
EK026SF: Total CN by Segmented Flow Analyser								
Total Cyanide	57-12-5	0.004	mg/L	----	<0.004	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	----	0.9	----	----	----
EK085M: Sulfide as S2-								
Sulfide as S2-	18496-25-8	0.1	mg/L	----	<0.1	----	----	----



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				TSS_36	TSS_36 Deep	WQ_09	WQ_15	WQ_05
Client sampling date / time				12-Apr-2019 00:00	12-Apr-2019 00:00	14-Apr-2019 00:00	13-Apr-2019 00:00	13-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910136-011	EB1910136-012	EB1910136-013	EB1910136-014	EB1910136-015
				Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	1	mg/L	<1	2	6	<1	<1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	----	----	2450	2550	2410
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	----	----	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	----	----	<0.0001	<0.0001	<0.0001
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS								
Aluminium	7429-90-5	5	µg/L	----	----	<5	<5	<5
Antimony	7440-36-0	0.5	µg/L	----	----	<0.5	<0.5	<0.5
Arsenic	7440-38-2	0.5	µg/L	----	----	1.6	1.7	1.5
Barium	7440-39-3	1	µg/L	----	----	10	4	5
Beryllium	7440-41-7	0.1	µg/L	----	----	<0.1	<0.1	<0.1
Boron	7440-42-8	100	µg/L	----	----	4300	4450	4340
Cadmium	7440-43-9	0.1	µg/L	----	----	<0.1	<0.1	<0.1
Chromium	7440-47-3	0.5	µg/L	----	----	0.7	<0.5	<0.5
Cobalt	7440-48-4	0.2	µg/L	----	----	<0.2	<0.2	<0.2
Copper	7440-50-8	1	µg/L	----	----	<1	<1	1
Iron	7439-89-6	5	µg/L	----	----	6	<5	5
Lead	7439-92-1	0.2	µg/L	----	----	<0.2	<0.2	<0.2
Manganese	7439-96-5	0.5	µg/L	----	----	19.6	0.6	1.1
Molybdenum	7439-98-7	0.1	µg/L	----	----	9.3	9.8	9.6
Nickel	7440-02-0	0.5	µg/L	----	----	0.6	<0.5	0.5
Selenium	7782-49-2	2	µg/L	----	----	10	8	10
Silver	7440-22-4	0.1	µg/L	----	----	<0.1	<0.1	<0.1
Tin	7440-31-5	5	µg/L	----	----	<5	<5	<5
Vanadium	7440-62-2	0.5	µg/L	----	----	2.8	1.9	1.8
Zinc	7440-66-6	5	µg/L	----	----	<5	<5	<5
EG093T: Total Metals in Saline Water by ORC-ICPMS								
Antimony	7440-36-0	0.5	µg/L	----	----	<0.5	<0.5	<0.5
Arsenic	7440-38-2	0.5	µg/L	----	----	1.6	1.4	1.5
Barium	7440-39-3	1	µg/L	----	----	11	5	6
Beryllium	7440-41-7	0.1	µg/L	----	----	<0.1	<0.1	<0.1
Boron	7440-42-8	100	µg/L	----	----	3730	3730	3670



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				TSS_36	TSS_36 Deep	WQ_09	WQ_15	WQ_05
Client sampling date / time				12-Apr-2019 00:00	12-Apr-2019 00:00	14-Apr-2019 00:00	13-Apr-2019 00:00	13-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910136-011	EB1910136-012	EB1910136-013	EB1910136-014	EB1910136-015
				Result	Result	Result	Result	Result
EG093T: Total Metals in Saline Water by ORC-ICPMS - Continued								
Cadmium	7440-43-9	0.2	µg/L	----	----	<0.2	<0.2	<0.2
Chromium	7440-47-3	0.5	µg/L	----	----	<0.5	<0.5	0.7
Cobalt	7440-48-4	0.2	µg/L	----	----	0.2	<0.2	<0.2
Copper	7440-50-8	1	µg/L	----	----	<1	<1	<1
Iron	7439-89-6	5	µg/L	----	----	232	5	21
Lead	7439-92-1	0.2	µg/L	----	----	<0.2	<0.2	<0.2
Manganese	7439-96-5	0.5	µg/L	----	----	23.2	0.8	1.8
Molybdenum	7439-98-7	0.1	µg/L	----	----	10.2	10.6	10.2
Nickel	7440-02-0	0.5	µg/L	----	----	0.6	<0.5	<0.5
Selenium	7782-49-2	2	µg/L	----	----	4	4	4
Silver	7440-22-4	0.1	µg/L	----	----	<0.1	<0.1	<0.1
Tin	7440-31-5	5	µg/L	----	----	<5	<5	<5
Vanadium	7440-62-2	0.5	µg/L	----	----	2.8	1.7	1.9
Zinc	7440-66-6	5	µg/L	----	----	<5	<5	<5
EK026SF: Total CN by Segmented Flow Analyser								
Total Cyanide	57-12-5	0.004	mg/L	----	----	<0.004	<0.004	<0.004
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	----	----	0.9	0.9	0.8
EK085M: Sulfide as S2-								
Sulfide as S2-	18496-25-8	0.1	mg/L	----	----	<0.1	<0.1	<0.1



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	WQ_04	WQ_08	WQ_11	WQ_14	WQ_06
Client sampling date / time					14-Apr-2019 00:00	13-Apr-2019 00:00	14-Apr-2019 00:00	14-Apr-2019 00:00	12-Apr-2019 00:00
Compound	CAS Number	LOR	Unit		EB1910136-016	EB1910136-017	EB1910136-018	EB1910136-019	EB1910136-020
					Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	1	mg/L		1	3	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		2300	2470	2400	2360	2450
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS									
Aluminium	7429-90-5	5	µg/L		<5	<5	<5	<5	<5
Antimony	7440-36-0	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
Arsenic	7440-38-2	0.5	µg/L		1.6	1.8	1.5	1.5	1.8
Barium	7440-39-3	1	µg/L		6	5	6	6	4
Beryllium	7440-41-7	0.1	µg/L		<0.1	<0.1	<0.1	<0.1	<0.1
Boron	7440-42-8	100	µg/L		4230	4460	4270	4170	4470
Cadmium	7440-43-9	0.1	µg/L		<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	7440-47-3	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
Cobalt	7440-48-4	0.2	µg/L		<0.2	<0.2	<0.2	<0.2	<0.2
Copper	7440-50-8	1	µg/L		1	1	1	1	1
Iron	7439-89-6	5	µg/L		<5	<5	<5	<5	<5
Lead	7439-92-1	0.2	µg/L		<0.2	<0.2	<0.2	<0.2	<0.2
Manganese	7439-96-5	0.5	µg/L		<0.5	1.8	1.3	<0.5	1.0
Molybdenum	7439-98-7	0.1	µg/L		9.1	9.5	8.9	9.4	9.6
Nickel	7440-02-0	0.5	µg/L		<0.5	0.9	<0.5	<0.5	<0.5
Selenium	7782-49-2	2	µg/L		10	10	9	10	10
Silver	7440-22-4	0.1	µg/L		<0.1	<0.1	<0.1	<0.1	<0.1
Tin	7440-31-5	5	µg/L		<5	<5	<5	<5	<5
Vanadium	7440-62-2	0.5	µg/L		1.9	1.9	2.1	1.9	1.9
Zinc	7440-66-6	5	µg/L		<5	<5	<5	<5	7
EG093T: Total Metals in Saline Water by ORC-ICPMS									
Antimony	7440-36-0	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	0.5
Arsenic	7440-38-2	0.5	µg/L		1.4	1.4	1.4	1.3	1.5
Barium	7440-39-3	1	µg/L		6	5	7	6	5
Beryllium	7440-41-7	0.1	µg/L		<0.1	<0.1	<0.1	<0.1	<0.1
Boron	7440-42-8	100	µg/L		3680	4220	4100	3500	3840



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				WQ_04	WQ_08	WQ_11	WQ_14	WQ_06
Client sampling date / time				14-Apr-2019 00:00	13-Apr-2019 00:00	14-Apr-2019 00:00	14-Apr-2019 00:00	12-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910136-016	EB1910136-017	EB1910136-018	EB1910136-019	EB1910136-020
				Result	Result	Result	Result	Result
EG093T: Total Metals in Saline Water by ORC-ICPMS - Continued								
Cadmium	7440-43-9	0.2	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Chromium	7440-47-3	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Cobalt	7440-48-4	0.2	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Copper	7440-50-8	1	µg/L	<1	<1	<1	<1	<1
Iron	7439-89-6	5	µg/L	5	14	7	<5	15
Lead	7439-92-1	0.2	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Manganese	7439-96-5	0.5	µg/L	<0.5	2.2	1.4	<0.5	1.4
Molybdenum	7439-98-7	0.1	µg/L	10.4	10.0	9.9	9.8	10.9
Nickel	7440-02-0	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Selenium	7782-49-2	2	µg/L	4	4	4	4	4
Silver	7440-22-4	0.1	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Tin	7440-31-5	5	µg/L	<5	<5	<5	<5	<5
Vanadium	7440-62-2	0.5	µg/L	1.7	1.7	1.7	1.6	1.7
Zinc	7440-66-6	5	µg/L	<5	<5	<5	<5	<5
EK026SF: Total CN by Segmented Flow Analyser								
Total Cyanide	57-12-5	0.004	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	0.8	0.9	0.8	0.9	0.9
EK085M: Sulfide as S2-								
Sulfide as S2-	18496-25-8	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	----



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				WQ_07	WQ_02	WQ_18	WQ_13	TSS_25 Deep
Client sampling date / time				12-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910136-021	EB1910136-022	EB1910136-023	EB1910136-024	EB1910136-025
				Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	1	mg/L	<1	<1	----	----	1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	2430	2370	2350	2360	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	----
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS								
Aluminium	7429-90-5	5	µg/L	<5	<5	<5	<5	----
Antimony	7440-36-0	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	----
Arsenic	7440-38-2	0.5	µg/L	1.8	1.7	1.5	1.5	----
Barium	7440-39-3	1	µg/L	5	5	6	6	----
Beryllium	7440-41-7	0.1	µg/L	<0.1	<0.1	<0.1	<0.1	----
Boron	7440-42-8	100	µg/L	4420	4290	4190	4140	----
Cadmium	7440-43-9	0.1	µg/L	<0.1	<0.1	<0.1	<0.1	----
Chromium	7440-47-3	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	----
Cobalt	7440-48-4	0.2	µg/L	<0.2	<0.2	<0.2	<0.2	----
Copper	7440-50-8	1	µg/L	1	1	1	3	----
Iron	7439-89-6	5	µg/L	<5	5	<5	<5	----
Lead	7439-92-1	0.2	µg/L	<0.2	<0.2	<0.2	<0.2	----
Manganese	7439-96-5	0.5	µg/L	0.9	0.7	<0.5	<0.5	----
Molybdenum	7439-98-7	0.1	µg/L	9.6	9.5	9.0	9.0	----
Nickel	7440-02-0	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	----
Selenium	7782-49-2	2	µg/L	9	9	9	9	----
Silver	7440-22-4	0.1	µg/L	<0.1	<0.1	<0.1	<0.1	----
Tin	7440-31-5	5	µg/L	<5	<5	<5	<5	----
Vanadium	7440-62-2	0.5	µg/L	1.8	1.7	1.9	2.0	----
Zinc	7440-66-6	5	µg/L	<5	<5	<5	<5	----
EG093T: Total Metals in Saline Water by ORC-ICPMS								
Antimony	7440-36-0	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	----
Arsenic	7440-38-2	0.5	µg/L	1.4	1.3	1.3	1.4	----
Barium	7440-39-3	1	µg/L	5	5	6	6	----
Beryllium	7440-41-7	0.1	µg/L	<0.1	<0.1	<0.1	<0.1	----
Boron	7440-42-8	100	µg/L	4350	4140	4250	4170	----



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				WQ_07	WQ_02	WQ_18	WQ_13	TSS_25 Deep
Client sampling date / time				12-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910136-021	EB1910136-022	EB1910136-023	EB1910136-024	EB1910136-025
				Result	Result	Result	Result	Result
EG093T: Total Metals in Saline Water by ORC-ICPMS - Continued								
Cadmium	7440-43-9	0.2	µg/L	<0.2	<0.2	<0.2	<0.2	----
Chromium	7440-47-3	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	----
Cobalt	7440-48-4	0.2	µg/L	<0.2	<0.2	<0.2	<0.2	----
Copper	7440-50-8	1	µg/L	<1	<1	<1	<1	----
Iron	7439-89-6	5	µg/L	10	6	<5	<5	----
Lead	7439-92-1	0.2	µg/L	<0.2	<0.2	<0.2	<0.2	----
Manganese	7439-96-5	0.5	µg/L	1.3	1.0	<0.5	<0.5	----
Molybdenum	7439-98-7	0.1	µg/L	10.0	10.0	9.4	9.8	----
Nickel	7440-02-0	0.5	µg/L	8.0	<0.5	<0.5	<0.5	----
Selenium	7782-49-2	2	µg/L	4	4	4	4	----
Silver	7440-22-4	0.1	µg/L	<0.1	<0.1	<0.1	<0.1	----
Tin	7440-31-5	5	µg/L	<5	<5	<5	<5	----
Vanadium	7440-62-2	0.5	µg/L	1.7	1.7	1.6	1.6	----
Zinc	7440-66-6	5	µg/L	<5	<5	<5	<5	----
EK026SF: Total CN by Segmented Flow Analyser								
Total Cyanide	57-12-5	0.004	mg/L	<0.004	<0.004	<0.004	<0.004	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	0.8	0.9	0.8	0.8	----
EK085M: Sulfide as S2-								
Sulfide as S2-	18496-25-8	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	----



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				TSS_40	TSS_20	TSS_39	TSS_15 Deep	TSS_02
Client sampling date / time				12-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00	14-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910136-026	EB1910136-027	EB1910136-028	EB1910136-029	EB1910136-030
				Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	1	mg/L	2	<1	2	2	<1



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	TSS_19	TSS_38	TSS_11	TSS_23 Deep	TSS_17 Deep
Client sampling date / time					13-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00	13-Apr-2019 00:00	13-Apr-2019 00:00
Compound	CAS Number	LOR	Unit		EB1910136-031	EB1910136-032	EB1910136-033	EB1910136-034	EB1910136-035
					Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	1	mg/L		<1	2	1	2	2



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				TSS_17	TSS_11 Deep	TSS_18	TSS_24	TSS_23
Client sampling date / time				13-Apr-2019 00:00	12-Apr-2019 00:00	13-Apr-2019 00:00	12-Apr-2019 00:00	12-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910136-036	EB1910136-037	EB1910136-038	EB1910136-039	EB1910136-040
				Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	1	mg/L	<1	<1	<1	<1	1



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	TSS_15	TSS_30	TSS_13	TSS_33	TSS_03
Client sampling date / time					12-Apr-2019 00:00	14-Apr-2019 00:00	13-Apr-2019 00:00	14-Apr-2019 00:00	14-Apr-2019 00:00
Compound	CAS Number	LOR	Unit		EB1910136-041	EB1910136-042	EB1910136-043	EB1910136-044	EB1910136-045
					Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	1	mg/L		<1	1	1	4	1

CERTIFICATE OF ANALYSIS

Work Order	: EB1910444	Page	: 1 of 23
Amendment	: 1		
Client	: COFFEY ENVIRONMENTS PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: ERICA COLLEY	Contact	: Andrew Epps
Address	: LEVEL WORKPLES BUILDING SAVANNAH HEIGHTS SECTION 531, LOT 12 WAIGANI DRIVE HOHOLA, NCD PNG	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: 64277004057	Telephone	: +61 7 3552 8639
Project	: 754-MELEN224697 JDD PROJECT	Date Samples Received	: 23-Apr-2019 13:55
Order number	: BN/065/19	Date Analysis Commenced	: 30-Apr-2019
C-O-C number	: ----	Issue Date	: 05-Dec-2019 11:40
Sampler	: ERICA COLLEY		
Site	:		
Quote number	: BN/065/19 V2		
No. of samples received	: 50		
No. of samples analysed	: 49		



Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics, Smithfield, NSW
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EP131B : LOR is raised due to high amount of moistures is present.
- **Organics & Nutrients analysis will be conducted by ALS Environmental, Sydney, NATA accreditation no. 825, Site No. 10911 (Micro site no. 14913).**
- EG005-SDH (1M HCL Extractable Metals): Limit of reporting has been raised due to matrix interference.
- Amendment (5/12/2019): This report has been amended following the removal of data from reports as per request by Erica Colley on the 5/12/2019



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	SED 12	SED 9	SED 3	SED 24	SED 25
Client sampling date / time					17-Apr-2019 00:00	17-Apr-2019 00:00	16-Apr-2019 00:00	16-Apr-2019 00:00	16-Apr-2019 00:00
Compound	CAS Number	LOR	Unit		EB1910444-001	EB1910444-002	EB1910444-003	EB1910444-004	EB1910444-005
					Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)									
pH Value	----	0.1	pH Unit		8.6	8.6	8.5	8.6	8.4
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	0.1	%		30.5	34.0	45.1	47.6	50.8
EA150: Particle Sizing									
+75µm	----	1	%		93	62	21	12	----
+150µm	----	1	%		78	48	6	8	----
+300µm	----	1	%		43	36	4	6	----
+425µm	----	1	%		35	31	3	5	----
+600µm	----	1	%		28	26	2	5	----
+1180µm	----	1	%		19	17	1	3	----
+2.36mm	----	1	%		12	8	<1	1	----
+4.75mm	----	1	%		4	2	<1	<1	----
+9.5mm	----	1	%		<1	<1	<1	<1	----
+19.0mm	----	1	%		<1	<1	<1	<1	----
+37.5mm	----	1	%		<1	<1	<1	<1	----
+75.0mm	----	1	%		<1	<1	<1	<1	----
EA150: Soil Classification based on Particle Size									
Clay (<2 µm)	----	1	%		4	27	38	41	----
Silt (2-60 µm)	----	1	%		2	11	40	45	----
Sand (0.06-2.00 mm)	----	1	%		80	51	21	12	----
Gravel (>2mm)	----	1	%		14	11	1	2	----
Cobbles (>6cm)	----	1	%		<1	<1	<1	<1	----
EA152: Soil Particle Density									
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3		2.67	2.44	2.42	2.46	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg		0.7	0.5	0.5	0.5	0.5
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg		380	510	810	830	1160
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg		380	510	810	830	1160
EP003: Total Organic Carbon (TOC) in Soil									
Total Organic Carbon	----	0.02	%		0.16	0.31	0.70	0.55	0.80
EP003TC: Total Carbon (TC) in Soil									
Total Carbon	TC	0.02	%		11.2	8.18	5.91	6.39	5.08



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	SED 12	SED 9	SED 3	SED 24	SED 25
Client sampling date / time					17-Apr-2019 00:00	17-Apr-2019 00:00	16-Apr-2019 00:00	16-Apr-2019 00:00	16-Apr-2019 00:00
Compound	CAS Number	LOR	Unit		EB1910444-001	EB1910444-002	EB1910444-003	EB1910444-004	EB1910444-005
					Result	Result	Result	Result	Result
EP003TIC: Total inorganic Carbon (TIC) in Soil									
Total Inorganic Carbon	----	0.02	%		11.0	7.87	5.21	5.84	4.28



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	SED 17	SED 2	SED 1	SED 13	SED 23
Client sampling date / time					17-Apr-2019 00:00	16-Apr-2019 00:00	16-Apr-2019 00:00	16-Apr-2019 00:00	16-Apr-2019 00:00
Compound	CAS Number	LOR	Unit		EB1910444-006	EB1910444-007	EB1910444-008	EB1910444-009	EB1910444-010
					Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)									
pH Value	----	0.1	pH Unit		8.4	8.5	8.4	8.5	8.6
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	0.1	%		31.5	51.2	53.9	34.1	50.5
EA150: Particle Sizing									
+75µm	----	1	%		74	11	5	40	14
+150µm	----	1	%		62	6	2	7	8
+300µm	----	1	%		60	4	1	3	6
+425µm	----	1	%		57	4	1	2	5
+600µm	----	1	%		45	3	<1	1	4
+1180µm	----	1	%		19	2	<1	<1	3
+2.36mm	----	1	%		4	1	<1	<1	2
+4.75mm	----	1	%		<1	<1	<1	<1	<1
+9.5mm	----	1	%		<1	<1	<1	<1	<1
+19.0mm	----	1	%		<1	<1	<1	<1	<1
+37.5mm	----	1	%		<1	<1	<1	<1	<1
+75.0mm	----	1	%		<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size									
Clay (<2 µm)	----	1	%		21	43	44	44	30
Silt (2-60 µm)	----	1	%		5	44	49	14	54
Sand (0.06-2.00 mm)	----	1	%		66	11	7	42	14
Gravel (>2mm)	----	1	%		8	2	<1	<1	2
Cobbles (>6cm)	----	1	%		<1	<1	<1	<1	<1
EA152: Soil Particle Density									
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3		2.53	2.47	2.41	2.53	2.36
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg		2.5	0.4	0.5	0.3	0.4
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg		260	1150	1400	690	1060
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg		260	1150	1400	690	1060
EP003: Total Organic Carbon (TOC) in Soil									
Total Organic Carbon	----	0.02	%		0.30	0.79	0.84	0.40	0.68
EP003TC: Total Carbon (TC) in Soil									
Total Carbon	TC	0.02	%		8.26	5.12	2.81	6.97	5.61



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	SED 17	SED 2	SED 1	SED 13	SED 23
Client sampling date / time					17-Apr-2019 00:00	16-Apr-2019 00:00	16-Apr-2019 00:00	16-Apr-2019 00:00	16-Apr-2019 00:00
Compound	CAS Number	LOR	Unit		EB1910444-006	EB1910444-007	EB1910444-008	EB1910444-009	EB1910444-010
					Result	Result	Result	Result	Result
EP003TIC: Total inorganic Carbon (TIC) in Soil									
Total Inorganic Carbon	----	0.02	%		7.96	4.33	1.97	6.57	4.93



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	SED 7	SED 11	SED 10	SED 18	SED 20
Client sampling date / time					17-Apr-2019 00:00	15-Apr-2019 00:00	16-Apr-2019 00:00	17-Apr-2019 00:00	16-Apr-2019 00:00
Compound	CAS Number	LOR	Unit		EB1910444-011	EB1910444-012	EB1910444-013	EB1910444-014	EB1910444-015
					Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)									
pH Value	----	0.1	pH Unit		8.6	8.4	8.4	8.4	8.5
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	0.1	%		27.7	38.0	36.4	42.0	55.8
EA150: Particle Sizing									
+75µm	----	1	%		86	72	63	66	25
+150µm	----	1	%		76	38	15	45	18
+300µm	----	1	%		59	20	4	32	10
+425µm	----	1	%		52	13	2	26	7
+600µm	----	1	%		45	7	2	21	4
+1180µm	----	1	%		33	1	<1	12	2
+2.36mm	----	1	%		22	<1	<1	4	<1
+4.75mm	----	1	%		11	<1	<1	<1	<1
+9.5mm	----	1	%		<1	<1	<1	<1	<1
+19.0mm	----	1	%		<1	<1	<1	<1	<1
+37.5mm	----	1	%		<1	<1	<1	<1	<1
+75.0mm	----	1	%		<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size									
Clay (<2 µm)	----	1	%		9	13	17	15	32
Silt (2-60 µm)	----	1	%		5	14	19	16	41
Sand (0.06-2.00 mm)	----	1	%		61	72	63	63	26
Gravel (>2mm)	----	1	%		25	1	1	6	1
Cobbles (>6cm)	----	1	%		<1	<1	<1	<1	<1
EA152: Soil Particle Density									
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3		2.56	2.51	2.65	2.57	2.45
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg		0.4	0.4	0.3	0.3	0.4
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg		260	870	770	940	1260
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg		260	870	770	940	1260
EP003: Total Organic Carbon (TOC) in Soil									
Total Organic Carbon	----	0.02	%		0.26	0.22	0.35	0.31	0.68
EP003TC: Total Carbon (TC) in Soil									
Total Carbon	TC	0.02	%		9.17	9.91	1.44	7.85	3.50



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	SED 7	SED 11	SED 10	SED 18	SED 20
Client sampling date / time					17-Apr-2019 00:00	15-Apr-2019 00:00	16-Apr-2019 00:00	17-Apr-2019 00:00	16-Apr-2019 00:00
Compound	CAS Number	LOR	Unit		EB1910444-011	EB1910444-012	EB1910444-013	EB1910444-014	EB1910444-015
					Result	Result	Result	Result	Result
EP003TIC: Total inorganic Carbon (TIC) in Soil									
Total Inorganic Carbon	----	0.02	%		8.91	9.69	1.09	7.54	2.82



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				SED 21	SED 22	SED 12 <2000µm Fraction	SED 9 <2000µm Fraction	SED 3 <2000µm Fraction
Client sampling date / time				16-Apr-2019 00:00	16-Apr-2019 00:00	17-Apr-2019 00:00	17-Apr-2019 00:00	16-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910444-016	EB1910444-017	EB1910444-019	EB1910444-020	EB1910444-021
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	8.6	8.5	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	54.9	47.6	----	----	----
EA150: Particle Sizing								
+75µm	----	1	%	6	24	----	----	----
+150µm	----	1	%	4	14	----	----	----
+300µm	----	1	%	2	7	----	----	----
+425µm	----	1	%	2	6	----	----	----
+600µm	----	1	%	2	4	----	----	----
+1180µm	----	1	%	<1	3	----	----	----
+2.36mm	----	1	%	<1	1	----	----	----
+4.75mm	----	1	%	<1	<1	----	----	----
+9.5mm	----	1	%	<1	<1	----	----	----
+19.0mm	----	1	%	<1	<1	----	----	----
+37.5mm	----	1	%	<1	<1	----	----	----
+75.0mm	----	1	%	<1	<1	----	----	----
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	40	29	----	----	----
Silt (2-60 µm)	----	1	%	53	45	----	----	----
Sand (0.06-2.00 mm)	----	1	%	6	24	----	----	----
Gravel (>2mm)	----	1	%	1	2	----	----	----
Cobbles (>6cm)	----	1	%	<1	<1	----	----	----
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.35	2.42	----	----	----
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES								
Aluminium	7429-90-5	50	mg/kg	----	----	1190	11900	11100
Antimony	7440-36-0	1.0	mg/kg	----	----	4.3	1.7	<1.0
Arsenic	7440-38-2	1.0	mg/kg	----	----	6.7	7.8	11.1
Barium	7440-39-3	1.0	mg/kg	----	----	38.7	32.7	26.3
Beryllium	7440-41-7	1.0	mg/kg	----	----	<1.0	1.2	1.0
Cadmium	7440-43-9	0.1	mg/kg	----	----	<0.2	0.6	0.6
Cobalt	7440-48-4	0.5	mg/kg	----	----	1.9	14.4	13.2
Chromium	7440-47-3	1.0	mg/kg	----	----	9.2	30.9	35.8
Copper	7440-50-8	1.0	mg/kg	----	----	3.2	9.2	21.8

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	SED 21	SED 22	SED 12 <2000µm Fraction	SED 9 <2000µm Fraction	SED 3 <2000µm Fraction
Client sampling date / time				16-Apr-2019 00:00	16-Apr-2019 00:00	17-Apr-2019 00:00	17-Apr-2019 00:00	16-Apr-2019 00:00	
Compound	CAS Number	LOR	Unit	EB1910444-016	EB1910444-017	EB1910444-019	EB1910444-020	EB1910444-021	
				Result	Result	Result	Result	Result	
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES - Continued									
Iron	7439-89-6	50	mg/kg	----	----	3250	48800	38900	
Lead	7439-92-1	1.0	mg/kg	----	----	6.5	26.0	34.0	
Manganese	7439-96-5	10	mg/kg	----	----	361	1770	1090	
Nickel	7440-02-0	1.0	mg/kg	----	----	2.7	15.8	13.9	
Vanadium	7440-62-2	2.0	mg/kg	----	----	2.9	19.6	29.6	
Zinc	7440-66-6	1.0	mg/kg	----	----	5.1	27.2	42.6	
Boron	7440-42-8	50	mg/kg	----	----	200	180	150	
EG005(ED093)T: Total Metals by ICP-AES									
Arsenic	7440-38-2	5	mg/kg	----	----	<5	6	7	
Barium	7440-39-3	10	mg/kg	----	----	<10	10	10	
Beryllium	7440-41-7	1	mg/kg	----	----	<1	<1	<1	
Boron	7440-42-8	50	mg/kg	----	----	<50	<50	<50	
Cadmium	7440-43-9	1	mg/kg	----	----	<1	<1	<1	
Chromium	7440-47-3	2	mg/kg	----	----	3	18	22	
Cobalt	7440-48-4	2	mg/kg	----	----	<2	7	7	
Copper	7440-50-8	5	mg/kg	----	----	<5	7	14	
Iron	7439-89-6	50	mg/kg	----	----	1930	27400	22300	
Lead	7439-92-1	5	mg/kg	----	----	<5	7	8	
Manganese	7439-96-5	5	mg/kg	----	----	76	408	349	
Nickel	7440-02-0	2	mg/kg	----	----	<2	11	13	
Selenium	7782-49-2	5	mg/kg	----	----	6	<5	<5	
Silver	7440-22-4	2	mg/kg	----	----	<2	<2	<2	
Tin	7440-31-5	5	mg/kg	----	----	<5	<5	<5	
Vanadium	7440-62-2	5	mg/kg	----	----	<5	15	21	
Zinc	7440-66-6	5	mg/kg	----	----	12	27	38	
EG035-SDH: 1M HCl extractable Mercury by FIMS									
Mercury	7439-97-6	0.10	mg/kg	----	----	<0.10	<0.10	<0.10	
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg	----	----	<0.1	<0.1	<0.1	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.5	0.4	----	----	----	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg	1070	840	----	----	----	
EK062: Total Nitrogen as N (TKN + NOx)									



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				SED 21	SED 22	SED 12 <2000µm Fraction	SED 9 <2000µm Fraction	SED 3 <2000µm Fraction
Client sampling date / time				16-Apr-2019 00:00	16-Apr-2019 00:00	17-Apr-2019 00:00	17-Apr-2019 00:00	16-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910444-016	EB1910444-017	EB1910444-019	EB1910444-020	EB1910444-021
				Result	Result	Result	Result	Result
EK062: Total Nitrogen as N (TKN + NOx) - Continued								
^ Total Nitrogen as N	----	20	mg/kg	1070	840	----	----	----
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.65	0.56	----	----	----
EP003TC: Total Carbon (TC) in Soil								
Total Carbon	TC	0.02	%	4.96	3.49	----	----	----
EP003TIC: Total inorganic Carbon (TIC) in Soil								
Total Inorganic Carbon	----	0.02	%	4.31	2.93	----	----	----
GEO26: Sieving								
-2000µm	----	0.01	%	----	----	87.0	87.0	96.7



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				SED 24 <2000µm Fraction	SED 17 <2000µm Fraction	SED 2 <2000µm Fraction	SED 1 <2000µm Fraction	SED 13 <2000µm Fraction
Client sampling date / time				16-Apr-2019 00:00	16-Apr-2019 00:00	26-Apr-2019 00:00	26-Apr-2019 00:00	16-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910444-022	EB1910444-024	EB1910444-025	EB1910444-026	EB1910444-027
				Result	Result	Result	Result	Result
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES								
Aluminium	7429-90-5	50	mg/kg	12800	8090	14700	15800	7350
Antimony	7440-36-0	1.0	mg/kg	<1.0	<1.0	1.1	1.2	<1.0
Arsenic	7440-38-2	1.0	mg/kg	6.2	8.4	9.0	7.7	3.3
Barium	7440-39-3	1.0	mg/kg	28.2	28.9	24.0	23.0	28.7
Beryllium	7440-41-7	1.0	mg/kg	1.3	<1.0	1.3	1.6	<1.0
Cadmium	7440-43-9	0.1	mg/kg	0.4	0.5	<0.2	<0.2	0.5
Cobalt	7440-48-4	0.5	mg/kg	14.4	10.3	17.4	21.2	5.2
Chromium	7440-47-3	1.0	mg/kg	40.3	29.5	41.1	41.4	31.4
Copper	7440-50-8	1.0	mg/kg	19.6	9.7	27.2	40.0	13.0
Iron	7439-89-6	50	mg/kg	35800	30800	47900	51800	20400
Lead	7439-92-1	1.0	mg/kg	35.4	17.3	38.4	47.8	28.7
Manganese	7439-96-5	10	mg/kg	1320	949	1110	1130	595
Nickel	7440-02-0	1.0	mg/kg	22.7	10.0	17.2	21.2	9.4
Vanadium	7440-62-2	2.0	mg/kg	36.6	13.3	38.7	59.8	13.1
Zinc	7440-66-6	1.0	mg/kg	43.7	29.8	51.8	60.8	31.1
Boron	7440-42-8	50	mg/kg	150	160	130	100	150
EG005(ED093)T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	5	8	6	8	5
Barium	7440-39-3	10	mg/kg	20	<10	20	20	<10
Beryllium	7440-41-7	1	mg/kg	<1	<1	<1	<1	<1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	26	13	26	32	13
Cobalt	7440-48-4	2	mg/kg	8	5	8	11	3
Copper	7440-50-8	5	mg/kg	17	6	18	26	6
Iron	7439-89-6	50	mg/kg	23700	14600	26600	33700	10800
Lead	7439-92-1	5	mg/kg	10	5	10	13	7
Manganese	7439-96-5	5	mg/kg	424	250	389	473	156
Nickel	7440-02-0	2	mg/kg	16	7	15	20	7
Selenium	7782-49-2	5	mg/kg	<5	<5	<5	<5	<5
Silver	7440-22-4	2	mg/kg	<2	<2	<2	<2	<2
Tin	7440-31-5	5	mg/kg	<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg	27	9	26	40	8
Zinc	7440-66-6	5	mg/kg	43	23	45	62	22



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				SED 24 <2000µm Fraction	SED 17 <2000µm Fraction	SED 2 <2000µm Fraction	SED 1 <2000µm Fraction	SED 13 <2000µm Fraction
Client sampling date / time				16-Apr-2019 00:00	16-Apr-2019 00:00	26-Apr-2019 00:00	26-Apr-2019 00:00	16-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910444-022	EB1910444-024	EB1910444-025	EB1910444-026	EB1910444-027
				Result	Result	Result	Result	Result
EG035-SDH: 1M HCl extractable Mercury by FIMS								
Mercury	7439-97-6	0.10	mg/kg	<0.10	<0.10	<0.10	<0.10	<0.10
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
GEO26: Sieving								
-2000µm	----	0.01	%	94.3	94.4	93.7	96.7	98.0



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				SED 23 <2000µm Fraction	SED 7 <2000µm Fraction	SED 11 <2000µm Fraction	SED 10 <2000µm Fraction	SED 18 <2000µm Fraction
Client sampling date / time				16-Apr-2019 00:00	17-Apr-2019 00:00	15-Apr-2019 00:00	16-Apr-2019 00:00	17-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910444-028	EB1910444-029	EB1910444-030	EB1910444-031	EB1910444-032
				Result	Result	Result	Result	Result
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES								
Aluminium	7429-90-5	50	mg/kg	15500	7370	4920	13700	9980
Antimony	7440-36-0	1.0	mg/kg	2.0	<1.0	1.4	<1.0	<1.0
Arsenic	7440-38-2	1.0	mg/kg	7.0	7.8	6.2	9.6	5.8
Barium	7440-39-3	1.0	mg/kg	29.2	36.9	43.4	16.8	35.3
Beryllium	7440-41-7	1.0	mg/kg	1.3	<1.0	<1.0	1.3	<1.0
Cadmium	7440-43-9	0.1	mg/kg	<0.2	0.4	<0.2	<0.2	0.5
Cobalt	7440-48-4	0.5	mg/kg	16.6	9.3	3.6	20.0	12.8
Chromium	7440-47-3	1.0	mg/kg	43.3	25.1	27.4	34.7	30.5
Copper	7440-50-8	1.0	mg/kg	25.8	7.1	5.9	19.3	9.6
Iron	7439-89-6	50	mg/kg	43200	22000	13300	58100	44600
Lead	7439-92-1	1.0	mg/kg	40.9	19.2	12.7	21.7	19.2
Manganese	7439-96-5	10	mg/kg	1280	1910	595	727	1140
Nickel	7440-02-0	1.0	mg/kg	19.2	12.3	7.7	15.6	11.9
Vanadium	7440-62-2	2.0	mg/kg	43.6	13.1	10.6	28.2	16.0
Zinc	7440-66-6	1.0	mg/kg	51.3	14.7	14.4	59.3	30.2
Boron	7440-42-8	50	mg/kg	140	160	180	90	170
EG005(ED093)T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	6	10	5	<5	8
Barium	7440-39-3	10	mg/kg	20	10	10	<10	10
Beryllium	7440-41-7	1	mg/kg	<1	<1	<1	<1	<1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	29	13	11	10	15
Cobalt	7440-48-4	2	mg/kg	9	5	2	5	6
Copper	7440-50-8	5	mg/kg	19	<5	<5	7	7
Iron	7439-89-6	50	mg/kg	27300	16600	8140	15400	18000
Lead	7439-92-1	5	mg/kg	12	5	<5	<5	6
Manganese	7439-96-5	5	mg/kg	440	388	142	165	287
Nickel	7440-02-0	2	mg/kg	18	9	5	7	8
Selenium	7782-49-2	5	mg/kg	<5	<5	<5	<5	<5
Silver	7440-22-4	2	mg/kg	<2	<2	<2	<2	<2
Tin	7440-31-5	5	mg/kg	<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg	30	13	6	12	11
Zinc	7440-66-6	5	mg/kg	48	20	17	24	26



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				SED 23 <2000µm Fraction	SED 7 <2000µm Fraction	SED 11 <2000µm Fraction	SED 10 <2000µm Fraction	SED 18 <2000µm Fraction
Client sampling date / time				16-Apr-2019 00:00	17-Apr-2019 00:00	15-Apr-2019 00:00	16-Apr-2019 00:00	17-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910444-028	EB1910444-029	EB1910444-030	EB1910444-031	EB1910444-032
				Result	Result	Result	Result	Result
EG035-SDH: 1M HCl extractable Mercury by FIMS								
Mercury	7439-97-6	0.10	mg/kg	<0.10	<0.10	<0.10	<0.10	<0.10
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
GEO26: Sieving								
-2000µm	----	0.01	%	95.3	79.2	97.6	97.5	88.9



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				SED 20 <2000µm Fraction	SED 21 <2000µm Fraction	SED 22 <2000µm Fraction	SED 12 <63µm Fraction	SED 9 <63µm Fraction
Client sampling date / time				16-Apr-2019 00:00	16-Apr-2019 00:00	16-Apr-2019 00:00	17-Apr-2019 00:00	17-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910444-033	EB1910444-034	EB1910444-035	EB1910444-036	EB1910444-037
				Result	Result	Result	Result	Result
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES								
Aluminium	7429-90-5	50	mg/kg	18400	17300	12500	13300	16600
Antimony	7440-36-0	1.0	mg/kg	<1.0	1.0	<1.0	3.8	<1.0
Arsenic	7440-38-2	1.0	mg/kg	6.4	9.7	4.5	13.8	8.3
Barium	7440-39-3	1.0	mg/kg	20.4	29.3	26.7	116	59.5
Beryllium	7440-41-7	1.0	mg/kg	1.8	1.5	1.3	<1.0	1.3
Cadmium	7440-43-9	0.1	mg/kg	<0.2	<0.2	0.5	<0.5	0.5
Cobalt	7440-48-4	0.5	mg/kg	23.2	20.0	13.8	9.2	16.1
Chromium	7440-47-3	1.0	mg/kg	45.6	47.6	38.2	228	68.0
Copper	7440-50-8	1.0	mg/kg	29.3	28.9	17.1	61.6	26.5
Iron	7439-89-6	50	mg/kg	50400	46700	35200	22100	35500
Lead	7439-92-1	1.0	mg/kg	45.5	46.6	31.5	219	45.1
Manganese	7439-96-5	10	mg/kg	1410	1580	1190	699	1270
Nickel	7440-02-0	1.0	mg/kg	26.9	24.1	18.0	22.9	20.6
Vanadium	7440-62-2	2.0	mg/kg	56.6	52.8	31.1	30.2	38.1
Zinc	7440-66-6	1.0	mg/kg	58.6	56.3	40.2	95.4	56.4
Boron	7440-42-8	50	mg/kg	120	130	150	190	150
EG005(ED093)T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	8	7	5	5	<5
Barium	7440-39-3	10	mg/kg	20	20	10	30	20
Beryllium	7440-41-7	1	mg/kg	<1	<1	<1	<2	<1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	35	33	23	61	33
Cobalt	7440-48-4	2	mg/kg	12	10	7	4	8
Copper	7440-50-8	5	mg/kg	22	22	13	19	18
Iron	7439-89-6	50	mg/kg	34400	30800	20800	12000	23500
Lead	7439-92-1	5	mg/kg	13	13	8	48	12
Manganese	7439-96-5	5	mg/kg	504	529	360	200	403
Nickel	7440-02-0	2	mg/kg	23	20	14	14	17
Selenium	7782-49-2	5	mg/kg	<5	<5	<5	6	<5
Silver	7440-22-4	2	mg/kg	<2	<2	<2	<2	<2
Tin	7440-31-5	5	mg/kg	<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg	40	37	22	17	28
Zinc	7440-66-6	5	mg/kg	58	54	36	42	45



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				SED 20 <2000µm Fraction	SED 21 <2000µm Fraction	SED 22 <2000µm Fraction	SED 12 <63µm Fraction	SED 9 <63µm Fraction
Client sampling date / time				16-Apr-2019 00:00	16-Apr-2019 00:00	16-Apr-2019 00:00	17-Apr-2019 00:00	17-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910444-033	EB1910444-034	EB1910444-035	EB1910444-036	EB1910444-037
				Result	Result	Result	Result	Result
EG035-SDH: 1M HCl extractable Mercury by FIMS								
Mercury	7439-97-6	0.10	mg/kg	<0.10	<0.10	<0.10	<0.10	<0.10
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
GEO26: Sieving								
-2000µm	----	0.01	%	94.0	93.4	96.8	----	----
-63µm	----	0.01	%	----	----	----	6.32	31.5



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				SED 3 <63µm Fraction	SED 24 <63µm Fraction	SED 17 <63µm Fraction	SED 2 <63µm Fraction	SED 1 <63µm Fraction
Client sampling date / time				16-Apr-2019 00:00	16-Apr-2019 00:00	17-Apr-2019 00:00	16-Apr-2019 00:00	16-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910444-038	EB1910444-039	EB1910444-041	EB1910444-042	EB1910444-043
				Result	Result	Result	Result	Result
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES								
Aluminium	7429-90-5	50	mg/kg	15500	16700	12300	18200	22600
Antimony	7440-36-0	1.0	mg/kg	<1.0	<1.0	<1.0	<1.0	<1.0
Arsenic	7440-38-2	1.0	mg/kg	11.4	6.4	7.0	3.0	8.8
Barium	7440-39-3	1.0	mg/kg	51.2	47.8	63.5	47.0	63.8
Beryllium	7440-41-7	1.0	mg/kg	1.3	1.3	1.1	1.5	1.8
Cadmium	7440-43-9	0.1	mg/kg	0.5	0.5	0.4	<0.1	<0.2
Cobalt	7440-48-4	0.5	mg/kg	15.5	17.6	11.1	19.5	25.0
Chromium	7440-47-3	1.0	mg/kg	51.6	48.6	71.9	49.2	60.7
Copper	7440-50-8	1.0	mg/kg	29.5	27.3	25.3	32.7	47.6
Iron	7439-89-6	50	mg/kg	40500	40500	28700	51600	58800
Lead	7439-92-1	1.0	mg/kg	42.0	48.3	50.7	48.7	58.8
Manganese	7439-96-5	10	mg/kg	1100	1340	934	1160	1230
Nickel	7440-02-0	1.0	mg/kg	18.1	23.2	15.4	21.2	26.9
Vanadium	7440-62-2	2.0	mg/kg	38.7	44.4	23.3	46.9	69.8
Zinc	7440-66-6	1.0	mg/kg	55.1	57.0	47.5	67.0	78.0
Boron	7440-42-8	50	mg/kg	160	150	160	130	100
EG005(ED093)T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	<5	5	6	7	7
Barium	7440-39-3	10	mg/kg	20	20	20	20	30
Beryllium	7440-41-7	1	mg/kg	<1	<1	<1	<1	<1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	24	31	27	28	36
Cobalt	7440-48-4	2	mg/kg	6	9	5	8	11
Copper	7440-50-8	5	mg/kg	14	19	12	19	26
Iron	7439-89-6	50	mg/kg	20000	26400	17000	27800	35000
Lead	7439-92-1	5	mg/kg	9	13	13	13	15
Manganese	7439-96-5	5	mg/kg	304	437	277	399	472
Nickel	7440-02-0	2	mg/kg	13	18	12	16	21
Selenium	7782-49-2	5	mg/kg	<5	<5	<5	<5	<5
Silver	7440-22-4	2	mg/kg	<2	<2	<2	<2	<2
Tin	7440-31-5	5	mg/kg	<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg	22	31	17	29	42
Zinc	7440-66-6	5	mg/kg	37	49	33	50	63



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				SED 3 <63µm Fraction	SED 24 <63µm Fraction	SED 17 <63µm Fraction	SED 2 <63µm Fraction	SED 1 <63µm Fraction
Client sampling date / time				16-Apr-2019 00:00	16-Apr-2019 00:00	17-Apr-2019 00:00	16-Apr-2019 00:00	16-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910444-038	EB1910444-039	EB1910444-041	EB1910444-042	EB1910444-043
				Result	Result	Result	Result	Result
EG035-SDH: 1M HCl extractable Mercury by FIMS								
Mercury	7439-97-6	0.10	mg/kg	<0.10	<0.10	<0.10	<0.10	<0.10
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
GEO26: Sieving								
-63µm	----	0.01	%	71.5	76.1	23.9	82.0	87.6



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				SED 13 <63µm Fraction	SED 23 <63µm Fraction	SED 7 <63µm Fraction	SED 11 <63µm Fraction	SED 10 <63µm Fraction
Client sampling date / time				16-Apr-2019 00:00	16-Apr-2019 00:00	17-Apr-2019 00:00	15-Apr-2019 00:00	16-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910444-044	EB1910444-045	EB1910444-046	EB1910444-047	EB1910444-048
				Result	Result	Result	Result	Result
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES								
Aluminium	7429-90-5	50	mg/kg	8140	20800	22200	13000	16100
Antimony	7440-36-0	1.0	mg/kg	<1.0	<1.0	<1.0	10.2	<1.0
Arsenic	7440-38-2	1.0	mg/kg	8.4	5.6	8.5	5.4	11.3
Barium	7440-39-3	1.0	mg/kg	51.8	53.0	108	72.3	56.4
Beryllium	7440-41-7	1.0	mg/kg	<1.0	1.7	1.3	1.0	1.3
Cadmium	7440-43-9	0.1	mg/kg	<0.2	<0.2	0.7	0.4	<0.2
Cobalt	7440-48-4	0.5	mg/kg	5.9	21.3	16.6	9.3	17.2
Chromium	7440-47-3	1.0	mg/kg	40.4	55.2	97.0	51.9	80.2
Copper	7440-50-8	1.0	mg/kg	20.8	34.8	40.4	32.1	40.3
Iron	7439-89-6	50	mg/kg	15500	50000	37100	21600	47000
Lead	7439-92-1	1.0	mg/kg	39.6	53.2	78.3	42.8	46.9
Manganese	7439-96-5	10	mg/kg	508	1330	1300	728	780
Nickel	7440-02-0	1.0	mg/kg	10.0	26.0	26.8	18.1	19.3
Vanadium	7440-62-2	2.0	mg/kg	16.1	54.7	43.8	29.5	38.7
Zinc	7440-66-6	1.0	mg/kg	37.9	67.8	76.0	50.2	65.5
Boron	7440-42-8	50	mg/kg	160	130	160	190	90
EG005(ED093)T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	<5	<5	<5	<5	8
Barium	7440-39-3	10	mg/kg	20	30	40	20	20
Beryllium	7440-41-7	1	mg/kg	<1	<1	<1	<1	<1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	17	35	40	26	40
Cobalt	7440-48-4	2	mg/kg	3	10	7	5	8
Copper	7440-50-8	5	mg/kg	9	22	20	15	20
Iron	7439-89-6	50	mg/kg	9680	30800	22300	14200	28500
Lead	7439-92-1	5	mg/kg	10	15	20	11	12
Manganese	7439-96-5	5	mg/kg	153	462	392	224	342
Nickel	7440-02-0	2	mg/kg	9	21	17	12	16
Selenium	7782-49-2	5	mg/kg	<5	<5	<5	<5	<5
Silver	7440-22-4	2	mg/kg	<2	<2	<2	<2	<2
Tin	7440-31-5	5	mg/kg	<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg	11	36	28	18	30
Zinc	7440-66-6	5	mg/kg	26	55	46	34	50



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				SED 13 <63µm Fraction	SED 23 <63µm Fraction	SED 7 <63µm Fraction	SED 11 <63µm Fraction	SED 10 <63µm Fraction
Client sampling date / time				16-Apr-2019 00:00	16-Apr-2019 00:00	17-Apr-2019 00:00	15-Apr-2019 00:00	16-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1910444-044	EB1910444-045	EB1910444-046	EB1910444-047	EB1910444-048
				Result	Result	Result	Result	Result
EG035-SDH: 1M HCl extractable Mercury by FIMS								
Mercury	7439-97-6	0.10	mg/kg	<0.10	<0.10	<0.10	<0.10	<0.10
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
GEO26: Sieving								
-63µm	----	0.01	%	53.4	76.5	12.9	30.4	35.6



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				SED 18 <63µm Fraction	SED 20 <63µm Fraction	SED 21 <63µm Fraction	SED 22 <63µm Fraction	----
Client sampling date / time				17-Apr-2019 00:00	16-Apr-2019 00:00	16-Apr-2019 00:00	16-Apr-2019 00:00	----
Compound	CAS Number	LOR	Unit	EB1910444-049	EB1910444-050	EB1910444-051	EB1910444-052	-----
				Result	Result	Result	Result	----

EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES

Aluminium	7429-90-5	50	mg/kg	16400	27700	23400	<50	----
Antimony	7440-36-0	1.0	mg/kg	4.2	<1.0	<1.0	<1.0	----
Arsenic	7440-38-2	1.0	mg/kg	8.8	8.0	11.3	<1.0	----
Barium	7440-39-3	1.0	mg/kg	70.9	70.9	65.8	<1.0	----
Beryllium	7440-41-7	1.0	mg/kg	1.3	2.1	1.9	<1.0	----
Cadmium	7440-43-9	0.1	mg/kg	0.6	<0.2	<0.2	<0.2	----
Cobalt	7440-48-4	0.5	mg/kg	14.0	30.6	24.0	<0.5	----
Chromium	7440-47-3	1.0	mg/kg	57.6	64.6	58.6	<1.0	----
Copper	7440-50-8	1.0	mg/kg	31.9	48.3	35.3	<1.0	----
Iron	7439-89-6	50	mg/kg	35500	63800	54000	<50	----
Lead	7439-92-1	1.0	mg/kg	50.0	70.1	61.7	1.3	----
Manganese	7439-96-5	10	mg/kg	1070	1600	1840	<10	----
Nickel	7440-02-0	1.0	mg/kg	20.0	39.8	31.6	<1.0	----
Vanadium	7440-62-2	2.0	mg/kg	34.7	79.6	62.4	<2.0	----
Zinc	7440-66-6	1.0	mg/kg	57.6	90.9	73.6	<1.0	----
Boron	7440-42-8	50	mg/kg	180	110	130	<50	----

EG005(ED093)T: Total Metals by ICP-AES

Arsenic	7440-38-2	5	mg/kg	<5	7	9	<5	----
Barium	7440-39-3	10	mg/kg	20	30	30	20	----
Beryllium	7440-41-7	1	mg/kg	<1	<1	<1	<1	----
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	----
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	----
Chromium	7440-47-3	2	mg/kg	26	43	39	30	----
Cobalt	7440-48-4	2	mg/kg	6	13	12	8	----
Copper	7440-50-8	5	mg/kg	15	30	25	18	----
Iron	7439-89-6	50	mg/kg	19200	40600	35000	25400	----
Lead	7439-92-1	5	mg/kg	12	19	18	13	----
Manganese	7439-96-5	5	mg/kg	302	576	618	432	----
Nickel	7440-02-0	2	mg/kg	14	28	23	19	----
Selenium	7782-49-2	5	mg/kg	<5	<5	<5	<5	----
Silver	7440-22-4	2	mg/kg	<2	<2	<2	<2	----
Tin	7440-31-5	5	mg/kg	<5	<5	<5	<5	----
Vanadium	7440-62-2	5	mg/kg	22	51	42	31	----
Zinc	7440-66-6	5	mg/kg	38	70	61	47	----



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	SED 18 <63µm Fraction	SED 20 <63µm Fraction	SED 21 <63µm Fraction	SED 22 <63µm Fraction	----
Client sampling date / time					17-Apr-2019 00:00	16-Apr-2019 00:00	16-Apr-2019 00:00	16-Apr-2019 00:00	----
Compound	CAS Number	LOR	Unit		EB1910444-049	EB1910444-050	EB1910444-051	EB1910444-052	-----
				Result	Result	Result	Result	Result	----
EG035-SDH: 1M HCl extractable Mercury by FIMS									
Mercury	7439-97-6	0.10	mg/kg		<0.10	<0.10	<0.10	<0.10	----
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	----
GEO26: Sieving									
-63µm	----	0.01	%		28.5	68.7	86.3	69.6	----

Certificate of Analysis

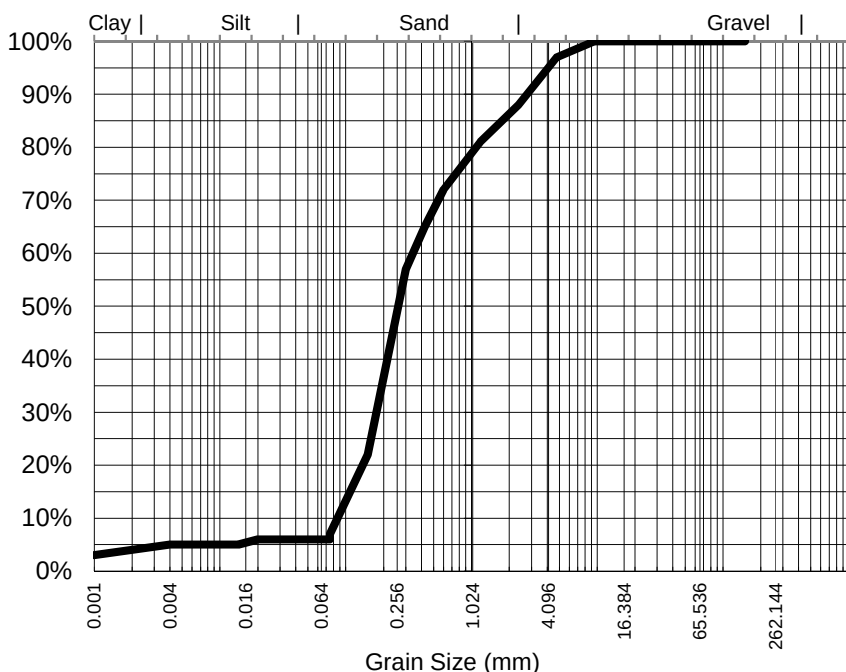
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fax 07 3352 3662
samples.brisbane@alsenviro.com

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Brisbane, QLD



CLIENT: ERICA COLLEY **DATE REPORTED:** 17-May-2019
COMPANY: COFFEY ENVIRONMENTS PTY LTD **DATE RECEIVED:** 23-Apr-2019
ADDRESS: LEVEL WORKPLES BUILDING **REPORT NO:** EB1910444-001 / PSD
LOT 12 WAIGANI DRIVE
HOHOLA, NCD PNG
PROJECT: 754-Melen224697 Jdd Project **SAMPLE ID:** SED 12

Particle Size Distribution



Particle Size (mm)	Percent Passing
9.50	100%
4.75	97%
2.36	88%
1.18	81%
0.600	72%
0.425	65%
0.300	57%
0.150	22%
0.075	7%
Particle Size (microns)	
75	6%
55	6%
39	6%
20	6%
10	5%
5	5%
1	3%

Samples analysed as received.

Median Particle Size (mm)*	0.270
----------------------------	-------

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments: AS1289.3.6.3 states that this method is not applicable for samples containing <10% fines (<75µm). Results should be assessed accordingly

Loss on Pretreatment NA

Sample Description:

Test Method: AS1289.3.6.3 2003

Soil Particle Density (<2.36mm) 2.67 g/cm3

NATA Accreditation: 825 Site: Newcastle
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Analysed: 8-May-19

Limit of Reporting: 1%

Dispersion Method Shaker

Hydrometer Type ASTM E100

Satish Trivedi
Soil Chemist
Authorised Signatory

Certificate of Analysis

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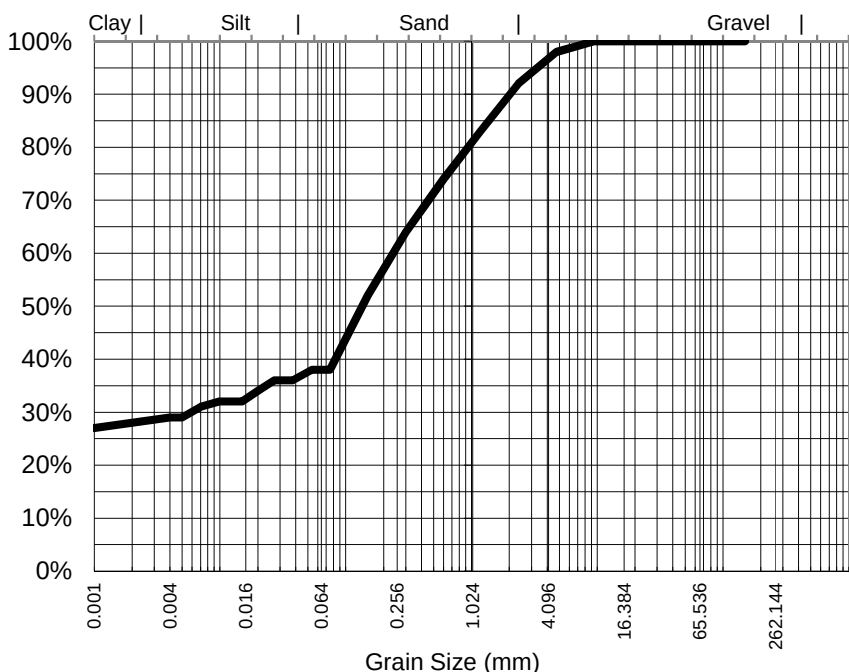
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COMPANY: COFFEY ENVIRONMENTS PTY LTD **DATE RECEIVED:** 23-Apr-2019

ADDRESS: LEVEL WORKPLES BUILDING **REPORT NO:** EB1910444-002 / PSD
LOT 12 WAIGANI DRIVE
HOHOLA, NCD PNG

PROJECT: 754-Melen224697 Jdd Project **SAMPLE ID:** SED 9

Particle Size Distribution



Particle Size (mm)	Percent Passing
9.50	100%
4.75	98%
2.36	92%
1.18	83%
0.600	74%
0.425	69%
0.300	64%
0.150	52%
0.075	38%
Particle Size (microns)	
75	38%
54	38%
38	36%
20	34%
10	32%
5	29%
1	27%

Samples analysed as received.

* Soil Particle Density results fell outside the scope of AS 1289.3.6.3. Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Loss on Pretreatment NA

Sample Description:

Test Method: AS1289.3.6.3 2003

Soil Particle Density (<2.36mm) 2.44 (2.45)* g/cm3

NATA Accreditation: 825 **Site:** Newcastle

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Analysed: 8-May-19

Limit of Reporting: 1%

Dispersion Method Shaker

Hydrometer Type ASTM E100

Satish Trivedi

Soil Chemist

Authorised Signatory

Certificate of Analysis

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CLIENT:

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DATE REPORTED: 17-May-2019

COMPANY:

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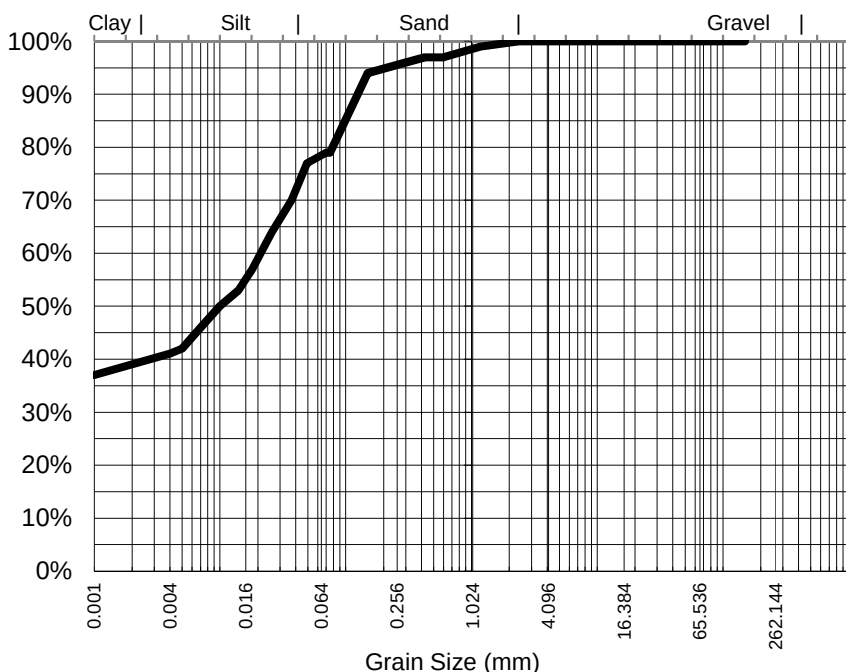
ADDRESS:

LEVEL WORKPLES BUILDING **REPORT NO:** EB1910444-003 / PSD
LOT 12 WAIGANI DRIVE
HOHOLA, NCD PNG

PROJECT:

754-Melen224697 Jdd Project **SAMPLE ID:** SED 3

Particle Size Distribution



Particle Size (mm)	Percent Passing
2.36	100%
1.18	99%
0.600	97%
0.425	97%
0.300	96%
0.150	94%
0.075	79%
Particle Size (microns)	
70	79%
49	77%
37	70%
18	57%
10	50%
5	42%
1	37%

Samples analysed as received.

* Soil Particle Density results fell outside the scope of AS 1289.3.6.3. Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Loss on Pretreatment NA

Sample Description:

Test Method: AS1289.3.6.3 2003

Soil Particle Density (<2.36mm) 2.42 (2.45)* g/cm3

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Analysed:

8-May-19

Limit of Reporting: 1%

Dispersion Method Shaker

Hydrometer Type ASTM E100

Satish Trivedi

Soil Chemist

Authorised Signatory

Certificate of Analysis

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DATE REPORTED: 17-May-2019

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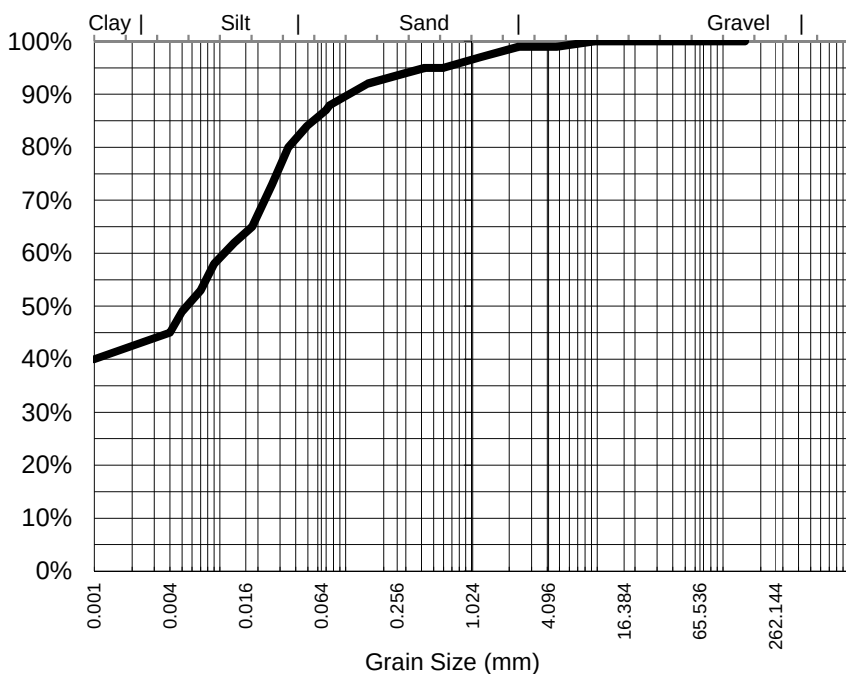
ADDRESS:

LEVEL WORKPLES BUILDING **REPORT NO:** EB1910444-004 / PSD
LOT 12 WAIGANI DRIVE
HOHOLA, NCD PNG

PROJECT:

754-Melen224697 Jdd Project **SAMPLE ID:** SED 24

Particle Size Distribution



Particle Size (mm)	Percent Passing
9.50	100%
4.75	99%
2.36	99%
1.18	97%
0.600	95%
0.425	95%
0.300	94%
0.150	92%
0.075	88%
Particle Size (microns)	
70	87%
49	84%
35	80%
18	65%
9	58%
5	49%
1	40%

Samples analysed as received.

Median Particle Size (mm)*	0.006
----------------------------	-------

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Loss on Pretreatment NA

Sample Description:

Test Method: AS1289.3.6.3 2003

Soil Particle Density (<2.36mm) 2.46 g/cm3

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Analysed: 8-May-19

Limit of Reporting: 1%

Dispersion Method Shaker

Hydrometer Type ASTM E100

Satish Trivedi
Soil Chemist
Authorised Signatory

Certificate of Analysis

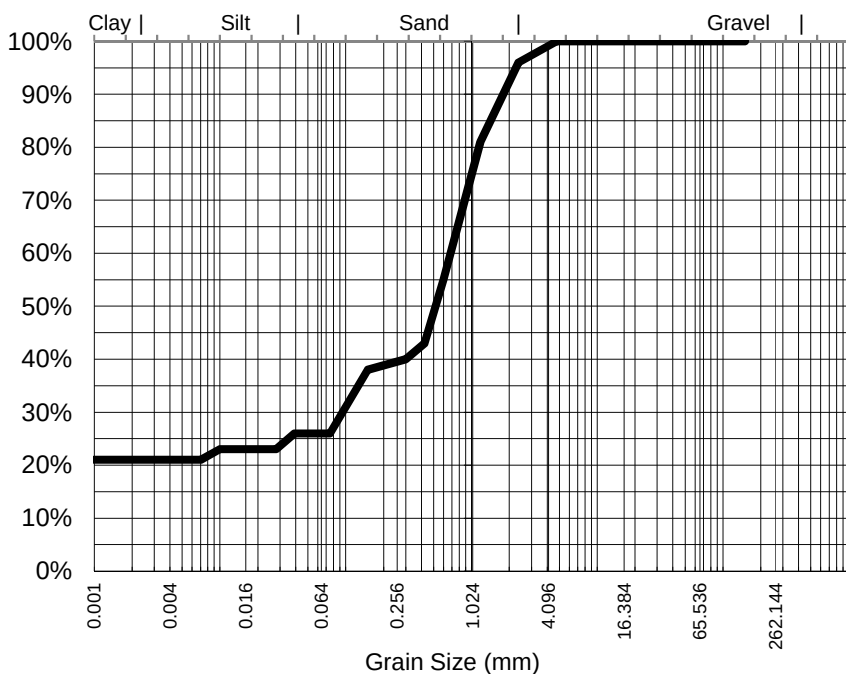
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LOT 12 WAIGANI DRIVE
HOHOLA, NCD PNG
PROJECT: 754-Melen224697 Jdd Project **SAMPLE ID:** SED 17

Particle Size Distribution



Particle Size (mm)	Percent Passing
4.75	100%
2.36	96%
1.18	81%
0.600	55%
0.425	43%
0.300	40%
0.150	38%
0.075	26%
Particle Size (microns)	
75	26%
56	26%
39	26%
20	23%
10	23%
5	21%
1	21%

Samples analysed as received.

Median Particle Size (mm)*	0.527
----------------------------	-------

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Loss on Pretreatment NA

Sample Description:

Test Method: AS1289.3.6.3 2003

Soil Particle Density (<2.36mm) 2.53 g/cm3

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Analysed: 8-May-19

Limit of Reporting: 1%

Dispersion Method Shaker

Hydrometer Type ASTM E100

Satish Trivedi
Soil Chemist
Authorised Signatory

Certificate of Analysis

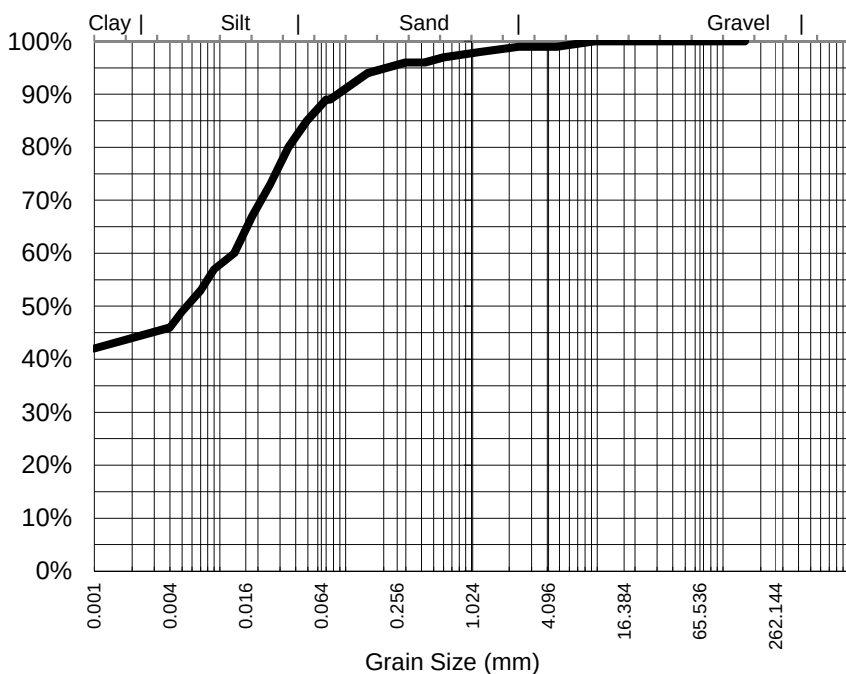
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LOT 12 WAIGANI DRIVE
HOHOLA, NCD PNG
PROJECT: 754-Melen224697 Jdd Project **SAMPLE ID:** SED 2

Particle Size Distribution



Particle Size (mm)	Percent Passing
9.50	100%
4.75	99%
2.36	99%
1.18	98%
0.600	97%
0.425	96%
0.300	96%
0.150	94%
0.075	89%
Particle Size (microns)	
70	89%
49	85%
35	80%
18	67%
9	57%
5	49%
1	42%

Samples analysed as received.

Median Particle Size (mm)*	0.006
----------------------------	-------

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Loss on Pretreatment NA

Sample Description:

Test Method: AS1289.3.6.3 2003

Soil Particle Density (<2.36mm) 2.47 g/cm3

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Analysed: 8-May-19

Limit of Reporting: 1%

Dispersion Method Shaker

Hydrometer Type ASTM E100

Satish Trivedi
Soil Chemist
Authorised Signatory

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CLIENT:

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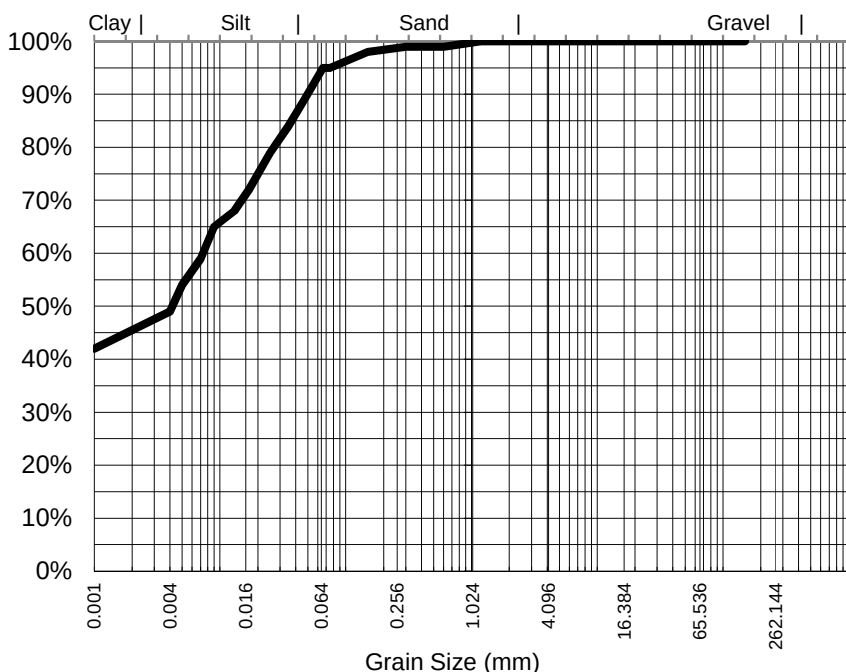
ADDRESS:

LEVEL WORKPLES BUILDING **REPORT NO:** EB1910444-008 / PSD
LOT 12 WAIGANI DRIVE
HOHOLA, NCD PNG

PROJECT:

754-Melen224697 Jdd Project **SAMPLE ID:** SED 1

Particle Size Distribution



Particle Size (mm)	Percent Passing
1.18	100%
0.600	99%
0.425	99%
0.300	99%
0.150	98%
0.075	95%
Particle Size (microns)	
66	95%
47	89%
35	84%
17	72%
9	65%
5	54%
1	42%

Samples analysed as received.

* Soil Particle Density results fell outside the scope of AS 1289.3.6.3. Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Loss on Pretreatment NA

Sample Description:

Test Method: AS1289.3.6.3 2003

Soil Particle Density (<2.36mm) 2.41 (2.45)* g/cm3

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Analysed:

8-May-19

Limit of Reporting: 1%

Dispersion Method Shaker

Hydrometer Type ASTM E100

Satish Trivedi

Soil Chemist

Authorised Signatory

Certificate of Analysis

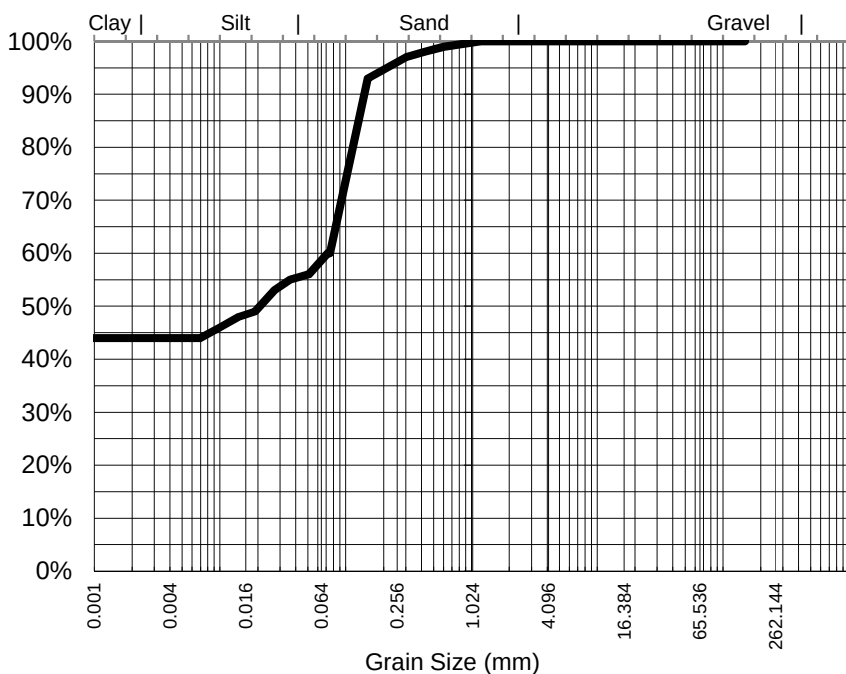
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ADDRESS: LEVEL WORKPLES BUILDING **REPORT NO:** EB1910444-009 / PSD
LOT 12 WAIGANI DRIVE
HOHOLA, NCD PNG
PROJECT: 754-Melen224697 Jdd Project **SAMPLE ID:** SED 13

Particle Size Distribution



Particle Size (mm)	Percent Passing
1.18	100%
0.600	99%
0.425	98%
0.300	97%
0.150	93%
0.075	60%
Particle Size (microns)	
72	60%
51	56%
36	55%
19	49%
10	46%
5	44%
1	44%

Samples analysed as received.

Median Particle Size (mm)*	0.021
----------------------------	-------

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Loss on Pretreatment NA

Sample Description:

Test Method: AS1289.3.6.3 2003

Soil Particle Density (<2.36mm) 2.53 g/cm3

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Analysed: 8-May-19

Limit of Reporting: 1%

Dispersion Method Shaker

Hydrometer Type ASTM E100

Satish Trivedi
Soil Chemist
Authorised Signatory

Certificate of Analysis

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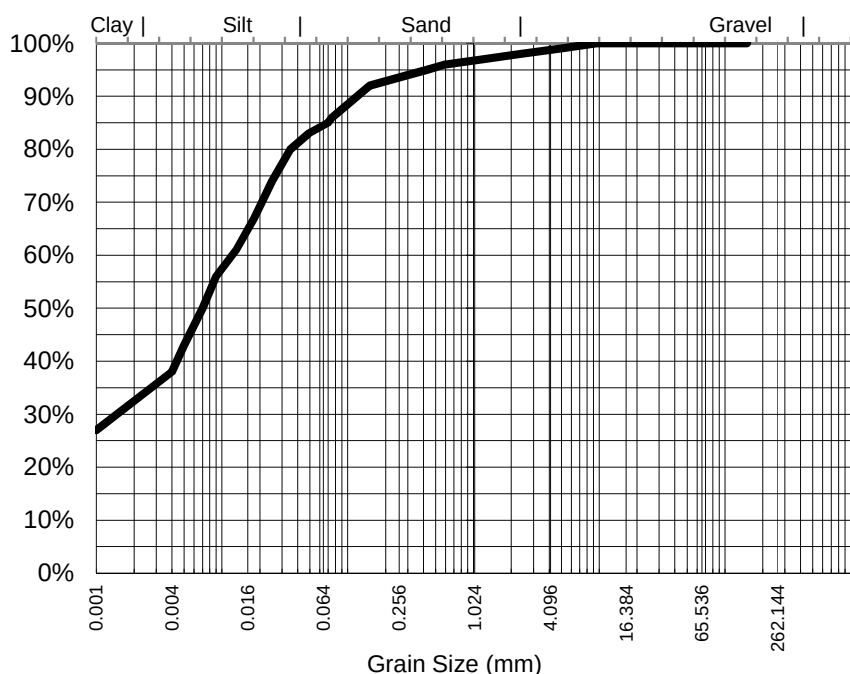
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ADDRESS: LEVEL WORKPLES BUILDING **REPORT NO:** EB1910444-010 / PSD
LOT 12 WAIGANI DRIVE
HOHOLA, NCD PNG

PROJECT: 754-Melen224697 Jdd Project **SAMPLE ID:** SED 23

Particle Size Distribution



Particle Size (mm)	Percent Passing
9.50	100%
4.75	99%
2.36	98%
1.18	97%
0.600	96%
0.425	95%
0.300	94%
0.150	92%
0.075	86%
Particle Size (microns)	
70	85%
49	83%
35	80%
18	67%
9	56%
5	43%
1	27%

Samples analysed as received.

* Soil Particle Density results fell outside the scope of AS 1289.3.6.3. Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Loss on Pretreatment NA

Sample Description:

Test Method: AS1289.3.6.3 2003

Soil Particle Density (<2.36mm) 2.36 (2.45)* g/cm3

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Analysed: 8-May-19

Limit of Reporting: 1%

Dispersion Method Shaker

Hydrometer Type ASTM E100

Satish Trivedi
Soil Chemist
Authorised Signatory

Certificate of Analysis

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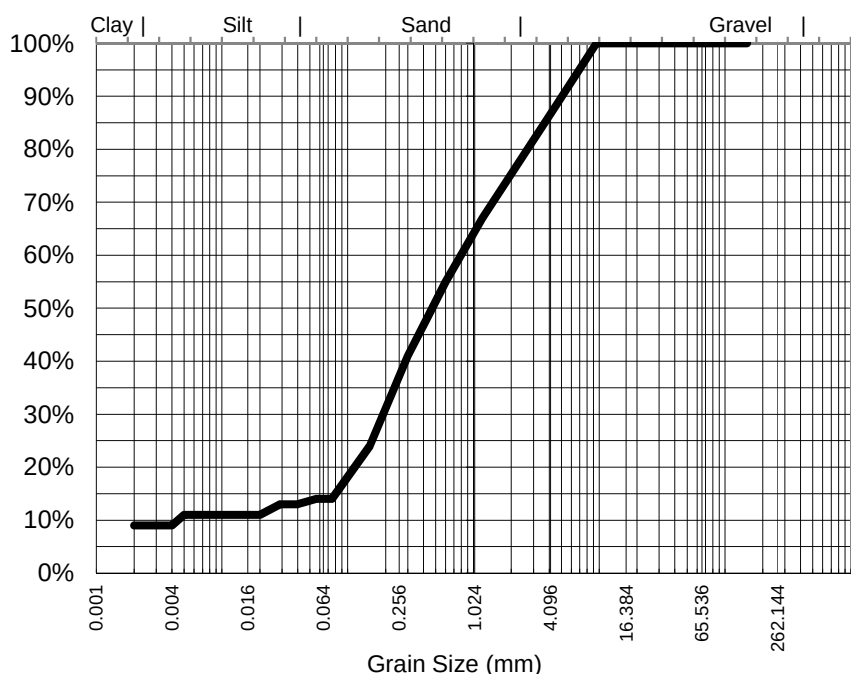
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COMPANY: COFFEY ENVIRONMENTS PTY LTD **DATE RECEIVED:** 23-Apr-2019

ADDRESS: LEVEL WORKPLES BUILDING **REPORT NO:** EB1910444-011 / PSD
LOT 12 WAIGANI DRIVE
HOHOLA, NCD PNG

PROJECT: 754-Melen224697 Jdd Project **SAMPLE ID:** SED 7

Particle Size Distribution



Particle Size (mm)	Percent Passing
9.50	100%
4.75	89%
2.36	78%
1.18	67%
0.600	55%
0.425	48%
0.300	41%
0.150	24%
0.075	14%
Particle Size (microns)	
75	14%
57	14%
40	13%
20	11%
10	11%
5	11%
2	9%

Samples analysed as received.

Median Particle Size (mm)*	0.475
----------------------------	-------

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Loss on Pretreatment NA

Sample Description:

Test Method: AS1289.3.6.3 2003

Soil Particle Density (<2.36mm) 2.56 g/cm3

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Analysed: 8-May-19

Limit of Reporting: 1%

Dispersion Method Shaker

Hydrometer Type ASTM E100

Satish Trivedi
Soil Chemist
Authorised Signatory

Certificate of Analysis

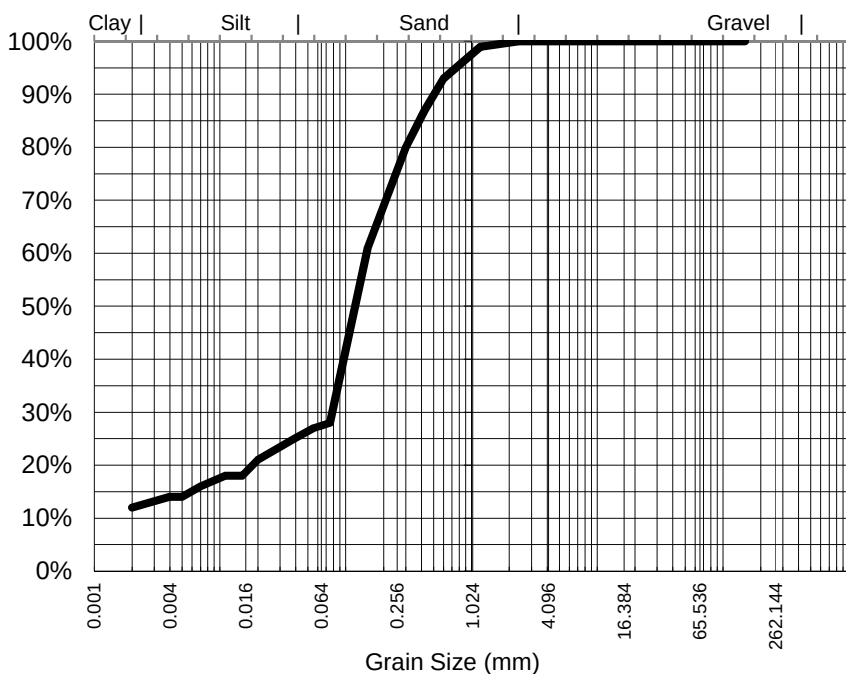
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pH 07 3552 8678
fax 07 3352 3662
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CLIENT: ERICA COLLEY **DATE REPORTED:** 17-May-2019
COMPANY: COFFEY ENVIRONMENTS PTY LTD **DATE RECEIVED:** 23-Apr-2019
ADDRESS: LEVEL WORKPLES BUILDING **REPORT NO:** EB1910444-012 / PSD
LOT 12 WAIGANI DRIVE
HOHOLA, NCD PNG
PROJECT: 754-Melen224697 Jdd Project **SAMPLE ID:** SED 11

Particle Size Distribution



Particle Size (mm)	Percent Passing
2.36	100%
1.18	99%
0.600	93%
0.425	87%
0.300	80%
0.150	61%
0.075	28%
Particle Size (microns)	
75	28%
56	27%
39	25%
20	21%
11	18%
5	14%
2	12%

Samples analysed as received.

Median Particle Size (mm)*	0.125
----------------------------	-------

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Loss on Pretreatment NA

Sample Description:

Test Method: AS1289.3.6.3 2003

Soil Particle Density (<2.36mm) 2.51 g/cm3

NATA Accreditation: 825 Site: Newcastle
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Analysed: 8-May-19

Limit of Reporting: 1%

Dispersion Method Shaker

Hydrometer Type ASTM E100

Satish Trivedi
Soil Chemist
Authorised Signatory

Certificate of Analysis

ALS Laboratory Group Pty Ltd
2 Byth Street, Stafford, QLD 4053
pH 07 3552 8678
fax 07 3352 3662
samples.brisbane@alsenviro.com

ALS Environmental
Brisbane, QLD



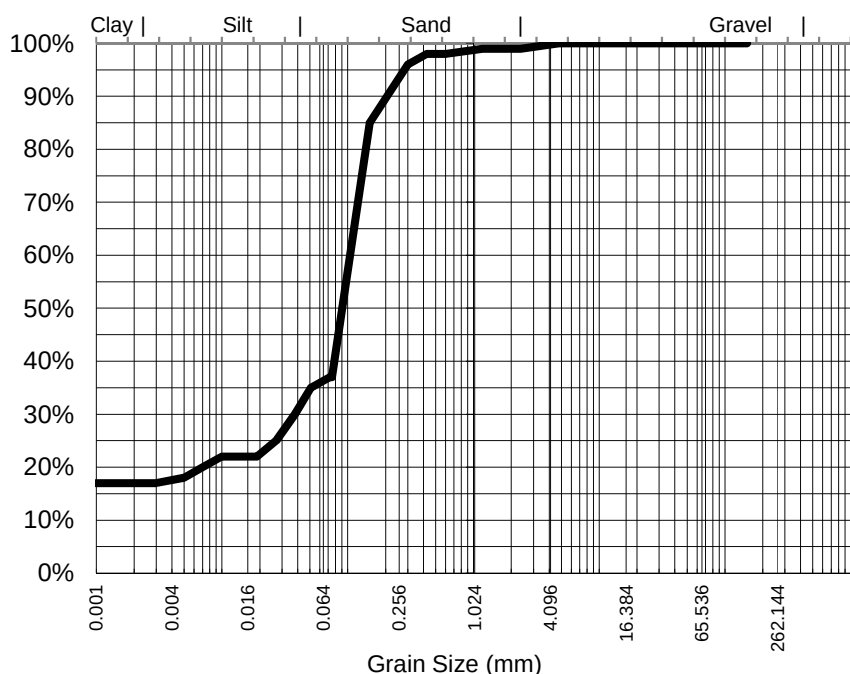
CLIENT: ERICA COLLEY **DATE REPORTED:** 17-May-2019

COMPANY: COFFEY ENVIRONMENTS PTY LTD **DATE RECEIVED:** 23-Apr-2019

ADDRESS: LEVEL WORKPLES BUILDING **REPORT NO:** EB1910444-013 / PSD
LOT 12 WAIGANI DRIVE
HOHOLA, NCD PNG

PROJECT: 754-Melen224697 Jdd Project **SAMPLE ID:** SED 10

Particle Size Distribution



Particle Size (mm)	Percent Passing
4.75	100%
2.36	99%
1.18	99%
0.600	98%
0.425	98%
0.300	96%
0.150	85%
0.075	37%
Particle Size (microns)	
72	37%
51	35%
38	30%
19	22%
10	22%
5	18%
1	17%

Samples analysed as received.

Median Particle Size (mm)*	0.095
----------------------------	-------

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Loss on Pretreatment NA

Sample Description:

Test Method: AS1289.3.6.3 2003

Soil Particle Density (<2.36mm) 2.65 g/cm3

NATA Accreditation: 825 Site: Newcastle
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Analysed: 8-May-19

Limit of Reporting: 1%

Dispersion Method Shaker

Hydrometer Type ASTM E100

Satish Trivedi
Soil Chemist
Authorised Signatory

Certificate of Analysis

ALS Laboratory Group Pty Ltd
2 Byth Street, Stafford, QLD 4053
pH 07 3552 8678
fax 07 3352 3662
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ALS Environmental
Brisbane, QLD



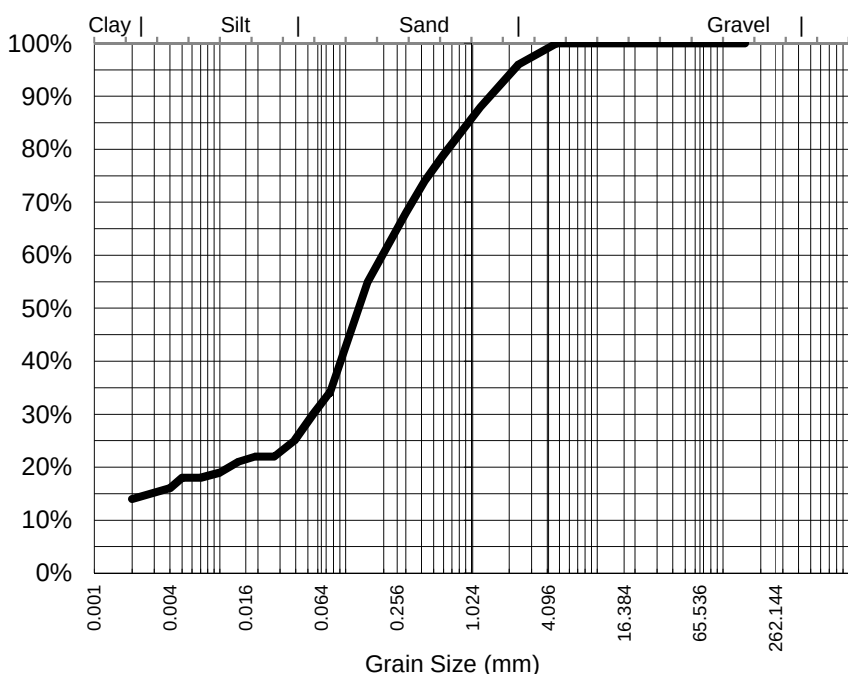
CLIENT: ERICA COLLEY **DATE REPORTED:** 17-May-2019

COMPANY: COFFEY ENVIRONMENTS PTY LTD **DATE RECEIVED:** 23-Apr-2019

ADDRESS: LEVEL WORKPLES BUILDING **REPORT NO:** EB1910444-014 / PSD
LOT 12 WAIGANI DRIVE
HOHOLA, NCD PNG

PROJECT: 754-Melen224697 Jdd Project **SAMPLE ID:** SED 18

Particle Size Distribution



Particle Size (mm)	Percent Passing
4.75	100%
2.36	96%
1.18	88%
0.600	79%
0.425	74%
0.300	68%
0.150	55%
0.075	34%
Particle Size (microns)	
74	34%
55	30%
39	25%
19	22%
10	19%
5	18%
2	14%

Median Particle Size (mm)*	0.132
----------------------------	-------

Samples analysed as received.

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Loss on Pretreatment NA

Sample Description:

Test Method: AS1289.3.6.3 2003

Soil Particle Density (<2.36mm) 2.57 g/cm3

NATA Accreditation: 825 **Site:** Newcastle

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Analysed: 8-May-19

Limit of Reporting: 1%

Dispersion Method Shaker

Hydrometer Type ASTM E100

Satish Trivedi

Soil Chemist

Authorised Signatory

Certificate of Analysis

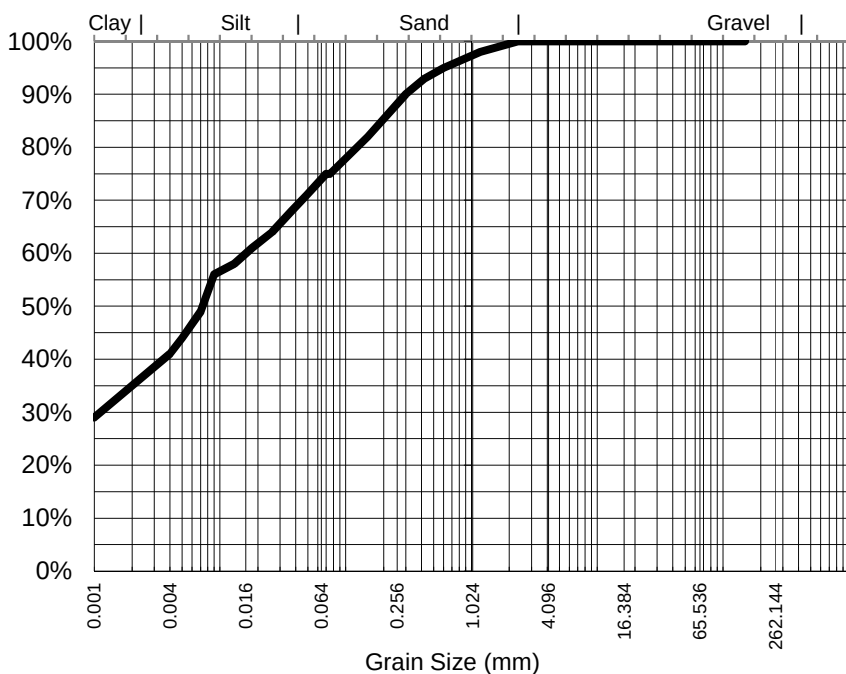
ALS Laboratory Group Pty Ltd
2 Byth Street, Stafford, QLD 4053
pH 07 3552 8678
fax 07 3352 3662
samples.brisbane@alsenviro.com

ALS Environmental
Brisbane, QLD



CLIENT: ERICA COLLEY **DATE REPORTED:** 17-May-2019
COMPANY: COFFEY ENVIRONMENTS PTY LTD **DATE RECEIVED:** 23-Apr-2019
ADDRESS: LEVEL WORKPLES BUILDING **REPORT NO:** EB1910444-015 / PSD
LOT 12 WAIGANI DRIVE
HOHOLA, NCD PNG
PROJECT: 754-Melen224697 Jdd Project **SAMPLE ID:** SED 20

Particle Size Distribution



Particle Size (mm)	Percent Passing
2.36	100%
1.18	98%
0.600	95%
0.425	93%
0.300	90%
0.150	82%
0.075	75%
Particle Size (microns)	
70	75%
49	71%
37	68%
18	61%
9	56%
5	44%
1	29%

Samples analysed as received.

Median Particle Size (mm)*	0.007
----------------------------	-------

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Loss on Pretreatment NA

Sample Description:

Test Method: AS1289.3.6.3 2003

Soil Particle Density (<2.36mm) 2.45 g/cm3

NATA Accreditation: 825 Site: Newcastle
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Analysed: 8-May-19

Limit of Reporting: 1%

Dispersion Method Shaker

Hydrometer Type ASTM E100

Satish Trivedi
Soil Chemist
Authorised Signatory

Certificate of Analysis

ALS Laboratory Group Pty Ltd
2 Byth Street, Stafford, QLD 4053
pH 07 3552 8678
fax 07 3352 3662
samples.brisbane@alsenviro.com

ALS Environmental
Brisbane, QLD



CLIENT:

ERICA COLLEY

DATE REPORTED: 17-May-2019

COMPANY:

COFFEY ENVIRONMENTS PTY LTD **DATE RECEIVED:** 23-Apr-2019

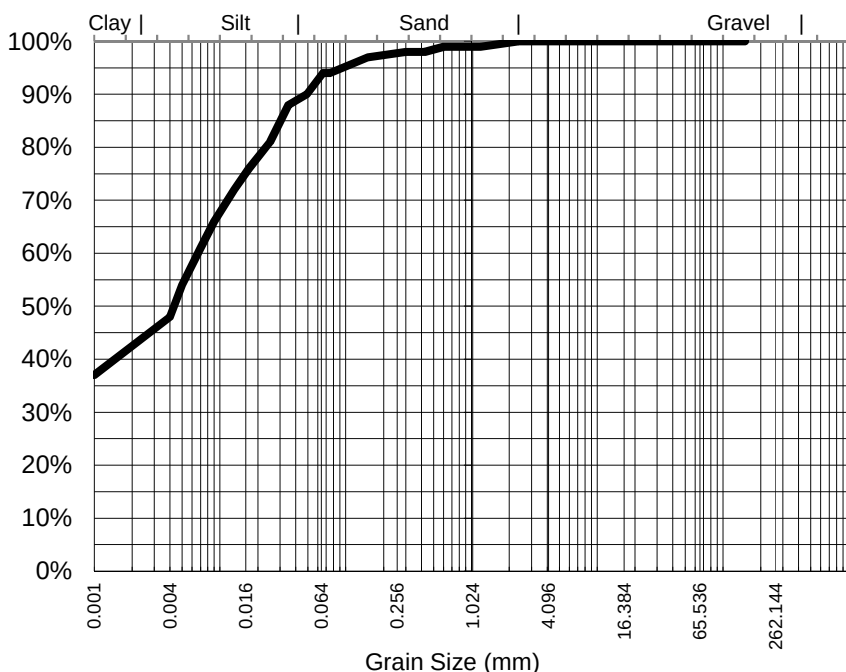
ADDRESS:

LEVEL WORKPLES BUILDING **REPORT NO:** EB1910444-016 / PSD
LOT 12 WAIGANI DRIVE
HOHOLA, NCD PNG

PROJECT:

754-Melen224697 Jdd Project **SAMPLE ID:** SED 21

Particle Size Distribution



Particle Size (mm)	Percent Passing
2.36	100%
1.18	99%
0.600	99%
0.425	98%
0.300	98%
0.150	97%
0.075	94%
Particle Size (microns)	
66	94%
49	90%
35	88%
17	76%
9	66%
5	54%
1	37%

Samples analysed as received.

* Soil Particle Density results fell outside the scope of AS 1289.3.6.3. Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Loss on Pretreatment NA

Sample Description:

Test Method: AS1289.3.6.3 2003

Soil Particle Density (<2.36mm) 2.35 (2.45)* g/cm3

NATA Accreditation: 825 Site: Newcastle
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Analysed:

8-May-19

Limit of Reporting: 1%

Dispersion Method Shaker

Hydrometer Type ASTM E100

Satish Trivedi

Soil Chemist

Authorised Signatory

Certificate of Analysis

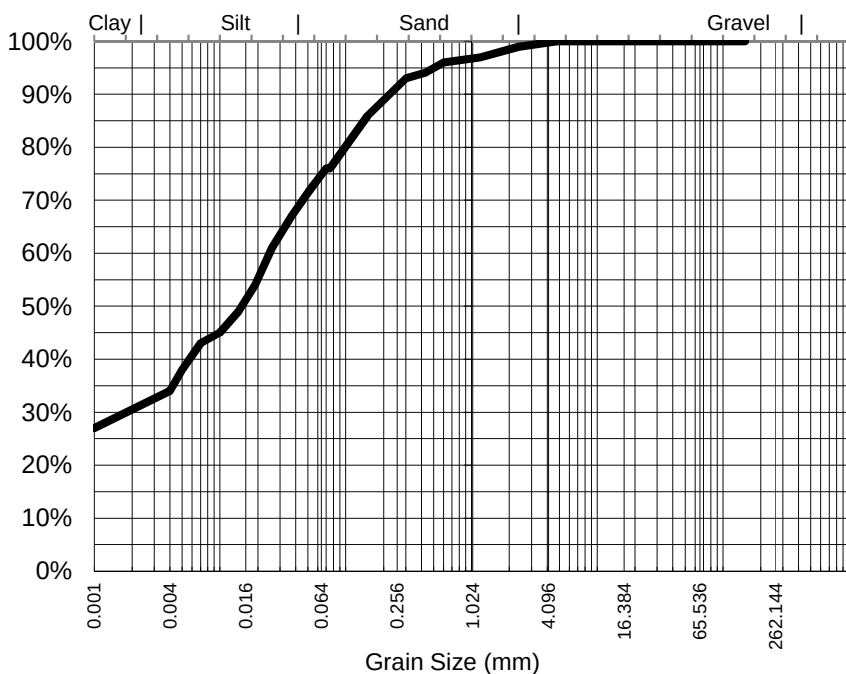
ALS Laboratory Group Pty Ltd
2 Byth Street, Stafford, QLD 4053
pH 07 3552 8678
fax 07 3352 3662
samples.brisbane@alsenviro.com

ALS Environmental
Brisbane, QLD



CLIENT: ERICA COLLEY **DATE REPORTED:** 17-May-2019
COMPANY: COFFEY ENVIRONMENTS PTY LTD **DATE RECEIVED:** 23-Apr-2019
ADDRESS: LEVEL WORKPLES BUILDING **REPORT NO:** EB1910444-017 / PSD
LOT 12 WAIGANI DRIVE
HOHOLA, NCD PNG
PROJECT: 754-Melen224697 Jdd Project **SAMPLE ID:** SED 22

Particle Size Distribution



Particle Size (mm)	Percent Passing
4.75	100%
2.36	99%
1.18	97%
0.600	96%
0.425	94%
0.300	93%
0.150	86%
0.075	76%
Particle Size (microns)	
70	76%
52	72%
37	67%
19	54%
10	45%
5	38%
1	27%

Samples analysed as received.

* Soil Particle Density results fell outside the scope of AS 1289.3.6.3. Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Loss on Pretreatment NA

Sample Description:

Test Method: AS1289.3.6.3 2003

Soil Particle Density (<2.36mm) 2.42 (2.45)* g/cm3

NATA Accreditation: 825 Site: Newcastle
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Analysed: 8-May-19

Limit of Reporting: 1%

Dispersion Method Shaker

Hydrometer Type ASTM E100

Satish Trivedi
Soil Chemist
Authorised Signatory

CERTIFICATE OF ANALYSIS

Work Order	: EB1910671	Page	: 1 of 4
Amendment	: 3		
Client	: COFFEY ENVIRONMENTS PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: ERICA COLLEY	Contact	: Andrew Epps
Address	: LEVEL WORKPLES BUILDING SAVANNAH HEIGHTS SECTION	Address	: 2 Byth Street Stafford QLD Australia 4053
	531, LOT 12 WAIGANI DRIVE		
	HOHOLA, NCD PNG		
Telephone	: 64277004057	Telephone	: +61 7 3552 8639
Project	: 754-MELEN224697 JDD PROJECT	Date Samples Received	: 23-Apr-2019 13:55
Order number	:	Date Analysis Commenced	: 26-Apr-2019
C-O-C number	: ----	Issue Date	: 05-Dec-2019 11:33
Sampler	: ERICA COLLEY		
Site	: ----		
Quote number	: BN/065/19 V2		
No. of samples received	: 8		
No. of samples analysed	: 1		



Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- It is recognised that EG094-T (Total Metals in Fresh Water by ORC-ICP-MS) is less than EG094-F (Dissolved Metals in Fresh Water by ORC-ICP-MS) for sample EB1910671-001(WQ 19). However, the difference is within experimental variation of the methods.
- Benzo(a)pyrene Toxicity Equivalent Quotient (TEQ) per the NEPM (2013) is the sum total of the concentration of the eight carcinogenic PAHs multiplied by their Toxicity Equivalence Factor (TEF) relative to Benzo(a)pyrene. TEF values are provided in brackets as follows: Benz(a)anthracene (0.1), Chrysene (0.01), Benzo(b+j) & Benzo(k)fluoranthene (0.1), Benzo(a)pyrene (1.0), Indeno(1.2.3.cd)pyrene (0.1), Dibenz(a,h)anthracene (1.0), Benzo(g,h,i)perylene (0.01). Less than LOR results for 'TEQ Zero' are treated as zero.
- Amendment (14/06/2019): This report has been amended and re-released to allow the reporting of additional analytical data.
- Amendment (5/12/2019): This report has been amended following the removal of data from reports as per request by Erica Colley on the 5/12/2019.
- EG093: Samples containing high levels of sulfate may precipitate barium under the acidic conditions of this method and may therefore bias results low.



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	WQ 19	----	----	----	----
Client sampling date / time				17-Apr-2019 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1910671-001	-----	-----	-----	-----
Result				----	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	----	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS								
Antimony	7440-36-0	0.2	µg/L	<0.2	----	----	----	----
Arsenic	7440-38-2	0.2	µg/L	<0.2	----	----	----	----
Barium	7440-39-3	0.5	µg/L	0.9	----	----	----	----
Beryllium	7440-41-7	0.1	µg/L	<0.1	----	----	----	----
Boron	7440-42-8	5	µg/L	<5	----	----	----	----
Cadmium	7440-43-9	0.05	µg/L	<0.05	----	----	----	----
Chromium	7440-47-3	0.2	µg/L	<0.2	----	----	----	----
Cobalt	7440-48-4	0.1	µg/L	<0.1	----	----	----	----
Copper	7440-50-8	0.5	µg/L	<0.5	----	----	----	----
Iron	7439-89-6	2	µg/L	<2	----	----	----	----
Lead	7439-92-1	0.1	µg/L	<0.1	----	----	----	----
Manganese	7439-96-5	0.5	µg/L	0.6	----	----	----	----
Molybdenum	7439-98-7	0.1	µg/L	<0.1	----	----	----	----
Nickel	7440-02-0	0.5	µg/L	<0.5	----	----	----	----
Selenium	7782-49-2	0.2	µg/L	<0.2	----	----	----	----
Silver	7440-22-4	0.1	µg/L	<0.1	----	----	----	----
Tin	7440-31-5	0.2	µg/L	<0.2	----	----	----	----
Vanadium	7440-62-2	0.2	µg/L	<0.2	----	----	----	----
Zinc	7440-66-6	1	µg/L	9	----	----	----	----
EG094T: Total metals in Fresh water by ORC-ICPMS								
Aluminium	7429-90-5	5	µg/L	<5	----	----	----	----
Antimony	7440-36-0	0.2	µg/L	<0.2	----	----	----	----
Arsenic	7440-38-2	0.2	µg/L	<0.2	----	----	----	----
Barium	7440-39-3	0.5	µg/L	0.8	----	----	----	----
Beryllium	7440-41-7	0.1	µg/L	<0.1	----	----	----	----
Boron	7440-42-8	5	µg/L	<5	----	----	----	----
Cadmium	7440-43-9	0.05	µg/L	<0.05	----	----	----	----
Chromium	7440-47-3	0.2	µg/L	<0.2	----	----	----	----



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				WQ 19	----	----	----	----
Client sampling date / time				17-Apr-2019 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1910671-001	-----	-----	-----	-----
				Result	----	----	----	----
EG094T: Total metals in Fresh water by ORC-ICPMS - Continued								
Cobalt	7440-48-4	0.1	µg/L	<0.1	----	----	----	----
Copper	7440-50-8	0.5	µg/L	<0.5	----	----	----	----
Lead	7439-92-1	0.1	µg/L	<0.1	----	----	----	----
Manganese	7439-96-5	0.5	µg/L	0.6	----	----	----	----
Molybdenum	7439-98-7	0.1	µg/L	<0.1	----	----	----	----
Selenium	7782-49-2	0.2	µg/L	<0.2	----	----	----	----
Nickel	7440-02-0	0.5	µg/L	<0.5	----	----	----	----
Silver	7440-22-4	0.1	µg/L	<0.1	----	----	----	----
Tin	7440-31-5	0.2	µg/L	<0.2	----	----	----	----
Vanadium	7440-62-2	0.2	µg/L	<0.2	----	----	----	----
Zinc	7440-66-6	1	µg/L	7	----	----	----	----
EK026SF: Total CN by Segmented Flow Analyser								
Total Cyanide	57-12-5	0.004	mg/L	<0.004	----	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	<0.1	----	----	----	----

CERTIFICATE OF ANALYSIS

Work Order : **EB1912881**
Client : **COFFEY ENVIRONMENTS PTY LTD**
Contact : **ERICA COLLEY**
Address : **LEVEL WORKPLES BUILDING SAVANNAH HEIGHTS SECTION**
 531, LOT 12 WAIGANI DRIVE
 HOHOLA, NCD PNG
Telephone : **64277004057**
Project : **754-MELEN224697 JDD PROJECT**
Order number : **BN/065/19**
C-O-C number : **----**
Sampler : **ERICA COLLEY**
Site : **----**
Quote number : **BN/065/19 V2**
No. of samples received : **9**
No. of samples analysed : **6**

Page : 1 of 5
Laboratory : Environmental Division Brisbane
Contact : Andrew Epps
Address : 2 Byth Street Stafford QLD Australia 4053

Telephone : +61 7 3552 8639
Date Samples Received : 21-May-2019 09:11
Date Analysis Commenced : 04-Jun-2019
Issue Date : 07-Jun-2019 11:24



Accreditation No. 825
 Accredited for compliance with
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- Analytical Results

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Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

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Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

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Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EG005-SDH (1M HCL Extractable Metals): Sample EB1912881-005 (SED 23) shows poor matrix spike recovery due to sample heterogeneity. Confirmed by re-extraction and re-analysis.
- EG035-SDH (1M HCl Extractable Mercury) Sample EB19128801-005 shows poor matrix spike recovery due to sample matrix interference. Confirmed by re-extraction and re-analysis.



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				SED 14 <2mm Fraction	SED 23 <2mm Fraction	SED 15 <2mm Fraction	SED 14 <63µm Fraction	SED 23 <63µm Fraction
Client sampling date / time				06-Apr-2019 00:00	06-Apr-2019 00:00	08-Apr-2019 00:00	06-Apr-2019 00:00	06-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1912881-004	EB1912881-005	EB1912881-006	EB1912881-007	EB1912881-008
				Result	Result	Result	Result	Result
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES								
Aluminium	7429-90-5	50	mg/kg	2550	2610	100	4230	4380
Antimony	7440-36-0	1.0	mg/kg	<1.0	<1.0	<1.0	<1.0	<1.0
Arsenic	7440-38-2	1.0	mg/kg	<1.0	1.7	<1.0	<1.0	<1.0
Barium	7440-39-3	1.0	mg/kg	5.9	5.5	6.7	11.6	13.2
Beryllium	7440-41-7	1.0	mg/kg	<1.0	<1.0	<1.0	<1.0	<1.0
Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	<0.1	0.1	0.1
Cobalt	7440-48-4	0.5	mg/kg	3.8	3.9	<0.5	5.6	5.5
Chromium	7440-47-3	1.0	mg/kg	7.2	6.8	2.7	11.0	11.0
Copper	7440-50-8	1.0	mg/kg	10.0	9.6	<1.0	12.4	12.4
Iron	7439-89-6	50	mg/kg	8350	8760	120	11700	11700
Lead	7439-92-1	1.0	mg/kg	8.4	8.2	1.1	10.2	10.1
Manganese	7439-96-5	10	mg/kg	250	256	42	287	279
Nickel	7440-02-0	1.0	mg/kg	4.0	4.0	<1.0	5.6	5.8
Vanadium	7440-62-2	2.0	mg/kg	11.8	12.6	<2.0	16.8	16.4
Zinc	7440-66-6	1.0	mg/kg	9.9	9.9	<1.0	15.3	15.3
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
EG005(ED093)T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	10	9	10	8	8
Barium	7440-39-3	10	mg/kg	20	20	<10	30	30
Beryllium	7440-41-7	1	mg/kg	<1	<1	<1	<1	<1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	29	30	4	36	37
Cobalt	7440-48-4	2	mg/kg	10	9	<2	12	12
Copper	7440-50-8	5	mg/kg	25	28	<5	29	30
Iron	7439-89-6	50	mg/kg	30400	34800	300	37500	38100
Lead	7439-92-1	5	mg/kg	13	12	<5	14	14
Manganese	7439-96-5	5	mg/kg	446	449	49	496	501
Nickel	7440-02-0	2	mg/kg	17	19	<2	23	22
Selenium	7782-49-2	5	mg/kg	<5	<5	5	<5	<5
Silver	7440-22-4	2	mg/kg	<2	<2	<2	<2	<2
Tin	7440-31-5	5	mg/kg	<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg	35	39	<5	44	44
Zinc	7440-66-6	5	mg/kg	52	46	14	62	63



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				SED 14 <2mm Fraction	SED 23 <2mm Fraction	SED 15 <2mm Fraction	SED 14 <63µm Fraction	SED 23 <63µm Fraction
Client sampling date / time				06-Apr-2019 00:00	06-Apr-2019 00:00	08-Apr-2019 00:00	06-Apr-2019 00:00	06-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	EB1912881-004	EB1912881-005	EB1912881-006	EB1912881-007	EB1912881-008
				Result	Result	Result	Result	Result
EG035-SDH: 1M HCl extractable Mercury by FIMS								
Mercury	7439-97-6	0.10	mg/kg	<0.10	<0.10	<0.10	<0.10	<0.10
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
GEO26: Sieving								
-2000µm	----	0.01	%	96.7	97.0	80.4	----	----
-63µm	----	0.01	%	----	----	----	75.2	74.7



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				SED 15 <63µm Fraction	----	----	----	----
Client sampling date / time				08-Apr-2019 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1912881-009	-----	-----	-----	-----
Result				----	----	----	----	----
EG005(ED093)T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	10	----	----	----	----
Barium	7440-39-3	10	mg/kg	30	----	----	----	----
Beryllium	7440-41-7	1	mg/kg	<1	----	----	----	----
Boron	7440-42-8	50	mg/kg	<50	----	----	----	----
Cadmium	7440-43-9	1	mg/kg	<1	----	----	----	----
Chromium	7440-47-3	2	mg/kg	12	----	----	----	----
Cobalt	7440-48-4	2	mg/kg	<2	----	----	----	----
Copper	7440-50-8	5	mg/kg	28	----	----	----	----
Iron	7439-89-6	50	mg/kg	2640	----	----	----	----
Lead	7439-92-1	5	mg/kg	13	----	----	----	----
Manganese	7439-96-5	5	mg/kg	101	----	----	----	----
Nickel	7440-02-0	2	mg/kg	6	----	----	----	----
Selenium	7782-49-2	5	mg/kg	<5	----	----	----	----
Silver	7440-22-4	2	mg/kg	<2	----	----	----	----
Tin	7440-31-5	5	mg/kg	<5	----	----	----	----
Vanadium	7440-62-2	5	mg/kg	<5	----	----	----	----
Zinc	7440-66-6	5	mg/kg	34	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	----	----	----	----
GEO26: Sieving								
-63µm	----	0.01	%	3.22	----	----	----	----

CERTIFICATE OF ANALYSIS

Work Order : **EB1922738**
Client : **COFFEY ENVIRONMENTS PTY LTD**
Contact : **ERICA COLLEY**
Address : **Level 5 12 Creek St**
Brisbane QLD, AUSTRALIA 4000
Telephone : **64277004057**
Project : **JDD PROJECT**
Order number :
C-O-C number : **----**
Sampler : **ERICA COLLEY**
Site :
Quote number : **EN/222**
No. of samples received : **14**
No. of samples analysed : **14**

Page : 1 of 9
Laboratory : **Environmental Division Brisbane**
Contact : **Andrew Epps**
Address : **2 Byth Street Stafford QLD Australia 4053**
Telephone : **+61 7 3552 8639**
Date Samples Received : **29-Aug-2019 19:25**
Date Analysis Commenced : **30-Aug-2019**
Issue Date : **06-Sep-2019 08:37**



Accreditation No. 825
 Accredited for compliance with
 ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

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Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Sarah Ashworth	Laboratory Manager - Brisbane	Brisbane Organics, Stafford, QLD



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Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EK061G (Total Kjeldahl Nitrogen as N) / EK067G (Total Phosphorus as P): Some samples were diluted due to matrix interference. LOR adjusted accordingly.
- EP026SP(COD) Particular samples required dilution prior to analysis due to matrix interferences. LOR values have been adjusted accordingly.



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	WQ-01	WQ-02	WQ-03	WQ-4	TSS27
Client sampling date / time					28-Aug-2019 00:00	28-Aug-2019 00:00	28-Aug-2019 00:00	28-Aug-2019 00:00	28-Aug-2019 00:00
Compound	CAS Number	LOR	Unit		EB1922738-001	EB1922738-002	EB1922738-003	EB1922738-004	EB1922738-005
					Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L		<5	----	----	----	<5
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		0.01	0.02	0.01	0.01	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		<1.0	<1.0	<1.0	<1.0	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		<1.0	<1.0	<1.0	<1.0	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		<0.10	<0.10	<0.10	<0.10	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
EK085M: Sulfide as S2-									
Sulfide as S2-	18496-25-8	0.1	mg/L		<0.1	<0.1	<0.1	----	----
EP020: Oil and Grease (O&G)									
Oil & Grease	----	5	mg/L		<5	<5	<5	<5	----
EP026SP: Chemical Oxygen Demand (Spectrophotometric)									
Chemical Oxygen Demand	----	10	mg/L		----	----	430	<400	----
EP030: Biochemical Oxygen Demand (BOD)									
Biochemical Oxygen Demand	----	2	mg/L		<2	<2	<2	<2	----
EP080/071: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	----	20	µg/L		<20	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions									
C6 - C10 Fraction	C6_C10	20	µg/L		<20	----	----	----	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L		<20	----	----	----	----
EP080: BTEXN									
Benzene	71-43-2	1	µg/L		<1	----	----	----	----



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				WQ-01	WQ-02	WQ-03	WQ-4	TSS27
Client sampling date / time				28-Aug-2019 00:00	28-Aug-2019 00:00	28-Aug-2019 00:00	28-Aug-2019 00:00	28-Aug-2019 00:00
Compound	CAS Number	LOR	Unit	EB1922738-001	EB1922738-002	EB1922738-003	EB1922738-004	EB1922738-005
				Result	Result	Result	Result	Result
EP080: BTEXN - Continued								
Toluene	108-88-3	2	µg/L	<2	----	----	----	----
Ethylbenzene	100-41-4	2	µg/L	<2	----	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	----	----	----	----
ortho-Xylene	95-47-6	2	µg/L	<2	----	----	----	----
^ Total Xylenes	----	2	µg/L	<2	----	----	----	----
^ Sum of BTEX	----	1	µg/L	<1	----	----	----	----
Naphthalene	91-20-3	5	µg/L	<5	----	----	----	----
EP080S: TPH(V)/BTEX Surrogates								
1,2-Dichloroethane-D4	17060-07-0	2	%	101	----	----	----	----
Toluene-D8	2037-26-5	2	%	98.7	----	----	----	----
4-Bromofluorobenzene	460-00-4	2	%	107	----	----	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	TSS27 DEEP	WQ-12	WQ-11	WQ-10	WQ-13
Client sampling date / time					28-Aug-2019 00:00	28-Aug-2019 00:00	28-Aug-2019 00:00	28-Aug-2019 00:00	28-Aug-2019 00:00
Compound	CAS Number	LOR	Unit		EB1922738-006	EB1922738-007	EB1922738-008	EB1922738-009	EB1922738-010
					Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L		<5	<5	<5	----	<5
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		----	<0.01	0.03	0.02	0.02
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		----	<0.01	<0.01	<0.01	<0.01
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		----	<0.01	<0.01	<0.01	<0.01
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		----	<0.01	<0.01	<0.01	<0.01
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		----	<1.0	<1.0	<1.0	<1.0
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		----	<1.0	<1.0	<1.0	<1.0
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		----	<0.10	<0.10	<0.10	<0.10
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		----	<0.01	<0.01	<0.01	<0.01
EK085M: Sulfide as S2-									
Sulfide as S2-	18496-25-8	0.1	mg/L		----	<0.1	----	----	<0.1
EP020: Oil and Grease (O&G)									
Oil & Grease	----	5	mg/L		----	<5	<5	<5	<5
EP026SP: Chemical Oxygen Demand (Spectrophotometric)									
Chemical Oxygen Demand	----	10	mg/L		----	----	550	<400	<400
EP030: Biochemical Oxygen Demand (BOD)									
Biochemical Oxygen Demand	----	2	mg/L		----	<2	<2	<2	<2
EP080/071: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	----	20	µg/L		----	<20	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions									
C6 - C10 Fraction	C6_C10	20	µg/L		----	<20	----	----	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L		----	<20	----	----	----
EP080: BTEXN									
Benzene	71-43-2	1	µg/L		----	<1	----	----	----



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				TSS27 DEEP	WQ-12	WQ-11	WQ-10	WQ-13
Client sampling date / time				28-Aug-2019 00:00	28-Aug-2019 00:00	28-Aug-2019 00:00	28-Aug-2019 00:00	28-Aug-2019 00:00
Compound	CAS Number	LOR	Unit	EB1922738-006	EB1922738-007	EB1922738-008	EB1922738-009	EB1922738-010
				Result	Result	Result	Result	Result
EP080: BTEXN - Continued								
Toluene	108-88-3	2	µg/L	----	<2	----	----	----
Ethylbenzene	100-41-4	2	µg/L	----	<2	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	----	<2	----	----	----
ortho-Xylene	95-47-6	2	µg/L	----	<2	----	----	----
^ Total Xylenes	----	2	µg/L	----	<2	----	----	----
^ Sum of BTEX	----	1	µg/L	----	<1	----	----	----
Naphthalene	91-20-3	5	µg/L	----	<5	----	----	----
EP080S: TPH(V)/BTEX Surrogates								
1,2-Dichloroethane-D4	17060-07-0	2	%	----	98.1	----	----	----
Toluene-D8	2037-26-5	2	%	----	96.9	----	----	----
4-Bromofluorobenzene	460-00-4	2	%	----	104	----	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	WQ-15	WQ-16	WQ-24	WQ-25	----
Client sampling date / time					28-Aug-2019 00:00	28-Aug-2019 00:00	28-Aug-2019 00:00	28-Aug-2019 00:00	----
Compound	CAS Number	LOR	Unit		EB1922738-011	EB1922738-012	EB1922738-013	EB1922738-014	-----
				Result	Result	Result	Result	Result	----
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L		----	----	<5	<5	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		0.03	0.03	<0.01	<0.01	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		<1.0	<1.0	<0.1	<0.1	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		<1.0	<1.0	<0.1	<0.1	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		<0.10	<0.10	<0.01	<0.01	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
EK085M: Sulfide as S2-									
Sulfide as S2-	18496-25-8	0.1	mg/L		----	----	<0.1	<0.1	----
EP020: Oil and Grease (O&G)									
Oil & Grease	----	5	mg/L		<5	<5	<5	----	----
EP026SP: Chemical Oxygen Demand (Spectrophotometric)									
Chemical Oxygen Demand	----	10	mg/L		<400	<400	<10	<10	----
EP030: Biochemical Oxygen Demand (BOD)									
Biochemical Oxygen Demand	----	2	mg/L		<2	<2	<2	<2	----
EP080/071: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	----	20	µg/L		----	----	<20	<20	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions									
C6 - C10 Fraction	C6_C10	20	µg/L		----	----	<20	<20	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L		----	----	<20	<20	----
EP080: BTEXN									
Benzene	71-43-2	1	µg/L		----	----	<1	<1	----



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				WQ-15	WQ-16	WQ-24	WQ-25	----
Client sampling date / time				28-Aug-2019 00:00	28-Aug-2019 00:00	28-Aug-2019 00:00	28-Aug-2019 00:00	----
Compound	CAS Number	LOR	Unit	EB1922738-011	EB1922738-012	EB1922738-013	EB1922738-014	-----
				Result	Result	Result	Result	----
EP080: BTEXN - Continued								
Toluene	108-88-3	2	µg/L	----	----	<2	<2	----
Ethylbenzene	100-41-4	2	µg/L	----	----	<2	<2	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	----	----	<2	<2	----
ortho-Xylene	95-47-6	2	µg/L	----	----	<2	<2	----
^ Total Xylenes	----	2	µg/L	----	----	<2	<2	----
^ Sum of BTEX	----	1	µg/L	----	----	<1	<1	----
Naphthalene	91-20-3	5	µg/L	----	----	<5	<5	----
EP080S: TPH(V)/BTEX Surrogates								
1,2-Dichloroethane-D4	17060-07-0	2	%	----	----	97.1	99.4	----
Toluene-D8	2037-26-5	2	%	----	----	98.0	96.6	----
4-Bromofluorobenzene	460-00-4	2	%	----	----	109	104	----



Surrogate Control Limits

Sub-Matrix: WATER		Recovery Limits (%)	
Compound	CAS Number	Low	High
EP080S: TPH(V)/BTEX Surrogates			
1,2-Dichloroethane-D4	17060-07-0	66	138
Toluene-D8	2037-26-5	79	120
4-Bromofluorobenzene	460-00-4	74	118

CERTIFICATE OF ANALYSIS

Work Order	: EB1922738	Page	: 1 of 9
Amendment	: 1		
Client	: COFFEY ENVIRONMENTS PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: ERICA COLLEY	Contact	: Andrew Epps
Address	: Level 5 12 Creek St Brisbane QLD, AUSTRALIA 4000	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: 64277004057	Telephone	: +61 7 3552 8639
Project	: JDD PROJECT	Date Samples Received	: 29-Aug-2019 19:25
Order number	:	Date Analysis Commenced	: 30-Aug-2019
C-O-C number	: ----	Issue Date	: 11-Sep-2019 15:22
Sampler	: ERICA COLLEY		
Site	:		
Quote number	: EN/222		
No. of samples received	: 14		
No. of samples analysed	: 14		



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<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Sarah Ashworth	Laboratory Manager - Brisbane	Brisbane Organics, Stafford, QLD



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ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

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Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	WQ-01	WQ-02	WQ-03	WQ-4	TSS27
Client sampling date / time					28-Aug-2019 00:00	28-Aug-2019 00:00	28-Aug-2019 00:00	28-Aug-2019 00:00	28-Aug-2019 00:00
Compound	CAS Number	LOR	Unit		EB1922738-001	EB1922738-002	EB1922738-003	EB1922738-004	EB1922738-005
					Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L		<5	----	----	----	<5
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		0.01	0.02	0.01	0.01	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		<1.0	<1.0	<1.0	<1.0	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		<1.0	<1.0	<1.0	<1.0	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		<0.10	<0.10	<0.10	<0.10	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
EK085M: Sulfide as S2-									
Sulfide as S2-	18496-25-8	0.1	mg/L		<0.1	<0.1	<0.1	----	----
EP020: Oil and Grease (O&G)									
Oil & Grease	----	5	mg/L		<5	<5	<5	<5	----
EP026SP: Chemical Oxygen Demand (Spectrophotometric)									
Chemical Oxygen Demand	----	10	mg/L		----	----	430	<400	----
EP030: Biochemical Oxygen Demand (BOD)									
Biochemical Oxygen Demand	----	2	mg/L		<2	<2	<2	<2	----
EP080/071: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	----	20	µg/L		<20	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions									
C6 - C10 Fraction	C6_C10	20	µg/L		<20	----	----	----	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L		<20	----	----	----	----
EP080: BTEXN									
Benzene	71-43-2	1	µg/L		<1	----	----	----	----



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				WQ-01	WQ-02	WQ-03	WQ-4	TSS27
Client sampling date / time				28-Aug-2019 00:00	28-Aug-2019 00:00	28-Aug-2019 00:00	28-Aug-2019 00:00	28-Aug-2019 00:00
Compound	CAS Number	LOR	Unit	EB1922738-001	EB1922738-002	EB1922738-003	EB1922738-004	EB1922738-005
				Result	Result	Result	Result	Result
EP080: BTEXN - Continued								
Toluene	108-88-3	2	µg/L	<2	----	----	----	----
Ethylbenzene	100-41-4	2	µg/L	<2	----	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	----	----	----	----
ortho-Xylene	95-47-6	2	µg/L	<2	----	----	----	----
^ Total Xylenes	----	2	µg/L	<2	----	----	----	----
^ Sum of BTEX	----	1	µg/L	<1	----	----	----	----
Naphthalene	91-20-3	5	µg/L	<5	----	----	----	----
EP080S: TPH(V)/BTEX Surrogates								
1,2-Dichloroethane-D4	17060-07-0	2	%	101	----	----	----	----
Toluene-D8	2037-26-5	2	%	98.7	----	----	----	----
4-Bromofluorobenzene	460-00-4	2	%	107	----	----	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	TSS27 DEEP	WQ-12	WQ-11	WQ-10	WQ-13
Client sampling date / time					28-Aug-2019 00:00	28-Aug-2019 00:00	28-Aug-2019 00:00	28-Aug-2019 00:00	28-Aug-2019 00:00
Compound	CAS Number	LOR	Unit		EB1922738-006	EB1922738-007	EB1922738-008	EB1922738-009	EB1922738-010
					Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L		<5	<5	<5	----	<5
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		----	<0.01	0.03	0.02	0.02
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		----	<0.01	<0.01	<0.01	<0.01
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		----	<0.01	<0.01	<0.01	<0.01
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		----	<0.01	<0.01	<0.01	<0.01
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		----	<1.0	<1.0	<1.0	<1.0
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		----	<1.0	<1.0	<1.0	<1.0
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		----	<0.10	<0.10	<0.10	<0.10
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		----	<0.01	<0.01	<0.01	<0.01
EK085M: Sulfide as S2-									
Sulfide as S2-	18496-25-8	0.1	mg/L		----	<0.1	----	----	<0.1
EP020: Oil and Grease (O&G)									
Oil & Grease	----	5	mg/L		----	<5	<5	<5	<5
EP026SP: Chemical Oxygen Demand (Spectrophotometric)									
Chemical Oxygen Demand	----	10	mg/L		----	----	550	<400	<400
EP030: Biochemical Oxygen Demand (BOD)									
Biochemical Oxygen Demand	----	2	mg/L		----	<2	<2	<2	<2
EP080/071: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	----	20	µg/L		----	<20	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions									
C6 - C10 Fraction	C6_C10	20	µg/L		----	<20	----	----	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L		----	<20	----	----	----
EP080: BTEXN									
Benzene	71-43-2	1	µg/L		----	<1	----	----	----



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				TSS27 DEEP	WQ-12	WQ-11	WQ-10	WQ-13
Client sampling date / time				28-Aug-2019 00:00	28-Aug-2019 00:00	28-Aug-2019 00:00	28-Aug-2019 00:00	28-Aug-2019 00:00
Compound	CAS Number	LOR	Unit	EB1922738-006	EB1922738-007	EB1922738-008	EB1922738-009	EB1922738-010
				Result	Result	Result	Result	Result
EP080: BTEXN - Continued								
Toluene	108-88-3	2	µg/L	----	<2	----	----	----
Ethylbenzene	100-41-4	2	µg/L	----	<2	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	----	<2	----	----	----
ortho-Xylene	95-47-6	2	µg/L	----	<2	----	----	----
^ Total Xylenes	----	2	µg/L	----	<2	----	----	----
^ Sum of BTEX	----	1	µg/L	----	<1	----	----	----
Naphthalene	91-20-3	5	µg/L	----	<5	----	----	----
EP080S: TPH(V)/BTEX Surrogates								
1,2-Dichloroethane-D4	17060-07-0	2	%	----	98.1	----	----	----
Toluene-D8	2037-26-5	2	%	----	96.9	----	----	----
4-Bromofluorobenzene	460-00-4	2	%	----	104	----	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	WQ-15	WQ-16	WQ-24	WQ-25	----
Client sampling date / time					28-Aug-2019 00:00	28-Aug-2019 00:00	28-Aug-2019 00:00	28-Aug-2019 00:00	----
Compound	CAS Number	LOR	Unit		EB1922738-011	EB1922738-012	EB1922738-013	EB1922738-014	-----
					Result	Result	Result	Result	----
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L		----	----	<5	<5	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		0.03	0.03	<0.01	<0.01	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		<1.0	<1.0	<0.1	<0.1	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		<1.0	<1.0	<0.1	<0.1	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		<0.10	<0.10	<0.01	<0.01	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
EK085M: Sulfide as S2-									
Sulfide as S2-	18496-25-8	0.1	mg/L		----	----	<0.1	<0.1	----
EP020: Oil and Grease (O&G)									
Oil & Grease	----	5	mg/L		<5	<5	<5	----	----
EP026SP: Chemical Oxygen Demand (Spectrophotometric)									
Chemical Oxygen Demand	----	10	mg/L		<400	<400	<10	<10	----
EP030: Biochemical Oxygen Demand (BOD)									
Biochemical Oxygen Demand	----	2	mg/L		<2	<2	<2	<2	----
EP080/071: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	----	20	µg/L		----	----	<20	<20	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions									
C6 - C10 Fraction	C6_C10	20	µg/L		----	----	<20	<20	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L		----	----	<20	<20	----
EP080: BTEXN									
Benzene	71-43-2	1	µg/L		----	----	<1	<1	----



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				WQ-15	WQ-16	WQ-24	WQ-25	----
Client sampling date / time				28-Aug-2019 00:00	28-Aug-2019 00:00	28-Aug-2019 00:00	28-Aug-2019 00:00	----
Compound	CAS Number	LOR	Unit	EB1922738-011	EB1922738-012	EB1922738-013	EB1922738-014	-----
				Result	Result	Result	Result	----
EP080: BTEXN - Continued								
Toluene	108-88-3	2	µg/L	----	----	<2	<2	----
Ethylbenzene	100-41-4	2	µg/L	----	----	<2	<2	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	----	----	<2	<2	----
ortho-Xylene	95-47-6	2	µg/L	----	----	<2	<2	----
^ Total Xylenes	----	2	µg/L	----	----	<2	<2	----
^ Sum of BTEX	----	1	µg/L	----	----	<1	<1	----
Naphthalene	91-20-3	5	µg/L	----	----	<5	<5	----
EP080S: TPH(V)/BTEX Surrogates								
1,2-Dichloroethane-D4	17060-07-0	2	%	----	----	97.1	99.4	----
Toluene-D8	2037-26-5	2	%	----	----	98.0	96.6	----
4-Bromofluorobenzene	460-00-4	2	%	----	----	109	104	----



Surrogate Control Limits

Sub-Matrix: WATER		Recovery Limits (%)	
Compound	CAS Number	Low	High
EP080S: TPH(V)/BTEX Surrogates			
1,2-Dichloroethane-D4	17060-07-0	66	138
Toluene-D8	2037-26-5	79	120
4-Bromofluorobenzene	460-00-4	74	118

CERTIFICATE OF ANALYSIS

Work Order : **EB1922795**
Client : **COFFEY ENVIRONMENTS PTY LTD**
Contact : **MS ERICA COLLEY**
Address : **Level 5 12 Creek St**
Brisbane QLD, AUSTRALIA 4000
Telephone : **+61 07 3608 2500**
Project : **754-MCLCN221697/JDD PROJECT**
Order number :
C-O-C number :
Sampler :
Site :
Quote number : **EN/222**
No. of samples received : **8**
No. of samples analysed : **8**

Page : 1 of 4
Laboratory : Environmental Division Brisbane
Contact : Andrew Epps
Address : 2 Byth Street Stafford QLD Australia 4053
Telephone : +61 7 3552 8639
Date Samples Received : 29-Aug-2019 19:25
Date Analysis Commenced : 30-Aug-2019
Issue Date : 13-Sep-2019 12:04



Accreditation No. 825
 Accredited for compliance with
 ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Franco Lentini	LCMS Coordinator	Sydney Organics, Smithfield, NSW
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- EP262: Poor matrix spike recovery for particular compounds due to matrix interferences.
- EK061G (Total Kjeldahl Nitrogen as N) / EK067G (Total Phosphorus as P): Some samples were diluted due to matrix interference. LOR adjusted accordingly.
- EP026SP(COD) Particular samples required dilution prior to analysis due to matrix interferences. LOR values have been adjusted accordingly.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	WQ-06	WQ-07	WQ-08	WQ-14	WQ-26
Client sampling date / time					29-Aug-2019 00:00	29-Aug-2019 00:00	29-Aug-2019 00:00	29-Aug-2019 00:00	29-Aug-2019 00:00
Compound	CAS Number	LOR	Unit		EB1922795-001	EB1922795-002	EB1922795-003	EB1922795-004	EB1922795-005
					Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L		<5	----	----	<5	<5
ED093F: Dissolved Major Cations									
Potassium	7440-09-7	1	mg/L		395	400	409	396	410
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		<1.0	<1.0	<1.0	<1.0	<1.0
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		<1.0	<1.0	<1.0	<1.0	<1.0
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		<0.10	<0.10	<0.10	<0.10	<0.10
EK085M: Sulfide as S2-									
Sulfide as S2-	18496-25-8	0.1	mg/L		<0.1	<0.1	----	----	<0.1
EP020: Oil and Grease (O&G)									
Oil & Grease	----	5	mg/L		<5	<5	<5	<5	<5
EP026SP: Chemical Oxygen Demand (Spectrophotometric)									
Chemical Oxygen Demand	----	10	mg/L		<400	<400	420	620	580
EP030: Biochemical Oxygen Demand (BOD)									
Biochemical Oxygen Demand	----	2	mg/L		<2	<2	<2	<2	<2
EP262: Ethanolamines									
Ethanolamine	141-43-5	1	µg/L		<1	<1	<1	<1	<1
Diethanolamine	111-42-2	1	µg/L		<1	<1	<1	<1	<1
Methyl diethanolamine (MDEA)	105-59-9	1	µg/L		<1	<1	<1	<1	<1



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	WQ-27	WQ-28	WQ-05	----	----
Client sampling date / time					29-Aug-2019 00:00	29-Aug-2019 00:00	29-Aug-2019 00:00	----	----
Compound	CAS Number	LOR	Unit		EB1922795-006	EB1922795-007	EB1922795-008	-----	-----
					Result	Result	Result	----	----
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L		<5	<5	----	----	----
ED093F: Dissolved Major Cations									
Potassium	7440-09-7	1	mg/L		<1	<1	423	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		<0.01	<0.01	<0.01	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		<0.1	<0.1	<1.0	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		<0.1	<0.1	<1.0	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		<0.01	0.01	<0.10	----	----
EK085M: Sulfide as S2-									
Sulfide as S2-	18496-25-8	0.1	mg/L		<0.1	<0.1	----	----	----
EP020: Oil and Grease (O&G)									
Oil & Grease	----	5	mg/L		<5	----	<5	----	----
EP026SP: Chemical Oxygen Demand (Spectrophotometric)									
Chemical Oxygen Demand	----	10	mg/L		<10	<10	480	----	----
EP030: Biochemical Oxygen Demand (BOD)									
Biochemical Oxygen Demand	----	2	mg/L		<2	<2	<2	----	----
EP262: Ethanolamines									
Ethanolamine	141-43-5	1	µg/L		<1	<1	<1	----	----
Diethanolamine	111-42-2	1	µg/L		<1	<1	<1	----	----
Methyl diethanolamine (MDEA)	105-59-9	1	µg/L		<1	<1	<1	----	----

Certificate of Analysis

Work Order:	EB1922795	Laboratory:	ALS Environmental - Sydney
Client:	COFFEY ENVIRONMENTS PTY LTD	Date Received:	5/09/2019
Contact:	ERICA COLLEY	Date Analysed:	9/09/2019
Address:	Level 5, 12 Creek St	Date Issued:	10/09/2019
	Brisbane, Australia	Sample Type:	Water
		No. of Samples	8

Comments

1) ALS is not NATA accredited for the analysis of Piperazine in water.

Notes

This is the final report and supersedes any preliminary reports with this batch number. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

Issuing Laboratory: ALS Environmental - Sydney

Address:	277 Woodpark Rd	Telephone:	(02) 8784 8555
	Smithfield	Facsimile:	(02) 8784 8500
	NSW 2164	Email:	edwandy.fadjar@alsglobal.com
Name and title:	Edwandy Fadjar	Signature:	
	Organic Co-ordinator		

Analysis Report

Work Order: EB1922795
 Client: COFFEY ENVIRONMNETS PTY LTD
 Date Received: 5/09/2019
 Date Analysed: 9/09/2019
 Date Issued: 10/09/2019
 No. of samples: 8

		ALS Reference:			EB1922795-001	EB1922795-002	EB1922795-003	
		Sample ID:			WQ-06	WQ-07	WQ-08	
		Sample Type:			Water	Water	Water	
Method Code	Analyte Name	Match Quality (%)	LOR	Units				
EP262	Piperazine	-	100	µg/L	<100	<100	<100	

Notes

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ALS Environmental - Sydney

277 Wookpark Rd, Smithfield, NSW 2164

Ph: +61 (02) 8784 8555

Fax: +61 (02) 8784 8500

Australian Laboratory Services Pty Ltd

ABN 84 009 936 029

Analysis Report

Work Order: EB1922795
Client: COFFEY ENVIRONMENTS PTY LTD
Date Received: 5/09/2019
Date Analysed: 9/09/2019
Date Issued: 10/09/2019
No. of samples: 8

		ALS Reference:			EB1922795-004	EB1922795-005	EB1922795-006	EB1922795-007	EB1922795-008
		Sample ID:			WQ-14	WQ-26	WQ-27	WQ-28	WQ-05
		Sample Type:			Water	Water	Water	Water	Water
Method Code	Analyte Name	Match Quality (%)	LOR	Units					
EP262	Piperazine	-	100	µg/L	<100	<100	<100	<100	<100

Notes

ALS Environmental - Sydney

277 Wookpark Rd, Smithfield, NSW 2164

Ph: +61 (02) 8784 8555

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Australian Laboratory Services Pty Ltd

ABN 84 009 936 029

Analysis Report

Work Order: EB1922795
Client: COFFEY ENVIRONMENT PTY LTD
Date Received: 5/09/2019
Date Analysed: 9/09/2019
Date Issued: 10/09/2019
No. of samples: 8

		ALS Reference:			EB1922795	EB1922795			
		Sample ID:			Method Blank	Lab Control spike			
		Sample Type:			Water	Water			
Method Code	Analyte Name	Match Quality (%)	LOR	Units					
EP262	Piperazine	-	100	µg/L	<100	92%			

Notes

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ALS Environmental - Sydney

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Australian Laboratory Services Pty Ltd

ABN 84 009 936 029

CERTIFICATE OF ANALYSIS

Work Order : **EB1923115**
Client : **COFFEY ENVIRONMENTS PTY LTD**
Contact : MS ERICA COLLEY
Address : Level 5 12 Creek St
 Brisbane QLD, AUSTRALIA 4000
Telephone : +61 07 3608 2500
Project : JDD PROJECT
Order number :
C-O-C number : ----
Sampler : ERICA COLLEY
Site :
Quote number : EN/222
No. of samples received : 31
No. of samples analysed : 30

Page : 1 of 16
Laboratory : Environmental Division Brisbane
Contact : Andrew Epps
Address : 2 Byth Street Stafford QLD Australia 4053

Telephone : +61 7 3552 8639
Date Samples Received : 03-Sep-2019 11:40
Date Analysis Commenced : 04-Sep-2019
Issue Date : 01-Oct-2019 10:01



Accreditation No. 825
 Accredited for compliance with
 ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane External Subcontracting, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Minh Wills	2IC Organic Chemist	Brisbane Organics, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

Ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- EG005T (Total Metals by ICP-AES): Limit of reporting for some samples have been raised due to matrix interference.
- EG005T (Total Metals by ICP-AES): The limit of reporting for has been raised for some samples due to matrix interference.
- Radiological work undertaken by ALS Laboratory Group (Ceska Lipa) under CAI accreditation No. L1163. Report No. \$\$. NATA and CAI accreditations' are both recognised under ILAC.
- Radiological work undertaken by ALS Laboratory Group (Ceska Lipa) under CAI accreditation No. L1163. Report No. PR1994255 . NATA and CAI accreditations' are both recognised under ILAC.



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	SED3	SED16	SED18	SED19	SED21
Client sampling date / time					25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00
Compound	CAS Number	LOR	Unit		EB1923115-001	EB1923115-002	EB1923115-003	EB1923115-004	EB1923115-005
					Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%		39.3	31.0	35.4	39.2	51.1
EA150: Particle Sizing									
+75µm	----	1	%		----	96	----	79	----
+150µm	----	1	%		----	96	----	47	----
+300µm	----	1	%		----	93	----	8	----
+425µm	----	1	%		----	88	----	4	----
+600µm	----	1	%		----	66	----	3	----
+1180µm	----	1	%		----	19	----	<1	----
+2.36mm	----	1	%		----	6	----	<1	----
+4.75mm	----	1	%		----	1	----	<1	----
+9.5mm	----	1	%		----	<1	----	<1	----
+19.0mm	----	1	%		----	<1	----	<1	----
+37.5mm	----	1	%		----	<1	----	<1	----
+75.0mm	----	1	%		----	<1	----	<1	----
EA150: Soil Classification based on Particle Size									
Clay (<2 µm)	----	1	%		----	1	----	12	----
Silt (2-60 µm)	----	1	%		----	3	----	8	----
Sand (0.06-2.00 mm)	----	1	%		----	86	----	80	----
Gravel (>2mm)	----	1	%		----	10	----	<1	----
Cobbles (>6cm)	----	1	%		----	<1	----	<1	----
EA152: Soil Particle Density									
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3		----	2.50	----	2.59	----
EG005(ED093)T: Total Metals by ICP-AES									
Barium	7440-39-3	10	mg/kg		----	<50	----	<40	----
Boron	7440-42-8	50	mg/kg		----	<50	----	<50	----
Cobalt	7440-48-4	2	mg/kg		----	<5	----	<4	----
Iron	7439-89-6	50	mg/kg		----	5160	----	3580	----
Manganese	7439-96-5	5	mg/kg		----	223	----	156	----
Selenium	7782-49-2	5	mg/kg		----	<5	----	<5	----
Silver	7440-22-4	2	mg/kg		----	<5	----	<4	----
Tin	7440-31-5	5	mg/kg		----	<5	----	<5	----
Vanadium	7440-62-2	5	mg/kg		----	<5	----	<5	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg		----	1.5	----	<0.1	----



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	SED3	SED16	SED18	SED19	SED21
Client sampling date / time					25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00
Compound	CAS Number	LOR	Unit		EB1923115-001	EB1923115-002	EB1923115-003	EB1923115-004	EB1923115-005
					Result	Result	Result	Result	Result
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg		----	400	----	340	----
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg		----	400	----	340	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg		----	333	----	422	----
EP003: Total Organic Carbon (TOC) in Soil									
Total Organic Carbon	----	0.02	%		----	0.18	----	0.38	----
EP003TC: Total Carbon (TC) in Soil									
Total Carbon	TC	0.02	%		----	10.2	----	3.40	----
EP003TIC: Total inorganic Carbon (TIC) in Soil									
Total Inorganic Carbon	----	0.02	%		----	10.0	----	3.02	----
EP066: Polychlorinated Biphenyls (PCB)									
Total Polychlorinated biphenyls	----	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	<0.1
EP068A: Organochlorine Pesticides (OC)									
alpha-BHC	319-84-6	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05
Hexachlorobenzene (HCB)	118-74-1	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05
beta-BHC	319-85-7	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05
gamma-BHC	58-89-9	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05
delta-BHC	319-86-8	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05
Heptachlor	76-44-8	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05
Aldrin	309-00-2	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05
Heptachlor epoxide	1024-57-3	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05
^ Total Chlordane (sum)	----	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05
trans-Chlordane	5103-74-2	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05
alpha-Endosulfan	959-98-8	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05
cis-Chlordane	5103-71-9	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05
Dieldrin	60-57-1	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05
4,4'-DDE	72-55-9	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05
Endrin	72-20-8	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05
beta-Endosulfan	33213-65-9	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05
^ Endosulfan (sum)	115-29-7	0.05	mg/kg		----	----	----	----	<0.05
^ Endosulfan (sum)	115-29-7	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
4,4'-DDD	72-54-8	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05
Endrin aldehyde	7421-93-4	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	SED3	SED16	SED18	SED19	SED21
Client sampling date / time					25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00
Compound	CAS Number	LOR	Unit		EB1923115-001	EB1923115-002	EB1923115-003	EB1923115-004	EB1923115-005
					Result	Result	Result	Result	Result
EP068A: Organochlorine Pesticides (OC) - Continued									
Endosulfan sulfate	1031-07-8	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05
4,4'-DDT	50-29-3	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2
Endrin ketone	53494-70-5	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05
Methoxychlor	72-43-5	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2
^ Sum of Aldrin + Dieldrin	309-00-2/60-57-1	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05
^ Sum of DDD + DDE + DDT	72-54-8/72-55-9/5 0-2	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05
EP080/071: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	----	10	mg/kg		<10	<10	<10	<10	<10
C10 - C14 Fraction	----	50	mg/kg		<50	<50	<50	<50	<50
C15 - C28 Fraction	----	100	mg/kg		<100	<100	<100	<100	<100
C29 - C36 Fraction	----	100	mg/kg		<100	<100	<100	<100	<100
^ C10 - C36 Fraction (sum)	----	50	mg/kg		<50	<50	<50	<50	<50
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions									
C6 - C10 Fraction	C6_C10	10	mg/kg		<10	<10	<10	<10	<10
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	10	mg/kg		<10	<10	<10	<10	<10
>C10 - C16 Fraction	----	50	mg/kg		<50	<50	<50	<50	<50
>C16 - C34 Fraction	----	100	mg/kg		<100	<100	<100	<100	<100
>C34 - C40 Fraction	----	100	mg/kg		<100	<100	<100	<100	<100
^ >C10 - C40 Fraction (sum)	----	50	mg/kg		<50	<50	<50	<50	<50
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	50	mg/kg		<50	<50	<50	<50	<50
EP080: BTEXN									
Benzene	71-43-2	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2
Toluene	108-88-3	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5
Ethylbenzene	100-41-4	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5
meta- & para-Xylene	108-38-3 106-42-3	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5
ortho-Xylene	95-47-6	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5
^ Sum of BTEX	----	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2
^ Total Xylenes	----	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5
Naphthalene	91-20-3	1	mg/kg		<1	<1	<1	<1	<1
EP090: Organotin Compounds									
Tributyltin	56573-85-4	0.5	µgSn/kg		<0.5	----	<0.5	----	<0.5



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	SED3	SED16	SED18	SED19	SED21
Client sampling date / time					25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00
Compound	CAS Number	LOR	Unit		EB1923115-001	EB1923115-002	EB1923115-003	EB1923115-004	EB1923115-005
					Result	Result	Result	Result	Result
Radionuclides / Activity									
Gross alpha	----	500	Bq/kg DW		<500	----	<500	----	<500
Gross beta	----	500	Bq/kg DW		<500	----	<500	----	540
EP066S: PCB Surrogate									
Decachlorobiphenyl	2051-24-3	0.1	%		102	84.4	90.1	98.5	98.9
EP068S: Organochlorine Pesticide Surrogate									
Dibromo-DDE	21655-73-2	0.05	%		112	115	119	123	117
EP068T: Organophosphorus Pesticide Surrogate									
DEF	78-48-8	0.05	%		96.8	90.2	90.3	97.1	93.1
EP080S: TPH(V)/BTEX Surrogates									
1,2-Dichloroethane-D4	17060-07-0	0.2	%		78.7	76.4	80.1	78.0	104
Toluene-D8	2037-26-5	0.2	%		69.6	64.9	68.4	64.7	82.0
4-Bromofluorobenzene	460-00-4	0.2	%		82.4	80.2	80.2	79.0	112
EP090S: Organotin Surrogate									
Tripropyltin	----	0.5	%		92.3	----	81.6	----	68.6



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				SED22	SED27	SED28	SED29	SED16 <2000µm Fraction
Client sampling date / time				25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00
Compound	CAS Number	LOR	Unit	EB1923115-006	EB1923115-007	EB1923115-008	EB1923115-009	EB1923115-026
				Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	49.4	46.4	46.7	44.3	----
EA150: Particle Sizing								
+75µm	----	1	%	----	5	9	----	----
+150µm	----	1	%	----	2	4	----	----
+300µm	----	1	%	----	1	2	----	----
+425µm	----	1	%	----	1	1	----	----
+600µm	----	1	%	----	<1	1	----	----
+1180µm	----	1	%	----	<1	<1	----	----
+2.36mm	----	1	%	----	<1	<1	----	----
+4.75mm	----	1	%	----	<1	<1	----	----
+9.5mm	----	1	%	----	<1	<1	----	----
+19.0mm	----	1	%	----	<1	<1	----	----
+37.5mm	----	1	%	----	<1	<1	----	----
+75.0mm	----	1	%	----	<1	<1	----	----
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	----	28	28	----	----
Silt (2-60 µm)	----	1	%	----	66	58	----	----
Sand (0.06-2.00 mm)	----	1	%	----	6	14	----	----
Gravel (>2mm)	----	1	%	----	<1	<1	----	----
Cobbles (>6cm)	----	1	%	----	<1	<1	----	----
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	----	2.47	2.35	----	----
EG005(ED093)T: Total Metals by ICP-AES								
Barium	7440-39-3	10	mg/kg	----	<30	<20	<20	<20
Boron	7440-42-8	50	mg/kg	----	<50	<50	<50	<50
Cobalt	7440-48-4	2	mg/kg	----	7	8	7	<2
Iron	7439-89-6	50	mg/kg	----	25600	28100	23700	5130
Manganese	7439-96-5	5	mg/kg	----	409	430	364	154
Selenium	7782-49-2	5	mg/kg	----	<5	<5	<5	<5
Silver	7440-22-4	2	mg/kg	----	<3	<2	<2	<2
Tin	7440-31-5	5	mg/kg	----	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg	----	26	31	25	<5
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	----	<0.1	<0.1	<0.1	----



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	SED22	SED27	SED28	SED29	SED16 <2000µm Fraction
Client sampling date / time					25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00
Compound	CAS Number	LOR	Unit		EB1923115-006	EB1923115-007	EB1923115-008	EB1923115-009	EB1923115-026
					Result	Result	Result	Result	Result
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg		----	1230	1240	1140	----
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg		----	1230	1240	1140	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg		----	591	551	527	----
EP003: Total Organic Carbon (TOC) in Soil									
Total Organic Carbon	----	0.02	%		----	<0.02	<0.02	0.76	----
EP003TC: Total Carbon (TC) in Soil									
Total Carbon	TC	0.02	%		----	4.84	5.36	5.40	----
EP003TIC: Total inorganic Carbon (TIC) in Soil									
Total Inorganic Carbon	----	0.02	%		----	4.84	5.36	4.64	----
EP066: Polychlorinated Biphenyls (PCB)									
Total Polychlorinated biphenyls	----	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	----
EP068A: Organochlorine Pesticides (OC)									
alpha-BHC	319-84-6	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
Hexachlorobenzene (HCB)	118-74-1	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
beta-BHC	319-85-7	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
gamma-BHC	58-89-9	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
delta-BHC	319-86-8	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
Heptachlor	76-44-8	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
Aldrin	309-00-2	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
Heptachlor epoxide	1024-57-3	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
^ Total Chlordane (sum)	----	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
trans-Chlordane	5103-74-2	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
alpha-Endosulfan	959-98-8	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
cis-Chlordane	5103-71-9	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
Dieldrin	60-57-1	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
4,4'-DDE	72-55-9	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
Endrin	72-20-8	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
beta-Endosulfan	33213-65-9	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
^ Endosulfan (sum)	115-29-7	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
4,4'-DDD	72-54-8	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
Endrin aldehyde	7421-93-4	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----
Endosulfan sulfate	1031-07-8	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	----

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	SED22	SED27	SED28	SED29	SED16 <2000µm Fraction
Client sampling date / time				25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	
Compound	CAS Number	LOR	Unit	EB1923115-006	EB1923115-007	EB1923115-008	EB1923115-009	EB1923115-026	
				Result	Result	Result	Result	Result	
EP068A: Organochlorine Pesticides (OC) - Continued									
4,4'-DDT	50-29-3	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	----	
Endrin ketone	53494-70-5	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	----	
Methoxychlor	72-43-5	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	----	
^ Sum of Aldrin + Dieldrin	309-00-2/60-57-1	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	----	
^ Sum of DDD + DDE + DDT	72-54-8/72-55-9/50-2	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	----	
EP080/071: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	----	10	mg/kg	<10	<10	<10	<10	----	
C10 - C14 Fraction	----	50	mg/kg	<50	<50	<50	<50	----	
C15 - C28 Fraction	----	100	mg/kg	<100	<100	<100	<100	----	
C29 - C36 Fraction	----	100	mg/kg	<100	<100	<100	<100	----	
^ C10 - C36 Fraction (sum)	----	50	mg/kg	<50	<50	<50	<50	----	
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions									
C6 - C10 Fraction	C6_C10	10	mg/kg	<10	<10	<10	<10	----	
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	10	mg/kg	<10	<10	<10	<10	----	
>C10 - C16 Fraction	----	50	mg/kg	<50	<50	<50	<50	----	
>C16 - C34 Fraction	----	100	mg/kg	<100	<100	<100	<100	----	
>C34 - C40 Fraction	----	100	mg/kg	<100	<100	<100	<100	----	
^ >C10 - C40 Fraction (sum)	----	50	mg/kg	<50	<50	<50	<50	----	
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	50	mg/kg	<50	<50	<50	<50	----	
EP080: BTEXN									
Benzene	71-43-2	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	----	
Toluene	108-88-3	0.5	mg/kg	<0.5	<0.5	<0.5	<0.5	----	
Ethylbenzene	100-41-4	0.5	mg/kg	<0.5	<0.5	<0.5	<0.5	----	
meta- & para-Xylene	108-38-3 106-42-3	0.5	mg/kg	<0.5	<0.5	<0.5	<0.5	----	
ortho-Xylene	95-47-6	0.5	mg/kg	<0.5	<0.5	<0.5	<0.5	----	
^ Sum of BTEX	----	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	----	
^ Total Xylenes	----	0.5	mg/kg	<0.5	<0.5	<0.5	<0.5	----	
Naphthalene	91-20-3	1	mg/kg	<1	<1	<1	<1	----	
EP090: Organotin Compounds									
Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	<0.5	<0.5	----	
GEO26: Sieving									



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				SED22	SED27	SED28	SED29	SED16 <2000µm Fraction
Client sampling date / time				25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00
Compound	CAS Number	LOR	Unit	EB1923115-006	EB1923115-007	EB1923115-008	EB1923115-009	EB1923115-026
				Result	Result	Result	Result	Result
GEO26: Sieving - Continued								
-2000µm	----	0.01	%	----	----	----	----	86.6
Radionuclides / Activity								
Gross alpha	----	500	Bq/kg DW	<500	<500	<500	<500	----
Gross beta	----	500	Bq/kg DW	<500	<500	<500	<500	----
EP066S: PCB Surrogate								
Decachlorobiphenyl	2051-24-3	0.1	%	94.8	83.6	88.0	82.7	----
EP068S: Organochlorine Pesticide Surrogate								
Dibromo-DDE	21655-73-2	0.05	%	112	110	110	102	----
EP068T: Organophosphorus Pesticide Surrogate								
DEF	78-48-8	0.05	%	89.4	79.0	81.5	80.0	----
EP080S: TPH(V)/BTEX Surrogates								
1,2-Dichloroethane-D4	17060-07-0	0.2	%	75.3	68.8	76.3	70.9	----
Toluene-D8	2037-26-5	0.2	%	66.0	61.8	67.3	66.3	----
4-Bromofluorobenzene	460-00-4	0.2	%	82.2	68.6	84.6	83.0	----
EP090S: Organotin Surrogate								
Tripopyltin	----	0.5	%	82.7	69.1	71.7	81.9	----



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				SED19 <2000µm Fraction	SED27 <2000µm Fraction	SED28 <2000µm Fraction	SED29 <2000µm Fraction	----
Client sampling date / time				25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	----
Compound	CAS Number	LOR	Unit	EB1923115-027	EB1923115-028	EB1923115-029	EB1923115-030	-----
				Result	Result	Result	Result	----
EG005(ED093)T: Total Metals by ICP-AES								
Barium	7440-39-3	10	mg/kg	<20	20	<20	<20	----
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	----
Cobalt	7440-48-4	2	mg/kg	5	8	7	7	----
Iron	7439-89-6	50	mg/kg	14100	30700	22900	22500	----
Manganese	7439-96-5	5	mg/kg	234	406	399	391	----
Selenium	7782-49-2	5	mg/kg	<5	<5	<5	<5	----
Silver	7440-22-4	2	mg/kg	<2	<2	<2	<2	----
Tin	7440-31-5	5	mg/kg	<5	<5	<5	<5	----
Vanadium	7440-62-2	5	mg/kg	11	32	26	25	----
GEO26: Sieving								
-2000µm	----	0.01	%	97.8	95.1	96.4	94.6	----



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				TSS 28	TSS 08	TSS 08 DEEP	TSS 05	TSS 05 DEEP
Client sampling date / time				26-Aug-2019 00:00	26-Aug-2019 00:00	26-Aug-2019 00:00	26-Aug-2019 00:00	26-Aug-2019 00:00
Compound	CAS Number	LOR	Unit	EB1923115-010	EB1923115-011	EB1923115-012	EB1923115-013	EB1923115-014
				Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	<5	<5	<5	<5	<5



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				TSS 02 DEEP	TSS 43 DEEP	TSS 43	TSS 09 DEEP	TSS 46
Client sampling date / time				26-Aug-2019 00:00	26-Aug-2019 00:00	26-Aug-2019 00:00	26-Aug-2019 00:00	26-Aug-2019 00:00
Compound	CAS Number	LOR	Unit	EB1923115-015	EB1923115-016	EB1923115-017	EB1923115-018	EB1923115-019
				Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	<5	<5	<5	<5	<5



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				TSS 44	TSS 44 DEEP	TSS 47	TSS 09	TSS 45
Client sampling date / time				26-Aug-2019 00:00	26-Aug-2019 00:00	26-Aug-2019 00:00	26-Aug-2019 00:00	26-Aug-2019 00:00
Compound	CAS Number	LOR	Unit	EB1923115-020	EB1923115-021	EB1923115-022	EB1923115-023	EB1923115-024
				Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	<5	<5	<5	<5	<5



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	TSS 18	----	----	----	----
				Client sampling date / time	26-Aug-2019 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit		EB1923115-025	-----	-----	-----	-----
					Result	----	----	----	----
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)				----	5	mg/L	<5	----	----



Surrogate Control Limits

Sub-Matrix: SOIL		Recovery Limits (%)	
Compound	CAS Number	Low	High
EP066S: PCB Surrogate			
Decachlorobiphenyl	2051-24-3	16	134
EP068S: Organochlorine Pesticide Surrogate			
Dibromo-DDE	21655-73-2	10	138
EP068T: Organophosphorus Pesticide Surrogate			
DEF	78-48-8	23	135
EP080S: TPH(V)/BTEX Surrogates			
1,2-Dichloroethane-D4	17060-07-0	53	134
Toluene-D8	2037-26-5	60	131
4-Bromofluorobenzene	460-00-4	59	127
EP090S: Organotin Surrogate			
Tripropyltin	----	35	130

CERTIFICATE OF ANALYSIS

Work Order	: EB1923115	Page	: 1 of 16
Amendment	: 1		
Client	: COFFEY ENVIRONMENTS PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MS ERICA COLLEY	Contact	: Andrew Epps
Address	: Level 5 12 Creek St Brisbane QLD, AUSTRALIA 4000	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3608 2500	Telephone	: +61 7 3552 8639
Project	: JDD PROJECT	Date Samples Received	: 03-Sep-2019 11:40
Order number	:	Date Analysis Commenced	: 04-Sep-2019
C-O-C number	: ----	Issue Date	: 13-Mar-2020 10:34
Sampler	: ERICA COLLEY		
Site	:		
Quote number	: EN/222		
No. of samples received	: 31		
No. of samples analysed	: 30		



Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane External Subcontracting, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Minh Wills	2IC Organic Chemist	Brisbane Organics, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EG005T (Total Metals by ICP-AES): Limit of reporting for some samples have been raised due to matrix interference.
- Amendment (13/03/2020): This report has been amended and re-released to allow the reporting of additional analytical data.
- EG005T (Total Metals by ICP-AES): The limit of reporting for has been raised for some samples due to matrix interference.
- Radiological work undertaken by ALS Laboratory Group (Ceska Lipa) under CAI accreditation No. L1163. Report No. \$\$. NATA and CAI accreditations' are both recognised under ILAC.
- Radiological work undertaken by ALS Laboratory Group (Ceska Lipa) under CAI accreditation No. L1163. Report No. PR1994255 . NATA and CAI accreditations' are both recognised under ILAC.



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	SED3	SED16	SED18	SED19	SED21
Client sampling date / time					25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00
Compound	CAS Number	LOR	Unit		EB1923115-001	EB1923115-002	EB1923115-003	EB1923115-004	EB1923115-005
					Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%		39.3	31.0	35.4	39.2	51.1
EA150: Particle Sizing									
+75µm	----	1	%		----	96	----	79	----
+150µm	----	1	%		----	96	----	47	----
+300µm	----	1	%		----	93	----	8	----
+425µm	----	1	%		----	88	----	4	----
+600µm	----	1	%		----	66	----	3	----
+1180µm	----	1	%		----	19	----	<1	----
+2.36mm	----	1	%		----	6	----	<1	----
+4.75mm	----	1	%		----	1	----	<1	----
+9.5mm	----	1	%		----	<1	----	<1	----
+19.0mm	----	1	%		----	<1	----	<1	----
+37.5mm	----	1	%		----	<1	----	<1	----
+75.0mm	----	1	%		----	<1	----	<1	----
EA150: Soil Classification based on Particle Size									
Clay (<2 µm)	----	1	%		----	1	----	12	----
Silt (2-60 µm)	----	1	%		----	3	----	8	----
Sand (0.06-2.00 mm)	----	1	%		----	86	----	80	----
Gravel (>2mm)	----	1	%		----	10	----	<1	----
Cobbles (>6cm)	----	1	%		----	<1	----	<1	----
EA152: Soil Particle Density									
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3		----	2.50	----	2.59	----
EG005(ED093)T: Total Metals by ICP-AES									
Arsenic	7440-38-2	5	mg/kg		----	8	----	<5	----
Barium	7440-39-3	10	mg/kg		----	<50	----	<40	----
Beryllium	7440-41-7	1	mg/kg		----	<1	----	<1	----
Boron	7440-42-8	50	mg/kg		----	<50	----	<50	----
Cadmium	7440-43-9	1	mg/kg		----	<1	----	<1	----
Chromium	7440-47-3	2	mg/kg		----	4	----	4	----
Cobalt	7440-48-4	2	mg/kg		----	<5	----	<4	----
Copper	7440-50-8	5	mg/kg		----	<5	----	<5	----
Iron	7439-89-6	50	mg/kg		----	5160	----	3580	----
Lead	7439-92-1	5	mg/kg		----	<5	----	<5	----
Manganese	7439-96-5	5	mg/kg		----	223	----	156	----



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	SED3	SED16	SED18	SED19	SED21
Client sampling date / time					25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00
Compound	CAS Number	LOR	Unit		EB1923115-001	EB1923115-002	EB1923115-003	EB1923115-004	EB1923115-005
					Result	Result	Result	Result	Result
EG005(ED093)T: Total Metals by ICP-AES - Continued									
Nickel	7440-02-0	2	mg/kg		----	2	----	<2	----
Selenium	7782-49-2	5	mg/kg		----	<5	----	<5	----
Silver	7440-22-4	2	mg/kg		----	<5	----	<4	----
Tin	7440-31-5	5	mg/kg		----	<5	----	<5	----
Vanadium	7440-62-2	5	mg/kg		----	<5	----	<5	----
Zinc	7440-66-6	5	mg/kg		----	<5	----	<5	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg		----	1.5	----	<0.1	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg		----	400	----	340	----
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg		----	400	----	340	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg		----	333	----	422	----
EP003: Total Organic Carbon (TOC) in Soil									
Total Organic Carbon	----	0.02	%		----	0.18	----	0.38	----
EP003TC: Total Carbon (TC) in Soil									
Total Carbon	TC	0.02	%		----	10.2	----	3.40	----
EP003TIC: Total inorganic Carbon (TIC) in Soil									
Total Inorganic Carbon	----	0.02	%		----	10.0	----	3.02	----
EP066: Polychlorinated Biphenyls (PCB)									
Total Polychlorinated biphenyls	----	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	<0.1
EP068A: Organochlorine Pesticides (OC)									
alpha-BHC	319-84-6	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05
Hexachlorobenzene (HCB)	118-74-1	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05
beta-BHC	319-85-7	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05
gamma-BHC	58-89-9	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05
delta-BHC	319-86-8	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05
Heptachlor	76-44-8	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05
Aldrin	309-00-2	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05
Heptachlor epoxide	1024-57-3	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05
^ Total Chlordane (sum)	----	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05
trans-Chlordane	5103-74-2	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05
alpha-Endosulfan	959-98-8	0.05	mg/kg		<0.05	<0.05	<0.05	<0.05	<0.05



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				SED3	SED16	SED18	SED19	SED21
Client sampling date / time				25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00
Compound	CAS Number	LOR	Unit	EB1923115-001	EB1923115-002	EB1923115-003	EB1923115-004	EB1923115-005
				Result	Result	Result	Result	Result
EP068A: Organochlorine Pesticides (OC) - Continued								
cis-Chlordane	5103-71-9	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05
Dieldrin	60-57-1	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05
4,4'-DDE	72-55-9	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05
Endrin	72-20-8	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05
beta-Endosulfan	33213-65-9	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05
^ Endosulfan (sum)	115-29-7	0.05	mg/kg	----	----	----	----	<0.05
^ Endosulfan (sum)	115-29-7	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	----
4,4'-DDD	72-54-8	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05
Endrin aldehyde	7421-93-4	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05
Endosulfan sulfate	1031-07-8	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05
4,4'-DDT	50-29-3	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
Endrin ketone	53494-70-5	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05
Methoxychlor	72-43-5	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
^ Sum of Aldrin + Dieldrin	309-00-2/60-57-1	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05
^ Sum of DDD + DDE + DDT	72-54-8/72-55-9/50-2	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	10	mg/kg	<10	<10	<10	<10	<10
C10 - C14 Fraction	----	50	mg/kg	<50	<50	<50	<50	<50
C15 - C28 Fraction	----	100	mg/kg	<100	<100	<100	<100	<100
C29 - C36 Fraction	----	100	mg/kg	<100	<100	<100	<100	<100
^ C10 - C36 Fraction (sum)	----	50	mg/kg	<50	<50	<50	<50	<50
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	10	mg/kg	<10	<10	<10	<10	<10
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	10	mg/kg	<10	<10	<10	<10	<10
>C10 - C16 Fraction	----	50	mg/kg	<50	<50	<50	<50	<50
>C16 - C34 Fraction	----	100	mg/kg	<100	<100	<100	<100	<100
>C34 - C40 Fraction	----	100	mg/kg	<100	<100	<100	<100	<100
^ >C10 - C40 Fraction (sum)	----	50	mg/kg	<50	<50	<50	<50	<50
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	50	mg/kg	<50	<50	<50	<50	<50
EP080: BTEXN								
Benzene	71-43-2	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
Toluene	108-88-3	0.5	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	SED3	SED16	SED18	SED19	SED21
Client sampling date / time					25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00
Compound	CAS Number	LOR	Unit		EB1923115-001	EB1923115-002	EB1923115-003	EB1923115-004	EB1923115-005
					Result	Result	Result	Result	Result
EP080: BTEXN - Continued									
Ethylbenzene	100-41-4	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5
meta- & para-Xylene	108-38-3 106-42-3	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5
ortho-Xylene	95-47-6	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5
^ Sum of BTEX	----	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2
^ Total Xylenes	----	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5
Naphthalene	91-20-3	1	mg/kg		<1	<1	<1	<1	<1
EP090: Organotin Compounds									
Tributyltin	56573-85-4	0.5	µgSn/kg		<0.5	----	<0.5	----	<0.5
Radionuclides / Activity									
Gross alpha	----	500	Bq/kg DW		<500	----	<500	----	<500
Gross beta	----	500	Bq/kg DW		<500	----	<500	----	540
EP066S: PCB Surrogate									
Decachlorobiphenyl	2051-24-3	0.1	%		102	84.4	90.1	98.5	98.9
EP068S: Organochlorine Pesticide Surrogate									
Dibromo-DDE	21655-73-2	0.05	%		112	115	119	123	117
EP068T: Organophosphorus Pesticide Surrogate									
DEF	78-48-8	0.05	%		96.8	90.2	90.3	97.1	93.1
EP080S: TPH(V)/BTEX Surrogates									
1,2-Dichloroethane-D4	17060-07-0	0.2	%		78.7	76.4	80.1	78.0	104
Toluene-D8	2037-26-5	0.2	%		69.6	64.9	68.4	64.7	82.0
4-Bromofluorobenzene	460-00-4	0.2	%		82.4	80.2	80.2	79.0	112
EP090S: Organotin Surrogate									
Tripropyltin	----	0.5	%		92.3	----	81.6	----	68.6



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				SED22	SED27	SED28	SED29	SED16 <2000µm Fraction
Client sampling date / time				25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00
Compound	CAS Number	LOR	Unit	EB1923115-006	EB1923115-007	EB1923115-008	EB1923115-009	EB1923115-026
				Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	49.4	46.4	46.7	44.3	----
EA150: Particle Sizing								
+75µm	----	1	%	----	5	9	----	----
+150µm	----	1	%	----	2	4	----	----
+300µm	----	1	%	----	1	2	----	----
+425µm	----	1	%	----	1	1	----	----
+600µm	----	1	%	----	<1	1	----	----
+1180µm	----	1	%	----	<1	<1	----	----
+2.36mm	----	1	%	----	<1	<1	----	----
+4.75mm	----	1	%	----	<1	<1	----	----
+9.5mm	----	1	%	----	<1	<1	----	----
+19.0mm	----	1	%	----	<1	<1	----	----
+37.5mm	----	1	%	----	<1	<1	----	----
+75.0mm	----	1	%	----	<1	<1	----	----
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	----	28	28	----	----
Silt (2-60 µm)	----	1	%	----	66	58	----	----
Sand (0.06-2.00 mm)	----	1	%	----	6	14	----	----
Gravel (>2mm)	----	1	%	----	<1	<1	----	----
Cobbles (>6cm)	----	1	%	----	<1	<1	----	----
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	----	2.47	2.35	----	----
EG005(ED093)T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	----	7	7	6	7
Barium	7440-39-3	10	mg/kg	----	<30	<20	<20	<20
Beryllium	7440-41-7	1	mg/kg	----	<1	<1	<1	<1
Boron	7440-42-8	50	mg/kg	----	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	----	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	----	24	26	22	4
Cobalt	7440-48-4	2	mg/kg	----	7	8	7	<2
Copper	7440-50-8	5	mg/kg	----	16	19	15	<5
Iron	7439-89-6	50	mg/kg	----	25600	28100	23700	5130
Lead	7439-92-1	5	mg/kg	----	8	8	7	<5
Manganese	7439-96-5	5	mg/kg	----	409	430	364	154



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				SED22	SED27	SED28	SED29	SED16 <2000µm Fraction
Client sampling date / time				25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00
Compound	CAS Number	LOR	Unit	EB1923115-006	EB1923115-007	EB1923115-008	EB1923115-009	EB1923115-026
				Result	Result	Result	Result	Result
EG005(ED093)T: Total Metals by ICP-AES - Continued								
Nickel	7440-02-0	2	mg/kg	----	15	17	14	<2
Selenium	7782-49-2	5	mg/kg	----	<5	<5	<5	<5
Silver	7440-22-4	2	mg/kg	----	<3	<2	<2	<2
Tin	7440-31-5	5	mg/kg	----	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg	----	26	31	25	<5
Zinc	7440-66-6	5	mg/kg	----	34	39	33	<5
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	----	<0.1	<0.1	<0.1	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	----	1230	1240	1140	----
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	----	1230	1240	1140	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	----	591	551	527	----
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	----	<0.02	<0.02	0.76	----
EP003TC: Total Carbon (TC) in Soil								
Total Carbon	TC	0.02	%	----	4.84	5.36	5.40	----
EP003TIC: Total inorganic Carbon (TIC) in Soil								
Total Inorganic Carbon	----	0.02	%	----	4.84	5.36	4.64	----
EP066: Polychlorinated Biphenyls (PCB)								
Total Polychlorinated biphenyls	----	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	----
EP068A: Organochlorine Pesticides (OC)								
alpha-BHC	319-84-6	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	----
Hexachlorobenzene (HCB)	118-74-1	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	----
beta-BHC	319-85-7	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	----
gamma-BHC	58-89-9	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	----
delta-BHC	319-86-8	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	----
Heptachlor	76-44-8	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	----
Aldrin	309-00-2	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	----
Heptachlor epoxide	1024-57-3	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	----
^ Total Chlordane (sum)	----	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	----
trans-Chlordane	5103-74-2	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	----



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				SED22	SED27	SED28	SED29	SED16 <2000µm Fraction
Client sampling date / time				25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00
Compound	CAS Number	LOR	Unit	EB1923115-006	EB1923115-007	EB1923115-008	EB1923115-009	EB1923115-026
				Result	Result	Result	Result	Result
EP068A: Organochlorine Pesticides (OC) - Continued								
alpha-Endosulfan	959-98-8	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	----
cis-Chlordane	5103-71-9	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	----
Dieldrin	60-57-1	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	----
4,4'-DDE	72-55-9	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	----
Endrin	72-20-8	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	----
beta-Endosulfan	33213-65-9	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	----
^ Endosulfan (sum)	115-29-7	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	----
4,4'-DDD	72-54-8	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	----
Endrin aldehyde	7421-93-4	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	----
Endosulfan sulfate	1031-07-8	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	----
4,4'-DDT	50-29-3	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	----
Endrin ketone	53494-70-5	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	----
Methoxychlor	72-43-5	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	----
^ Sum of Aldrin + Dieldrin	309-00-2/60-57-1	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	----
^ Sum of DDD + DDE + DDT	72-54-8/72-55-9/50-2	0.05	mg/kg	<0.05	<0.05	<0.05	<0.05	----
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	10	mg/kg	<10	<10	<10	<10	----
C10 - C14 Fraction	----	50	mg/kg	<50	<50	<50	<50	----
C15 - C28 Fraction	----	100	mg/kg	<100	<100	<100	<100	----
C29 - C36 Fraction	----	100	mg/kg	<100	<100	<100	<100	----
^ C10 - C36 Fraction (sum)	----	50	mg/kg	<50	<50	<50	<50	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	10	mg/kg	<10	<10	<10	<10	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	10	mg/kg	<10	<10	<10	<10	----
>C10 - C16 Fraction	----	50	mg/kg	<50	<50	<50	<50	----
>C16 - C34 Fraction	----	100	mg/kg	<100	<100	<100	<100	----
>C34 - C40 Fraction	----	100	mg/kg	<100	<100	<100	<100	----
^ >C10 - C40 Fraction (sum)	----	50	mg/kg	<50	<50	<50	<50	----
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	50	mg/kg	<50	<50	<50	<50	----
EP080: BTEXN								
Benzene	71-43-2	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	----



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				SED22	SED27	SED28	SED29	SED16 <2000µm Fraction
Client sampling date / time				25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00
Compound	CAS Number	LOR	Unit	EB1923115-006	EB1923115-007	EB1923115-008	EB1923115-009	EB1923115-026
				Result	Result	Result	Result	Result
EP080: BTEXN - Continued								
Toluene	108-88-3	0.5	mg/kg	<0.5	<0.5	<0.5	<0.5	----
Ethylbenzene	100-41-4	0.5	mg/kg	<0.5	<0.5	<0.5	<0.5	----
meta- & para-Xylene	108-38-3 106-42-3	0.5	mg/kg	<0.5	<0.5	<0.5	<0.5	----
ortho-Xylene	95-47-6	0.5	mg/kg	<0.5	<0.5	<0.5	<0.5	----
^ Sum of BTEX	----	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	----
^ Total Xylenes	----	0.5	mg/kg	<0.5	<0.5	<0.5	<0.5	----
Naphthalene	91-20-3	1	mg/kg	<1	<1	<1	<1	----
EP090: Organotin Compounds								
Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	<0.5	<0.5	----
GEO26: Sieving								
-2000µm	----	0.01	%	----	----	----	----	86.6
Radionuclides / Activity								
Gross alpha	----	500	Bq/kg DW	<500	<500	<500	<500	----
Gross beta	----	500	Bq/kg DW	<500	<500	<500	<500	----
EP066S: PCB Surrogate								
Decachlorobiphenyl	2051-24-3	0.1	%	94.8	83.6	88.0	82.7	----
EP068S: Organochlorine Pesticide Surrogate								
Dibromo-DDE	21655-73-2	0.05	%	112	110	110	102	----
EP068T: Organophosphorus Pesticide Surrogate								
DEF	78-48-8	0.05	%	89.4	79.0	81.5	80.0	----
EP080S: TPH(V)/BTEX Surrogates								
1,2-Dichloroethane-D4	17060-07-0	0.2	%	75.3	68.8	76.3	70.9	----
Toluene-D8	2037-26-5	0.2	%	66.0	61.8	67.3	66.3	----
4-Bromofluorobenzene	460-00-4	0.2	%	82.2	68.6	84.6	83.0	----
EP090S: Organotin Surrogate								
Tripropyltin	----	0.5	%	82.7	69.1	71.7	81.9	----



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

Client sampling date / time

				SED19 <2000µm Fraction	SED27 <2000µm Fraction	SED28 <2000µm Fraction	SED29 <2000µm Fraction	----
				25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	25-Aug-2019 00:00	----
Compound	CAS Number	LOR	Unit	EB1923115-027	EB1923115-028	EB1923115-029	EB1923115-030	-----
				Result	Result	Result	Result	----
EG005(ED093)T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	9	7	5	5	----
Barium	7440-39-3	10	mg/kg	<20	20	<20	<20	----
Beryllium	7440-41-7	1	mg/kg	<1	<1	<1	<1	----
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	----
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	----
Chromium	7440-47-3	2	mg/kg	14	29	25	25	----
Cobalt	7440-48-4	2	mg/kg	5	8	7	7	----
Copper	7440-50-8	5	mg/kg	7	23	18	17	----
Iron	7439-89-6	50	mg/kg	14100	30700	22900	22500	----
Lead	7439-92-1	5	mg/kg	<5	11	8	9	----
Manganese	7439-96-5	5	mg/kg	234	406	399	391	----
Nickel	7440-02-0	2	mg/kg	8	18	15	14	----
Selenium	7782-49-2	5	mg/kg	<5	<5	<5	<5	----
Silver	7440-22-4	2	mg/kg	<2	<2	<2	<2	----
Tin	7440-31-5	5	mg/kg	<5	<5	<5	<5	----
Vanadium	7440-62-2	5	mg/kg	11	32	26	25	----
Zinc	7440-66-6	5	mg/kg	24	42	42	40	----
GEO26: Sieving								
-2000µm	----	0.01	%	97.8	95.1	96.4	94.6	----



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				TSS 28	TSS 08	TSS 08 DEEP	TSS 05	TSS 05 DEEP
Client sampling date / time				26-Aug-2019 00:00	26-Aug-2019 00:00	26-Aug-2019 00:00	26-Aug-2019 00:00	26-Aug-2019 00:00
Compound	CAS Number	LOR	Unit	EB1923115-010	EB1923115-011	EB1923115-012	EB1923115-013	EB1923115-014
				Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	<5	<5	<5	<5	<5



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				TSS 02 DEEP	TSS 43 DEEP	TSS 43	TSS 09 DEEP	TSS 46
Client sampling date / time				26-Aug-2019 00:00	26-Aug-2019 00:00	26-Aug-2019 00:00	26-Aug-2019 00:00	26-Aug-2019 00:00
Compound	CAS Number	LOR	Unit	EB1923115-015	EB1923115-016	EB1923115-017	EB1923115-018	EB1923115-019
				Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	<5	<5	<5	<5	<5



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				TSS 44	TSS 44 DEEP	TSS 47	TSS 09	TSS 45
Client sampling date / time				26-Aug-2019 00:00	26-Aug-2019 00:00	26-Aug-2019 00:00	26-Aug-2019 00:00	26-Aug-2019 00:00
Compound	CAS Number	LOR	Unit	EB1923115-020	EB1923115-021	EB1923115-022	EB1923115-023	EB1923115-024
				Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	<5	<5	<5	<5	<5



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				<i>Client sample ID</i>	TSS 18	----	----	----	----
				<i>Client sampling date / time</i>	26-Aug-2019 00:00	----	----	----	----
<i>Compound</i>	<i>CAS Number</i>	<i>LOR</i>	<i>Unit</i>	EB1923115-025	-----	-----	-----	-----	-----
					Result	----	----	----	----
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L	<5	----	----	----	----	----



Surrogate Control Limits

Sub-Matrix: SOIL		Recovery Limits (%)	
Compound	CAS Number	Low	High
EP066S: PCB Surrogate			
Decachlorobiphenyl	2051-24-3	16	134
EP068S: Organochlorine Pesticide Surrogate			
Dibromo-DDE	21655-73-2	10	138
EP068T: Organophosphorus Pesticide Surrogate			
DEF	78-48-8	23	135
EP080S: TPH(V)/BTEX Surrogates			
1,2-Dichloroethane-D4	17060-07-0	53	134
Toluene-D8	2037-26-5	60	131
4-Bromofluorobenzene	460-00-4	59	127
EP090S: Organotin Surrogate			
Tripropyltin	----	35	130

CERTIFICATE OF ANALYSIS

Work Order : **EB1912822**
Client : **COFFEY ENVIRONMENTS PTY LTD**
Contact : MS ERICA COLLEY
Address : LEVEL WORKPLES BUILDING SAVANNAH HEIGHTS SECTION
 531, LOT 12 WAIGANI DRIVE
 HOHOLA,NCD PNG
Telephone : +61 07 3608 2500
Project : 224697 PNG JDD
Order number :
C-O-C number : ----
Sampler : LEMBAN KAKI
Site : ----
Quote number : BN/065/19 V2
No. of samples received : 1
No. of samples analysed : 1

Page : 1 of 3
Laboratory : Environmental Division Brisbane
Contact : Andrew Epps
Address : 2 Byth Street Stafford QLD Australia 4053

Telephone : +61 7 3552 8639
Date Samples Received : 20-May-2019 16:20
Date Analysis Commenced : 23-May-2019
Issue Date : 28-May-2019 08:21



Accreditation No. 825
 Accredited for compliance with
 ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EG094-T (Total Metals in Fresh Water by ORC-ICPMS): The high failing method blank for Boron is deemed acceptable as all results are less than the limit of reporting.
- EG093: Samples containing high levels of sulfate may precipitate barium under the acidic conditions of this method and may therefore bias results low.



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				DI WATER MARINE	----	----	----	----
Client sampling date / time				17-May-2019 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1912822-001	-----	-----	-----	-----
Result					----	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----
EG094T: Total metals in Fresh water by ORC-ICPMS								
Antimony	7440-36-0	0.2	µg/L	<0.2	----	----	----	----
Arsenic	7440-38-2	0.2	µg/L	<0.2	----	----	----	----
Beryllium	7440-41-7	0.1	µg/L	<0.1	----	----	----	----
Boron	7440-42-8	5	µg/L	<5	----	----	----	----
Cadmium	7440-43-9	0.05	µg/L	<0.05	----	----	----	----
Chromium	7440-47-3	0.2	µg/L	<0.2	----	----	----	----
Cobalt	7440-48-4	0.1	µg/L	<0.1	----	----	----	----
Copper	7440-50-8	0.5	µg/L	<0.5	----	----	----	----
Lead	7439-92-1	0.1	µg/L	<0.1	----	----	----	----
Manganese	7439-96-5	0.5	µg/L	0.7	----	----	----	----
Molybdenum	7439-98-7	0.1	µg/L	<0.1	----	----	----	----
Selenium	7782-49-2	0.2	µg/L	<0.2	----	----	----	----
Nickel	7440-02-0	0.5	µg/L	<0.5	----	----	----	----
Silver	7440-22-4	0.1	µg/L	<0.1	----	----	----	----
Tin	7440-31-5	0.2	µg/L	1.1	----	----	----	----
Zinc	7440-66-6	1	µg/L	9	----	----	----	----

Microbiological Results Report

Sample Details

SAMPLE DETAILS	INFORMATION
Samples Supplied by	Advanced Analytical
Sample Group ID	Water Samples (Marine)
Client Purchase Order No.	
Client contact details	Dana MacKenzie, Erica Colley
Number of samples supplied	8
Date Received at CSIRO	30 August 2019
Condition of samples on receipt	Received at CSIRO by hand delivery and stored in lab fridge
Sample analysis requested	Total Coliform (MPN), <i>E. coli</i> (MPN), Enterococci (MPN)

Analysis Results

SAMPLE ID	TOTAL COLIFORMS MPN/100ML [#]	E. COLI MPN/100ML [#]	ENTEROCOCCI MPN/100ML [#]
WQ-05	>2419.6	172.6	629.4
WQ-06	>2419.6	186	829.7
WQ-07	870.4	116.9	549.3
WQ-08	960.4	172.7	>2419.6
WQ-14	960.4	135	601.5
WQ-26	>2419.6	172.4	913.6
WQ-27	0	0	0
WQ-28	0	0	0

[#] MPN calculated using Tables provided by IDEXX

Positive control	Standard <i>E.coli</i> results in MPN detected Standard <i>E. faecalis</i> results in MPN detected
Negative control	No <i>E.coli</i> /coliform detected in MPN tray No enterococci detected in MPN tray
Media Blank	No growth detected in MPN tray

Comments:

All the samples were moderately high to above detection limits for Total Coliforms apart from samples WQ-27 and WQ-28. *E. coli* numbers were present but lower than Total Coliforms for all samples apart from WQ-27 and WQ-28 where no *E. coli* were detected.

Enterococci were moderate in numbers for all samples apart from WQ-08 which was above detection limits and WQ-27 and WQ-28 which had no enterococci detected.

All positive and negative controls were as expected.

Analysis undertaken by ...Jatinder Sidhu.....

Signature and date



.....30 August 2019

Results verified by ...Simon Toze...

Signature and date



.....13 September 2019...

APPENDIX L: RPD CALCULATIONS

Table 1 Comparison of duplicate WQ_01 against primary sample WQ_17 (April 2019)

Analytes	Analytical results (mg/L)		RPD%
	WQ_01	WQ_17	
	Primary	Duplicate	
Potassium	300	325	8
Sulphide	2,090	2,110	1
Fluoride	0.8	0.8	0
Aluminium	10	<5	67
Arsenic	1.4	1.5	7
Barium	10	9	11
Boron	3,520	3,640	3
Manganese	2.1	1.9	10
Molybdenum	7.5	7.6	1
Selenium	9	8	12
Vanadium	1.7	1.4	19
Zinc	8	6	29

Table 2 Comparison of duplicate WQ_18 against primary sample WQ_13 (April 2019)

Analytes	Analytical results (mg/L)		RPD%
	WQ_13	WQ_18	
	Primary	Duplicate	
Sulphate	2,360	2,350	0.4
Fluoride	0.8	0.8	0
Arsenic	1.5	1.5	0
Barium	6	6	0
Boron	4,140	4,190	1.2
Copper	3	1	100
Vanadium	2.0	1.9	5

Table 3 Comparison of duplicate TSS47 against primary sample TSS09 (August 2019)

Analytes	Analytical results (mg/L)		RPD%
	TSS09	TSS47	
	Primary	Duplicate	
TSS	<5	<5	0

Table 4 Comparison of duplicate Sed25 against primary sample Sed2 (August 2019)

Analytes	Analytical results (mg/L)		RPD%
	Sed2	Sed25	
	Primary	Duplicate	
Nitrate plus Nitrate as N	0.4	0.5	22
Total Kjeldahl nitrogen as N	1,150	1,160	1
Total nitrogen as N	1,150	1,160	1
Total organic carbon	0.79	0.80	1
Total carbon	5.12	5.08	1
Total inorganic carbon	4.33	4.28	1

Table 5 Comparison of duplicate Sed26 against primary sample Sed14 (August 2019)

Analytes	Analytical results (mg/L)		RPD%
	Sed14	Sed26	
	Primary	Duplicate	
Nitrate plus Nitrate as N	0.2	0.4	67
Total Kjeldahl nitrogen as N	1,320	1,330	1
Total nitrogen as N	1,320	1,330	1
Total organic carbon	0.93	0.96	3
Total carbon	5.14	5.22	2
Total inorganic carbon	4.21	4.26	1
TRH C10-C36 fraction	3	6	67
TRH C16-C34 fraction	28	36	25
TRH C34-C40 fraction	16	21	27
TRH C10-C40 fraction (sum)	47	63	29
TPH C10-C14 fraction	<3	4	29
TPH C15-C28 fraction	17	23	30
TPH C29-C36 fraction	20	24	18
TPH C10-C36 fraction (sum)	37	51	32

Table 6 Comparison of duplicate Sed29 against primary sample Sed27 (August 2019)

Analytes	Analytical results (mg/L)		RPD%
	Sed27	Sed29	
	Primary	Duplicate	
Total Kjeldahl nitrogen as N	1,230	1,140	6
Total nitrogen as N	1,230	1,140	6
Total phosphorus as P	591	527	11
Arsenic	7	6	15
Chromium	24	22	9
Cobalt	7	7	0
Copper	16	15	6
Iron	25,600	23,700	8
Lead	8	7	13
Manganese	409	364	12
Nickel	15	14	7
Vanadium	26	25	4
Zinc	34	33	3

APPENDIX M: LABORATORY QA/QC

QUALITY CONTROL REPORT

Work Order	: EB1909784	Page	: 1 of 6
Amendment	: 4		
Client	: COFFEY ENVIRONMENTS PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: ERICA COLLEY	Contact	: Andrew Epps
Address	: LEVEL WORKPLES BUILDING SAVANNAH HEIGHTS SECTION 531, LOT 12 WAIGANI DRIVE HOHOLA, NCD PNG	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: 64277004057	Telephone	: +61 7 3552 8639
Project	: 754-MELEN224697 JDD PROJECT	Date Samples Received	: 15-Apr-2019
Order number	: BN/065/19	Date Analysis Commenced	: 16-Apr-2019
C-O-C number	: ----	Issue Date	: 05-Dec-2019
Sampler	: ERICA COLLEY		
Site	:		
Quote number	: EN/222		
No. of samples received	: 5		
No. of samples analysed	: 3		



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This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Arenie Vijayaratham	Non-metals prep supervisor	Melbourne Inorganics, Springvale, VIC
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high

Key :
 Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
 CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
 LOR = Limit of reporting
 RPD = Relative Percentage Difference
 # = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 2299737)									
EB1909796-001	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	2	2	0.00	No Limit
EB1909842-005	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	16	16	0.00	0% - 50%
ED093T: Total Major Cations (QC Lot: 2301159)									
EB1909784-001	WQ-01	ED093T: Potassium	7440-09-7	1	mg/L	300	306	1.97	0% - 20%
EG035F: Dissolved Mercury by FIMS (QC Lot: 2300964)									
EB1909784-001	WQ-01	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 2301158)									
EB1909784-001	WQ-01	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EB1909911-001	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS (QC Lot: 2304668)									
EB1909784-001	WQ-01	EG093A-F: Beryllium	7440-41-7	0.1	µg/L	<0.1	<0.1	0.00	No Limit
		EG093A-F: Molybdenum	7439-98-7	0.1	µg/L	7.5	7.4	0.00	0% - 20%
		EG093A-F: Silver	7440-22-4	0.1	µg/L	<0.1	<0.1	0.00	No Limit
		EG093A-F: Cadmium	7440-43-9	0.2	µg/L	<0.2	<0.2	0.00	No Limit
		EG093A-F: Cobalt	7440-48-4	0.2	µg/L	<0.2	<0.2	0.00	No Limit
		EG093A-F: Lead	7439-92-1	0.2	µg/L	<0.2	<0.2	0.00	No Limit
		EG093A-F: Antimony	7440-36-0	0.5	µg/L	<0.5	<0.5	0.00	No Limit
		EG093A-F: Arsenic	7440-38-2	0.5	µg/L	1.4	1.3	0.00	No Limit
		EG093A-F: Chromium	7440-47-3	0.5	µg/L	<0.5	<0.5	0.00	No Limit
		EG093A-F: Manganese	7439-96-5	0.5	µg/L	2.1	2.2	0.00	No Limit
		EG093A-F: Nickel	7440-02-0	0.5	µg/L	<0.5	<0.5	0.00	No Limit
		EG093A-F: Vanadium	7440-62-2	0.5	µg/L	1.7	1.5	8.38	No Limit
		EG093A-F: Barium	7440-39-3	1	µg/L	10	10	0.00	0% - 50%
		EG093A-F: Copper	7440-50-8	1	µg/L	<1	<1	0.00	No Limit



Sub-Matrix: **WATER**

Sub-Matrix: WATER				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS (QC Lot: 2304668) - continued									
EB1909784-001	WQ-01	EG093A-F: Boron	7440-42-8	100	µg/L	3520	3520	0.130	0% - 20%
		EG093A-F: Aluminium	7429-90-5	5	µg/L	10	7	37.2	No Limit
		EG093A-F: Tin	7440-31-5	5	µg/L	<5	<5	0.00	No Limit
		EG093A-F: Zinc	7440-66-6	5	µg/L	8	8	0.00	No Limit
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS (QC Lot: 2304669)									
EB1909784-001	WQ-01	EG093B-F: Selenium	7782-49-2	2	µg/L	9	9	0.00	No Limit
		EG093B-F: Iron	7439-89-6	5	µg/L	<5	<5	0.00	No Limit
EG093T: Total Metals in Saline Water by ORC-ICPMS (QC Lot: 2304666)									
EB1909784-001	WQ-01	EG093A-T: Beryllium	7440-41-7	0.1	µg/L	<0.1	<0.1	0.00	No Limit
		EG093A-T: Molybdenum	7439-98-7	0.1	µg/L	7.8	7.9	0.00	0% - 20%
		EG093A-T: Silver	7440-22-4	0.1	µg/L	<0.1	<0.1	0.00	No Limit
		EG093A-T: Cadmium	7440-43-9	0.2	µg/L	<0.2	<0.2	0.00	No Limit
		EG093A-T: Cobalt	7440-48-4	0.2	µg/L	<0.2	<0.2	0.00	No Limit
		EG093A-T: Lead	7439-92-1	0.2	µg/L	<0.2	<0.2	0.00	No Limit
		EG093A-T: Antimony	7440-36-0	0.5	µg/L	<0.5	<0.5	0.00	No Limit
		EG093A-T: Arsenic	7440-38-2	0.5	µg/L	1.2	1.4	9.64	No Limit
		EG093A-T: Chromium	7440-47-3	0.5	µg/L	0.8	0.6	38.6	No Limit
		EG093A-T: Manganese	7439-96-5	0.5	µg/L	4.1	4.2	3.08	No Limit
		EG093A-T: Nickel	7440-02-0	0.5	µg/L	<0.5	<0.5	0.00	No Limit
		EG093A-T: Vanadium	7440-62-2	0.5	µg/L	1.7	1.7	0.00	No Limit
		EG093A-T: Barium	7440-39-3	1	µg/L	11	10	0.00	0% - 50%
		EG093A-T: Copper	7440-50-8	1	µg/L	<1	<1	0.00	No Limit
		EG093A-T: Boron	7440-42-8	100	µg/L	3570	3510	1.82	0% - 20%
		EG093A-T: Aluminium	7429-90-5	5	µg/L	39	34	12.9	No Limit
		EG093A-T: Tin	7440-31-5	5	µg/L	<5	<5	0.00	No Limit
		EG093A-T: Zinc	7440-66-6	5	µg/L	<5	<5	0.00	No Limit
EG093T: Total Metals in Saline Water by ORC-ICPMS (QC Lot: 2304667)									
EB1909784-001	WQ-01	EG093B-T: Selenium	7782-49-2	2	µg/L	8	8	0.00	No Limit
		EG093B-T: Iron	7439-89-6	5	µg/L	64	61	5.96	0% - 50%
EK026SF: Total CN by Segmented Flow Analyser (QC Lot: 2301793)									
EB1909901-007	Anonymous	EK026SF: Total Cyanide	57-12-5	0.004	mg/L	<0.004	<0.004	0.00	No Limit
EB1909708-005	Anonymous	EK026SF: Total Cyanide	57-12-5	0.004	mg/L	0.017	0.018	0.00	No Limit
EK040P: Fluoride by PC Titrator (QC Lot: 2309089)									
EB1909691-001	Anonymous	EK040P: Fluoride	16984-48-8	0.1	mg/L	0.1	0.1	0.00	No Limit
EP026SP: Chemical Oxygen Demand (Spectrophotometric) (QC Lot: 2318459)									
EB1909566-001	Anonymous	EP026SP: Chemical Oxygen Demand	----	10	mg/L	<50	<50	0.00	No Limit
EB1909819-001	Anonymous	EP026SP: Chemical Oxygen Demand	----	10	mg/L	2180	2240	3.17	0% - 20%



Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

Sub-Matrix: WATER				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result		LCS	Low	High
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 2299737)								
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	25 mg/L	104	85	118
				<1	100 mg/L	95.7	85	118
ED093T: Total Major Cations (QCLot: 2301159)								
ED093T: Potassium	7440-09-7	1	mg/L	<1	----	----	----	----
EG035F: Dissolved Mercury by FIMS (QCLot: 2300964)								
EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.01 mg/L	92.8	84	118
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2301158)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.01 mg/L	97.3	84	118
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS (QCLot: 2304668)								
EG093A-F: Aluminium	7429-90-5	5	µg/L	<5	50 µg/L	92.0	85	118
EG093A-F: Antimony	7440-36-0	0.5	µg/L	<0.5	10 µg/L	88.5	87	115
EG093A-F: Arsenic	7440-38-2	0.5	µg/L	<0.5	10 µg/L	95.7	87	116
EG093A-F: Barium	7440-39-3	1	µg/L	<1	50 µg/L	96.7	87	114
EG093A-F: Beryllium	7440-41-7	0.1	µg/L	<0.1	10 µg/L	91.5	80	120
EG093A-F: Boron	7440-42-8	100	µg/L	<100	500 µg/L	95.8	82	114
EG093A-F: Cadmium	7440-43-9	0.2	µg/L	<0.2	10 µg/L	96.6	88	114
EG093A-F: Chromium	7440-47-3	0.5	µg/L	<0.5	10 µg/L	86.8	83	115
EG093A-F: Cobalt	7440-48-4	0.2	µg/L	<0.2	10 µg/L	92.0	86	116
EG093A-F: Copper	7440-50-8	1	µg/L	<1	20 µg/L	95.4	81	117
EG093A-F: Lead	7439-92-1	0.2	µg/L	<0.2	10 µg/L	94.6	80	117
EG093A-F: Manganese	7439-96-5	0.5	µg/L	<0.5	10 µg/L	97.3	80	119
EG093A-F: Molybdenum	7439-98-7	0.1	µg/L	<0.1	10 µg/L	94.7	80	118
EG093A-F: Nickel	7440-02-0	0.5	µg/L	<0.5	10 µg/L	90.7	87	117
EG093A-F: Silver	7440-22-4	0.1	µg/L	<0.1	10 µg/L	113	80	127
EG093A-F: Tin	7440-31-5	5	µg/L	<5	10 µg/L	95.4	82	118
EG093A-F: Vanadium	7440-62-2	0.5	µg/L	<0.5	10 µg/L	92.0	89	117
EG093A-F: Zinc	7440-66-6	5	µg/L	<5	20 µg/L	99.8	81	120
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS (QCLot: 2304669)								
EG093B-F: Iron	7439-89-6	5	µg/L	<5	50 µg/L	92.1	78	123
EG093B-F: Selenium	7782-49-2	2	µg/L	<2	10 µg/L	108	87	121
EG093T: Total Metals in Saline Water by ORC-ICPMS (QCLot: 2304666)								
EG093A-T: Aluminium	7429-90-5	5	µg/L	<5	----	----	----	----
EG093A-T: Antimony	7440-36-0	0.5	µg/L	<0.5	10 µg/L	95.8	83	116
EG093A-T: Arsenic	7440-38-2	0.5	µg/L	<0.5	10 µg/L	102	86	117



Sub-Matrix: **WATER**

Method: Compound				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%)	Recovery Limits (%)	
						LCS	Low	High
CAS Number	LOR	Unit	Result					
EG093T: Total Metals in Saline Water by ORC-ICPMS (QCLot: 2304666) - continued								
EG093A-T: Barium	7440-39-3	1	µg/L	<1	50 µg/L	101	84	118
EG093A-T: Beryllium	7440-41-7	0.1	µg/L	<0.1	10 µg/L	97.8	87	120
EG093A-T: Boron	7440-42-8	100	µg/L	<105	500 µg/L	99.1	83	123
EG093A-T: Cadmium	7440-43-9	0.2	µg/L	<0.2	10 µg/L	102	84	115
EG093A-T: Chromium	7440-47-3	0.5	µg/L	<0.5	10 µg/L	103	84	120
EG093A-T: Cobalt	7440-48-4	0.2	µg/L	<0.2	10 µg/L	104	85	116
EG093A-T: Copper	7440-50-8	1	µg/L	<1	20 µg/L	101	84	119
EG093A-T: Lead	7439-92-1	0.2	µg/L	<0.2	10 µg/L	99.2	84	120
EG093A-T: Manganese	7439-96-5	0.5	µg/L	<0.5	10 µg/L	100	86	124
EG093A-T: Molybdenum	7439-98-7	0.1	µg/L	<0.1	10 µg/L	95.9	84	118
EG093A-T: Nickel	7440-02-0	0.5	µg/L	<0.5	10 µg/L	82.4	80	120
EG093A-T: Silver	7440-22-4	0.1	µg/L	<0.1	10 µg/L	101	80	120
EG093A-T: Tin	7440-31-5	5	µg/L	<5	10 µg/L	87.3	83	114
EG093A-T: Vanadium	7440-62-2	0.5	µg/L	<0.5	10 µg/L	94.0	84	120
EG093A-T: Zinc	7440-66-6	5	µg/L	<5	20 µg/L	103	81	124
EG093T: Total Metals in Saline Water by ORC-ICPMS (QCLot: 2304667)								
EG093B-T: Iron	7439-89-6	5	µg/L	<5	50 µg/L	101	80	128
EG093B-T: Selenium	7782-49-2	2	µg/L	<2	10 µg/L	99.0	89	119
EK026SF: Total CN by Segmented Flow Analyser (QCLot: 2301793)								
EK026SF: Total Cyanide	57-12-5	0.004	mg/L	<0.004	0.2 mg/L	102	85	119
EK040P: Fluoride by PC Titrator (QCLot: 2309089)								
EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	5 mg/L	95.4	80	117
EP026SP: Chemical Oxygen Demand (Spectrophotometric) (QCLot: 2318459)								
EP026SP: Chemical Oxygen Demand	----	10	mg/L	<10	500 mg/L	108	92	108

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

Laboratory sample ID				Matrix Spike (MS) Report			
				Spike Concentration	Spike Recovery (%)	Recovery Limits (%)	
					MS	Low	High
Client sample ID	Method: Compound	CAS Number					
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 2299737)							
EB1909784-002	WQ-17	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	20 mg/L	# Not Determined	70	130
EG035F: Dissolved Mercury by FIMS (QCLot: 2300964)							
EB1909784-002	WQ-17	EG035F: Mercury	7439-97-6	0.01 mg/L	85.4	70	130



Sub-Matrix: **WATER**

Sub-Matrix: WATER				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2301158)							
EB1909784-002	WQ-17	EG035T: Mercury	7439-97-6	0.01 mg/L	80.4	70	130
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS (QCLot: 2304668)							
EB1909784-002	WQ-17	EG093A-F: Arsenic	7440-38-2	50 µg/L	74.9	70	130
		EG093A-F: Beryllium	7440-41-7	50 µg/L	71.3	70	130
		EG093A-F: Cadmium	7440-43-9	50 µg/L	74.7	70	130
		EG093A-F: Chromium	7440-47-3	50 µg/L	72.7	70	130
		EG093A-F: Cobalt	7440-48-4	50 µg/L	76.4	70	130
		EG093A-F: Copper	7440-50-8	100 µg/L	72.8	70	130
		EG093A-F: Lead	7439-92-1	50 µg/L	72.4	70	130
		EG093A-F: Manganese	7439-96-5	50 µg/L	74.1	70	130
		EG093A-F: Nickel	7440-02-0	50 µg/L	71.7	70	130
		EG093A-F: Vanadium	7440-62-2	50 µg/L	72.1	70	130
		EG093A-F: Zinc	7440-66-6	100 µg/L	71.2	70	130
EG093T: Total Metals in Saline Water by ORC-ICPMS (QCLot: 2304666)							
EB1909784-002	WQ-17	EG093A-T: Arsenic	7440-38-2	50 µg/L	105	70	130
		EG093A-T: Barium	7440-39-3	250 µg/L	95.5	70	130
		EG093A-T: Beryllium	7440-41-7	50 µg/L	97.3	70	130
		EG093A-T: Cadmium	7440-43-9	50 µg/L	95.3	70	130
		EG093A-T: Chromium	7440-47-3	50 µg/L	102	70	130
		EG093A-T: Cobalt	7440-48-4	50 µg/L	103	70	130
		EG093A-T: Copper	7440-50-8	100 µg/L	101	70	130
		EG093A-T: Lead	7439-92-1	50 µg/L	93.8	70	130
		EG093A-T: Manganese	7439-96-5	50 µg/L	100	70	130
		EG093A-T: Nickel	7440-02-0	50 µg/L	99.9	70	130
		EG093A-T: Vanadium	7440-62-2	50 µg/L	99.6	70	130
				EG093A-T: Zinc	7440-66-6	100 µg/L	98.1
EK026SF: Total CN by Segmented Flow Analyser (QCLot: 2301793)							
EB1909784-001	WQ-01	EK026SF: Total Cyanide	57-12-5	0.4 mg/L	103	70	130
EK040P: Fluoride by PC Titrator (QCLot: 2309089)							
EB1909691-002	Anonymous	EK040P: Fluoride	16984-48-8	5 mg/L	91.2	70	130
EP026SP: Chemical Oxygen Demand (Spectrophotometric) (QCLot: 2318459)							
EB1909566-002	Anonymous	EP026SP: Chemical Oxygen Demand	----	100 mg/L	101	70	130

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: EB1909784	Page	: 1 of 7
Amendment	: 4		
Client	: COFFEY ENVIRONMENTS PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: ERICA COLLEY	Telephone	: +61 7 3552 8639
Project	: 754-MELEN224697 JDD PROJECT	Date Samples Received	: 15-Apr-2019
Site	:	Issue Date	: 05-Dec-2019
Sampler	: ERICA COLLEY	No. of samples received	: 5
Order number	: BN/065/19	No. of samples analysed	: 3

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO** Method Blank value outliers occur.
- **NO** Duplicate outliers occur.
- **NO** Laboratory Control outliers occur.
- Matrix Spike outliers exist - please see following pages for full details.
- For all regular sample matrices, **NO** surrogate recovery outliers occur.

Outliers : Analysis Holding Time Compliance

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- Quality Control Sample Frequency Outliers exist - please see following pages for full details.



Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries							
ED041G: Sulfate (Turbidimetric) as SO ₄ 2- by DA	EB1909784--002	WQ-17	Sulfate as SO ₄ - Turbidimetric	14808-79-8	Not Determined	----	MS recovery not determined, background level greater than or equal to 4x spike level.

Outliers : Analysis Holding Time Compliance

Matrix: **WATER**

Method	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)	Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EK026SF: Total CN by Segmented Flow Analyser						
Clear Plastic Bottle - Natural WQ-17	----	----	----	17-Apr-2019	07-Apr-2019	10

Outliers : Frequency of Quality Control Samples

Matrix: **WATER**

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
Method	QC	Regular	Actual	Expected	
Laboratory Control Samples (LCS)					
Major Cations - Total	0	3	0.00	5.00	NEPM 2013 B3 & ALS QC Standard

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for VOC in soils vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
ED041G: Sulfate (Turbidimetric) as SO₄ 2- by DA							
Clear Plastic Bottle - Natural (ED041G) WQ-01, WQ-12	WQ-17,	06-Apr-2019	----	----	16-Apr-2019	04-May-2019	✔
ED093T: Total Major Cations							
Clear Plastic Bottle - Unfiltered; Lab-acidified (ED093T) WQ-01, WQ-12	WQ-17,	06-Apr-2019	17-Apr-2019	04-May-2019	17-Apr-2019	04-May-2019	✔



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EG035F: Dissolved Mercury by FIMS								
Clear Plastic Bottle - Filtered; Lab-acidified (EG035F) WQ-01, WQ-12	WQ-17,	06-Apr-2019	----	----	----	17-Apr-2019	04-May-2019	✓
EG035T: Total Recoverable Mercury by FIMS								
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG035T) WQ-01, WQ-12	WQ-17,	06-Apr-2019	----	----	----	17-Apr-2019	04-May-2019	✓
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS								
Clear Plastic Bottle - Filtered; Lab-acidified (EG093A-F) WQ-01, WQ-12	WQ-17,	06-Apr-2019	----	----	----	18-Apr-2019	03-Oct-2019	✓
EG093T: Total Metals in Saline Water by ORC-ICPMS								
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG093A-T) WQ-01, WQ-12	WQ-17,	06-Apr-2019	18-Apr-2019	03-Oct-2019	✓	18-Apr-2019	03-Oct-2019	✓
EK026SF: Total CN by Segmented Flow Analyser								
Clear Plastic Bottle - Natural (EK026SF) WQ-17		06-Apr-2019	----	----	----	17-Apr-2019	07-Apr-2019	✗
Opaque plastic bottle - NaOH (EK026SF) WQ-01,	WQ-12	06-Apr-2019	----	----	----	17-Apr-2019	20-Apr-2019	✓
EK040P: Fluoride by PC Titrator								
Clear Plastic Bottle - Natural (EK040P) WQ-01, WQ-12	WQ-17,	06-Apr-2019	----	----	----	23-Apr-2019	04-May-2019	✓
EP026SP: Chemical Oxygen Demand (Spectrophotometric)								
Clear Plastic Bottle - Sulfuric Acid (EP026SP) WQ-01, WQ-12	WQ-17,	06-Apr-2019	----	----	----	29-Apr-2019	04-May-2019	✓

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)		Quality Control Specification	
Analytical Methods	Method	QC	Regular	Actual	Expected		Evaluation
Laboratory Duplicates (DUP)							
Chemical Oxygen Demand (COD) (Spectrophotometric)	EP026SP	2	19	10.53	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	3	33.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals in Saline Water -Suite A by ORC-ICPMS	EG093A-F	1	3	33.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals in Saline Water -Suite B by ORC-ICPMS	EG093B-F	1	3	33.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	1	10	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Total	ED093T	1	3	33.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Cyanide by Segmented Flow Analyser	EK026SF	2	18	11.11	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	2	17	11.76	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Saline Water Suite A by ORC-ICPMS	EG093A-T	1	3	33.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Saline Water -Suite B by ORC-ICPMS	EG093B-T	1	3	33.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Chemical Oxygen Demand (COD) (Spectrophotometric)	EP026SP	1	19	5.26	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	3	33.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals in Saline Water -Suite A by ORC-ICPMS	EG093A-F	1	3	33.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals in Saline Water -Suite B by ORC-ICPMS	EG093B-F	1	3	33.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	1	10	10.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Total	ED093T	0	3	0.00	5.00	✗	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Cyanide by Segmented Flow Analyser	EK026SF	1	18	5.56	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	17	5.88	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Saline Water Suite A by ORC-ICPMS	EG093A-T	1	3	33.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Saline Water -Suite B by ORC-ICPMS	EG093B-T	1	3	33.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Chemical Oxygen Demand (COD) (Spectrophotometric)	EP026SP	1	19	5.26	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	3	33.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals in Saline Water -Suite A by ORC-ICPMS	EG093A-F	1	3	33.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals in Saline Water -Suite B by ORC-ICPMS	EG093B-F	1	3	33.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	1	10	10.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Total	ED093T	1	3	33.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Cyanide by Segmented Flow Analyser	EK026SF	1	18	5.56	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	17	5.88	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Saline Water Suite A by ORC-ICPMS	EG093A-T	1	3	33.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Saline Water -Suite B by ORC-ICPMS	EG093B-T	1	3	33.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							



Matrix: **WATER**

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	
Matrix Spikes (MS) - Continued							
Chemical Oxygen Demand (COD) (Spectrophotometric)	EP026SP	1	19	5.26	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	3	33.33	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals in Saline Water -Suite A by ORC-ICPMS	EG093A-F	1	3	33.33	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	1	10	10.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Cyanide by Segmented Flow Analyser	EK026SF	1	18	5.56	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	17	5.88	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Metals in Saline Water Suite A by ORC-ICPMS	EG093A-T	1	3	33.33	5.00	✔	NEPM 2013 B3 & ALS QC Standard



Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Sulfate (Turbidimetric) as SO ₄ 2- by Discrete Analyser	ED041G	WATER	In house: Referenced to APHA 4500-SO ₄ . Dissolved sulfate is determined in a 0.45µm filtered sample. Sulfate ions are converted to a barium sulfate suspension in an acetic acid medium with barium chloride. Light absorbance of the BaSO ₄ suspension is measured by a photometer and the SO ₄ -2 concentration is determined by comparison of the reading with a standard curve. This method is compliant with NEPM (2013) Schedule B(3)
Major Cations - Total	ED093T	WATER	In house: Referenced to APHA 3120; USEPA SW 846 - 6010. Samples are digested by USEPA 3005 prior to analysis. The ICPAES technique ionises the sample atoms emitting a characteristic spectrum. This spectrum is then compared against matrix matched standards for quantification. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Mercury by FIMS	EG035F	WATER	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl ₂)(Cold Vapour generation) AAS) Samples are 0.45µm filtered prior to analysis. FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl ₂ which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Total Mercury by FIMS	EG035T	WATER	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl ₂)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the unfiltered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl ₂ which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Metals in Saline Water -Suite A by ORC-ICPMS	EG093A-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020 Samples are 0.45µm filtered prior to analysis. The ORC-ICPMS technique removes interfering species through a series of chemical reactions prior to ion detection. Ions are passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to measurement by a discrete dynode ion detector. This method is compliant with NEPM (2013) Schedule B(3)
Total Metals in Saline Water Suite A by ORC-ICPMS	EG093A-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020. The ORC-ICPMS technique removes interfering species through a series of chemical reactions prior to ion detection. Ions are passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to measurement by a discrete dynode ion detector. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Metals in Saline Water -Suite B by ORC-ICPMS	EG093B-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020 Samples are 0.45µm filtered prior to analysis. The ORC-ICPMS technique removes interfering species through a series of chemical reactions prior to ion detection. Ions are passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to measurement by a discrete dynode ion detector. This method is compliant with NEPM (2013) Schedule B(3)
Total Metals in Saline Water -Suite B by ORC-ICPMS	EG093B-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020. The ORC-ICPMS technique removes interfering species through a series of chemical reactions prior to ion detection. Ions are passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to measurement by a discrete dynode ion detector. This method is compliant with NEPM (2013) Schedule B(3)



Analytical Methods	Method	Matrix	Method Descriptions
Total Cyanide by Segmented Flow Analyser	EK026SF	WATER	In house: Referenced to APHA 4500-CN C / ASTM D7511. Sodium hydroxide preserved samples are introduced into an automated segmented flow analyser. Complex bound cyanide is decomposed in a continuously flowing stream, at a pH of 3.8, by the effect of UV light. A UV-B lamp (312 nm) and a decomposition spiral of borosilicate glass are used to filter out UV light with a wavelength of less than 290 nm thus preventing the conversion of thiocyanate into cyanide. The hydrogen cyanide present at a pH of 3.8 is separated by gas dialysis. The hydrogen cyanide is then determined photometrically, based on the reaction of cyanide with chloramine-T to form cyanogen chloride. This then reacts with 4-pyridine carboxylic acid and 1,3-dimethylbarbituric acid to give a red colour which is measured at 600 nm. This method is compliant with NEPM (2013) Schedule B(3)
Fluoride by PC Titrator	EK040P	WATER	In house: Referenced to APHA 4500-F C: CDTA is added to the sample to provide a uniform ionic strength background, adjust pH, and break up complexes. Fluoride concentration is determined by either manual or automatic ISE measurement. This method is compliant with NEPM (2013) Schedule B(3)
Chemical Oxygen Demand (COD) (Spectrophotometric)	EP026SP	WATER	In house: Referenced to APHA 5220 D. Samples are digested with a known excess of an acidic potassium dichromate solution using silver sulfate as a catalyst. The chromium is reduced from the Cr (VI) oxidation state to the Cr (III) state by the oxygen present in the organic material. Both of these chromium species are coloured and absorb in the visible region of (400nm & 600nm) the spectrum. The oxidisable organic matter can be calculated in terms of oxygen equivalents.

Preparation Methods	Method	Matrix	Method Descriptions
TKN/TP Digestion	EK061/EK067	WATER	In house: Referenced to APHA 4500 Norg - D; APHA 4500 P - H. This method is compliant with NEPM (2013) Schedule B(3)
Digestion for Total Recoverable Metals	EN25	WATER	In house: Referenced to USEPA SW846-3005. Method 3005 is a Nitric/Hydrochloric acid digestion procedure used to prepare surface and ground water samples for analysis by ICPAES or ICPMS. This method is compliant with NEPM (2013) Schedule B(3)
Digestion for Total Recoverable Metals - ORC	EN25-ORC	WATER	In house: Referenced to USEPA SW846-3005. This is an Ultrapure Nitric acid digestion procedure used to prepare surface and ground water samples for analysis by ORC- ICPMS. This method is compliant with NEPM (2013) Schedule B(3)
Separatory Funnel Extraction of Liquids	ORG14	WATER	In house: Referenced to USEPA SW 846 - 3510B 100 mL to 1L of sample is transferred to a separatory funnel and serially extracted three times using DCM for each extract. The resultant extracts are combined, dehydrated and concentrated for analysis. This method is compliant with NEPM (2013) Schedule B(3) . ALS default excludes sediment which may be resident in the container.
Volatiles Water Preparation	ORG16-W	WATER	A 5 mL aliquot or 5 mL of a diluted sample is added to a 40 mL VOC vial for sparging.

QUALITY CONTROL REPORT

Work Order	: EB1909792	Page	: 1 of 5
Amendment	: 3		
Client	: COFFEY ENVIRONMENTS PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: ERICA COLLEY	Contact	: Andrew Epps
Address	: LEVEL WORKPLES BUILDING SAVANNAH HEIGHTS SECTION 531, LOT 12 WAIGANI DRIVE HOHOLA, NCD PNG	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: 64277004057	Telephone	: +61 7 3552 8639
Project	: 754-MELEN224697 JDD PROJECT	Date Samples Received	: 15-Apr-2019
Order number	: BN/065/19	Date Analysis Commenced	: 15-Apr-2019
C-O-C number	: ----	Issue Date	: 31-Mar-2020
Sampler	: ERICA COLLEY		
Site	:		
Quote number	: EN/222		
No. of samples received	: 13		
No. of samples analysed	: 4		



Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics, Smithfield, NSW
Franco Lentini	LCMS Coordinator	Sydney Organics, Smithfield, NSW
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
 CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
 LOR = Limit of reporting
 RPD = Relative Percentage Difference
 # = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EA002: pH 1:5 (Soils) (QC Lot: 2329702)									
EB1909792-001	SED 14	EA002: pH Value	----	0.1	pH Unit	8.5	8.5	0.00	0% - 20%
EW1901846-001	Anonymous	EA002: pH Value	----	0.1	pH Unit	12.2	12.3	0.00	0% - 20%
EA002: pH 1:5 (Soils) (QC Lot: 2330089)									
EW1901825-007	Anonymous	EA002: pH Value	----	0.1	pH Unit	8.6	7.7	10.8	0% - 20%
EB1909792-002	SED 26	EA002: pH Value	----	0.1	pH Unit	8.5	8.5	0.00	0% - 20%
EA055: Moisture Content (Dried @ 105-110°C) (QC Lot: 2310338)									
EB1909792-003	SED 15	EA055: Moisture Content	----	0.1	%	21.7	23.6	8.48	0% - 20%
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 2329703)									
EB1909792-001	SED 14	EK059G: Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.2	0.3	51.7	No Limit
EW1901846-001	Anonymous	EK059G: Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.2	0.2	0.00	No Limit
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 2330090)									
EB1909792-002	SED 26	EK059G: Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.4	0.4	0.00	No Limit
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QC Lot: 2304015)									
EB1909792-001	SED 14	EK061G: Total Kjeldahl Nitrogen as N	----	20	mg/kg	1320	1340	1.52	0% - 20%
WN1902631-001	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	20	mg/kg	390	400	3.20	0% - 20%
EP003: Total Organic Carbon (TOC) in Soil (QC Lot: 2334418)									
EM1905995-001	Anonymous	EP003: Total Organic Carbon	----	0.02	%	4.47	3.87	14.3	0% - 20%
EB1909792-001	SED 14	EP003: Total Organic Carbon	----	0.02	%	0.93	0.93	0.00	0% - 20%
EP003TC: Total Carbon (TC) in Soil (QC Lot: 2334419)									
EB1909792-001	SED 14	EP003TC: Total Carbon	TC	0.02	%	5.14	5.14	0.00	0% - 20%
EP202A: Phenoxycetic Acid Herbicides by LCMS (QC Lot: 2303965)									
EB1909792-001	SED 14	EP202: 4-Chlorophenoxy acetic acid	122-88-3	0.02	mg/kg	<0.02	<0.02	0.00	No Limit
		EP202: 2,4-DB	94-82-6	0.02	mg/kg	<0.02	<0.02	0.00	No Limit

Page : 3 of 5
 Work Order : EB1909792 Amendment 3
 Client : COFFEY ENVIRONMENTS PTY LTD
 Project : 754-MELEN224697 JDD PROJECT



Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EP202A: Phenoxyacetic Acid Herbicides by LCMS (QC Lot: 2303965) - continued									
EB1909792-001	SED 14	EP202: Dicamba	1918-00-9	0.02	mg/kg	<0.02	<0.02	0.00	No Limit
		EP202: Mecoprop	93-65-2	0.02	mg/kg	<0.02	<0.02	0.00	No Limit
		EP202: MCPA	94-74-6	0.02	mg/kg	<0.02	<0.02	0.00	No Limit
		EP202: 2,4-DP	120-36-5	0.02	mg/kg	<0.02	<0.02	0.00	No Limit
		EP202: 2,4-D	94-75-7	0.02	mg/kg	<0.02	<0.02	0.00	No Limit
		EP202: Triclopyr	55335-06-3	0.02	mg/kg	<0.02	<0.02	0.00	No Limit
		EP202: 2,4,5-TP (Silvex)	93-72-1	0.02	mg/kg	<0.02	<0.02	0.00	No Limit
		EP202: 2,4,5-T	93-76-5	0.02	mg/kg	<0.02	<0.02	0.00	No Limit
		EP202: MCPB	94-81-5	0.02	mg/kg	<0.02	<0.02	0.00	No Limit
		EP202: Picloram	1918-02-1	0.02	mg/kg	<0.02	<0.02	0.00	No Limit
		EP202: Clopyralid	1702-17-6	0.02	mg/kg	<0.02	<0.02	0.00	No Limit
		EP202: Fluroxypyr	69377-81-7	0.02	mg/kg	<0.02	<0.02	0.00	No Limit
Sub-Matrix: WATER				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EA025: Total Suspended Solids dried at 104 ± 2°C (QC Lot: 2297721)									
EB1909792-004	TSS_08 DEEP	EA025: Suspended Solids (SS)	----	1	mg/L	1	<1	0.00	No Limit



Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

Sub-Matrix: SOIL				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low High	
Method: Compound	CAS Number	LOR	Unit	Result				
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2329703)								
EK059G: Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	<0.1	2.5 mg/kg	103	88	118
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2330090)								
EK059G: Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	<0.1	2.5 mg/kg	105	88	118
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2304015)								
EK061G: Total Kjeldahl Nitrogen as N	----	20	mg/kg	<20	1000 mg/kg	88.7	72	106
				<20	100 mg/kg	96.0	70	122
				<20	500 mg/kg	90.3	74	118
EP003: Total Organic Carbon (TOC) in Soil (QCLot: 2334418)								
EP003: Total Organic Carbon	----	0.02	%	<0.02	0.44 %	103	70	130
EP003TC: Total Carbon (TC) in Soil (QCLot: 2334419)								
EP003TC: Total Carbon	TC	0.02	%	<0.02	4.16 %	111	70	130
EP202A: Phenoxyacetic Acid Herbicides by LCMS (QCLot: 2303965)								
EP202: 4-Chlorophenoxy acetic acid	122-88-3	0.02	mg/kg	<0.02	0.1 mg/kg	75.0	54	128
EP202: 2,4-DB	94-82-6	0.02	mg/kg	<0.02	0.1 mg/kg	53.0	46	130
EP202: Dicamba	1918-00-9	0.02	mg/kg	<0.02	0.1 mg/kg	61.9	52	135
EP202: Mecoprop	93-65-2	0.02	mg/kg	<0.02	0.1 mg/kg	63.8	60	130
EP202: MCPA	94-74-6	0.02	mg/kg	<0.02	0.1 mg/kg	66.2	57	131
EP202: 2,4-DP	120-36-5	0.02	mg/kg	<0.02	0.1 mg/kg	63.2	50	141
EP202: 2,4-D	94-75-7	0.02	mg/kg	<0.02	0.1 mg/kg	79.9	69	131
EP202: Triclopyr	55335-06-3	0.02	mg/kg	<0.02	0.1 mg/kg	59.0	51	141
EP202: 2,4,5-TP (Silvex)	93-72-1	0.02	mg/kg	<0.02	0.1 mg/kg	52.0	41	126
EP202: 2,4,5-T	93-76-5	0.02	mg/kg	<0.02	0.1 mg/kg	65.9	57	139
EP202: MCPB	94-81-5	0.02	mg/kg	<0.02	0.1 mg/kg	56.1	39	137
EP202: Picloram	1918-02-1	0.02	mg/kg	<0.02	0.1 mg/kg	54.6	49	129
EP202: Clopyralid	1702-17-6	0.02	mg/kg	<0.02	0.1 mg/kg	63.1	49	106
EP202: Fluroxypyr	69377-81-7	0.02	mg/kg	<0.02	0.1 mg/kg	58.2	53	128

Sub-Matrix: **WATER**

Sub-Matrix: WATER				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) LowHigh	
Method: Compound	CAS Number	LOR	Unit	Result				
EA025: Total Suspended Solids dried at 104 ± 2°C (QCLot: 2297721)								
EA025: Suspended Solids (SS)	----	1	mg/L	<1	150 mg/L	107	84	120
				<1	1000 mg/L	95.7	84	120



Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **SOIL**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2329703)							
EB1909792-001	SED 14	EK059G: Nitrite + Nitrate as N (Sol.)	----	2.5 mg/kg	109	70	130
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2330090)							
EB1909792-002	SED 26	EK059G: Nitrite + Nitrate as N (Sol.)	----	2.5 mg/kg	107	70	130
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2304015)							
EB1909792-001	SED 14	EK061G: Total Kjeldahl Nitrogen as N	----	500 mg/kg	# 64.4	70	130
EP202A: Phenoxyacetic Acid Herbicides by LCMS (QCLot: 2303965)							
EB1909792-001	SED 14	EP202: Mecoprop	93-65-2	0.1 mg/kg	62.5	60	140
		EP202: MCPA	94-74-6	0.1 mg/kg	64.0	57	143
		EP202: 2,4-D	94-75-7	0.1 mg/kg	69.6	68	139
		EP202: Triclopyr	55335-06-3	0.1 mg/kg	65.6	51	145
		EP202: 2,4,5-T	93-76-5	0.1 mg/kg	70.5	57	142
		EP202: Picloram	1918-02-1	0.1 mg/kg	67.6	49	138
		EP202: Clopyralid	1702-17-6	0.1 mg/kg	54.4	49	149

QA/QC Compliance Assessment to assist with Quality Review

Work Order : **EB1909792**

Page : 1 of 8

Amendment : **3**

Client : **COFFEY ENVIRONMENTS PTY LTD**

Laboratory : Environmental Division Brisbane

Contact : ERICA COLLEY

Telephone : +61 7 3552 8639

Project : 754-MELEN224697 JDD PROJECT

Date Samples Received : 15-Apr-2019

Site :

Issue Date : 31-Mar-2020

Sampler : ERICA COLLEY

No. of samples received : 13

Order number : BN/065/19

No. of samples analysed : 4

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO** Method Blank value outliers occur.
- **NO** Duplicate outliers occur.
- **NO** Laboratory Control outliers occur.
- Matrix Spike outliers exist - please see following pages for full details.
- For all regular sample matrices, **NO** surrogate recovery outliers occur.

Outliers : Analysis Holding Time Compliance

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- Quality Control Sample Frequency Outliers exist - please see following pages for full details.



Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **SOIL**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries							
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser	EB1909792--001	SED 14	Total Kjeldahl Nitrogen as N	----	64.4 %	70-130%	Recovery less than lower data quality objective

Outliers : Analysis Holding Time Compliance

Matrix: **SOIL**

Method Container / Client Sample ID(s)	Extraction / Preparation			Analysis		
	Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EA002: pH 1:5 (Soils)						
Soil Glass Jar - Unpreserved SED 14	06-May-2019	13-Apr-2019	23	----	----	----
Soil Glass Jar - Unpreserved SED 26	07-May-2019	13-Apr-2019	24	----	----	----
Soil Glass Jar - Unpreserved SED 15	07-May-2019	15-Apr-2019	22	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)						
Soil Glass Jar - Unpreserved SED 14, SED 26	----	----	----	23-Apr-2019	20-Apr-2019	3
Soil Glass Jar - Unpreserved SED 15	----	----	----	23-Apr-2019	22-Apr-2019	1
EP003: Total Organic Carbon (TOC) in Soil						
Pulp Bag SED 14, SED 26	08-May-2019	04-May-2019	4	08-May-2019	04-May-2019	4
Pulp Bag SED 15	08-May-2019	06-May-2019	2	08-May-2019	06-May-2019	2
EP003TC: Total Carbon (TC) in Soil						
Pulp Bag SED 14, SED 26	08-May-2019	04-May-2019	4	08-May-2019	04-May-2019	4
Pulp Bag SED 15	08-May-2019	06-May-2019	2	08-May-2019	06-May-2019	2

Matrix: **WATER**

Method Container / Client Sample ID(s)	Extraction / Preparation			Analysis		
	Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EA025: Total Suspended Solids dried at 104 ± 2°C						
Clear Plastic Bottle - Natural TSS_43	----	----	----	15-Apr-2019	14-Apr-2019	1

Outliers : Frequency of Quality Control Samples

Matrix: **SOIL**



Matrix: **SOIL**

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
Method	QC	Regular	Actual	Expected	
Laboratory Control Samples (LCS)					
Total Organic Carbon	1	20	5.00	10.00	NEPM 2013 B3 & ALS QC Standard

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for VOC in soils vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **SOIL**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA002: pH 1:5 (Soils)							
Soil Glass Jar - Unpreserved (EA002) SED 14	06-Apr-2019	06-May-2019	13-Apr-2019	✖	06-May-2019	06-May-2019	✓
Soil Glass Jar - Unpreserved (EA002) SED 26	06-Apr-2019	07-May-2019	13-Apr-2019	✖	07-May-2019	07-May-2019	✓
Soil Glass Jar - Unpreserved (EA002) SED 15	08-Apr-2019	07-May-2019	15-Apr-2019	✖	07-May-2019	07-May-2019	✓
EA055: Moisture Content (Dried @ 105-110°C)							
Soil Glass Jar - Unpreserved (EA055) SED 14, SED 26	06-Apr-2019	----	----	----	23-Apr-2019	20-Apr-2019	✖
Soil Glass Jar - Unpreserved (EA055) SED 15	08-Apr-2019	----	----	----	23-Apr-2019	22-Apr-2019	✖
EA150: Particle Sizing							
Snap Lock Bag (EA150H) SED 14, SED 26	06-Apr-2019	----	----	----	08-May-2019	03-Oct-2019	✓
Snap Lock Bag (EA150H) SED 15	08-Apr-2019	----	----	----	08-May-2019	05-Oct-2019	✓
EA150: Soil Classification based on Particle Size							
Snap Lock Bag (EA150H) SED 14, SED 26	06-Apr-2019	----	----	----	08-May-2019	03-Oct-2019	✓
Snap Lock Bag (EA150H) SED 15	08-Apr-2019	----	----	----	08-May-2019	05-Oct-2019	✓
EA152: Soil Particle Density							
Snap Lock Bag (EA152) SED 14, SED 26	06-Apr-2019	----	----	----	08-May-2019	03-Oct-2019	✓
Snap Lock Bag (EA152) SED 15	08-Apr-2019	----	----	----	08-May-2019	05-Oct-2019	✓



Matrix: **SOIL**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser							
Soil Glass Jar - Unpreserved (EK059G) SED 14	06-Apr-2019	06-May-2019	03-Oct-2019	✔	06-May-2019	03-Oct-2019	✔
Soil Glass Jar - Unpreserved (EK059G) SED 26	06-Apr-2019	07-May-2019	03-Oct-2019	✔	07-May-2019	03-Oct-2019	✔
Soil Glass Jar - Unpreserved (EK059G) SED 15	08-Apr-2019	07-May-2019	05-Oct-2019	✔	07-May-2019	05-Oct-2019	✔
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser							
Soil Glass Jar - Unpreserved (EK061G) SED 14, SED 26	06-Apr-2019	18-Apr-2019	03-Oct-2019	✔	18-Apr-2019	03-Oct-2019	✔
Soil Glass Jar - Unpreserved (EK061G) SED 15	08-Apr-2019	18-Apr-2019	05-Oct-2019	✔	18-Apr-2019	05-Oct-2019	✔
EP003: Total Organic Carbon (TOC) in Soil							
Pulp Bag (EP003) SED 14, SED 26	06-Apr-2019	08-May-2019	04-May-2019	✖	08-May-2019	04-May-2019	✖
Pulp Bag (EP003) SED 15	08-Apr-2019	08-May-2019	06-May-2019	✖	08-May-2019	06-May-2019	✖
EP003TC: Total Carbon (TC) in Soil							
Pulp Bag (EP003TC) SED 14, SED 26	06-Apr-2019	08-May-2019	04-May-2019	✖	08-May-2019	04-May-2019	✖
Pulp Bag (EP003TC) SED 15	08-Apr-2019	08-May-2019	06-May-2019	✖	08-May-2019	06-May-2019	✖
EP202A: Phenoxyacetic Acid Herbicides by LCMS							
Soil Glass Jar - Unpreserved (EP202) SED 14, SED 26	06-Apr-2019	18-Apr-2019	20-Apr-2019	✔	18-Apr-2019	28-May-2019	✔
Soil Glass Jar - Unpreserved (EP202) SED 15	08-Apr-2019	18-Apr-2019	22-Apr-2019	✔	18-Apr-2019	28-May-2019	✔

Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA025: Total Suspended Solids dried at 104 ± 2°C							
Clear Plastic Bottle - Natural (EA025) TSS 43	07-Apr-2019	----	----	----	15-Apr-2019	14-Apr-2019	✖

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Matrix: **WATER** Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	
Laboratory Duplicates (DUP)							
Suspended Solids	EA025	1	1	100.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Suspended Solids	EA025	2	1	200.00	15.00	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							



Matrix: **WATER**

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	
Method Blanks (MB) - Continued							
Suspended Solids	EA025	1	1	100.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard



Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
pH (1:5)	EA002	SOIL	In house: Referenced to Rayment and Lyons 4A1 and APHA 4500H+. pH is determined on soil samples after a 1:5 soil/water leach. This method is compliant with NEPM (2013) Schedule B(3)
Moisture Content	EA055	SOIL	In house: A gravimetric procedure based on weight loss over a 12 hour drying period at 105-110 degrees C. This method is compliant with NEPM (2013) Schedule B(3) Section 6.1 and Table 1 (14 day holding time).
Particle Size Analysis by Hydrometer	EA150H	SOIL	Particle Size Analysis by Hydrometer according to AS1289.3.6.3 - 2003
Soil Particle Density	EA152	SOIL	Soil Particle Density by AS 1289.3.5.1-2006 : Methods of testing soils for engineering purposes - Soil classification tests - Determination of the soil particle density of a soil - Standard method
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	SOIL	In house: Thermo Scientific Method D08727 and NEMI (National Environmental Method Index) Method ID: 9171. This method covers the determination of total oxidised nitrogen (NOx-N) and nitrate (NO3-N) by calculation, Combined oxidised Nitrogen (NO2+NO3) in a water extract is determined by direct colourimetry by Discrete Analyser.
TKN as N By Discrete Analyser	EK061G	SOIL	In house: Referenced to APHA 4500-Norg-D Soil samples are digested using Kjeldahl digestion followed by determination by Discrete Analyser.
Total Nitrogen as N (TKN + NOx) By Discrete Analyser	EK062G	SOIL	In house: Referenced to APHA 4500 Norg/NO3- Total Nitrogen is determined as the sum of TKN and Oxidised Nitrogen, each determined separately as N.
Total Organic Carbon	EP003	SOIL	In house C-IR17. Dried and pulverised sample is reacted with acid to remove inorganic Carbonates, then combusted in a furnace in the presence of strong oxidants / catalysts. The evolved (Organic) Carbon (as CO2) is automatically measured by infra-red detector.
Total Carbon	EP003TC	SOIL	In house C-IR07. Dried and pulverised sample is combusted in a LECO furnace in the presence of strong oxidants / catalysts. The evolved Carbon (as CO2) is measured by infra-red detector
Total Inorganic Carbon	EP003TIC	SOIL	In house C-CAL15. Determined as the difference between Total Carbon and Organic Carbon.
Phenoxyacetic Acid Herbicides (LCMS - Standard DL)	EP202	SOIL	In house: LCMS (Electrospray in negative mode). Residues of acid herbicides are extracted from soil samples under the alkaline condition. An aliquot of the alkaline aqueous phase is taken and acidified before a SPE cleanup. After eluting off from the SPE cartridge, residues of acid herbicides are dissolved in HPLC mobile phase prior to instrument analysis.
Suspended Solids	EA025	WATER	In house: Referenced to APHA 2540D. A gravimetric procedure employed to determine the amount of 'non-filterable' residue in a aqueous sample. The prescribed GFC (1.2um) filter is rinsed with deionised water, oven dried and weighed prior to analysis. A well-mixed sample is filtered through a glass fibre filter (1.2um). The residue on the filter paper is dried at 104+/-2C . This method is compliant with NEPM (2013) Schedule B(3)

Preparation Methods	Method	Matrix	Method Descriptions
TKN/TP Digestion	EK061/EK067	SOIL	In house: Referenced to APHA 4500 Norg- D; APHA 4500 P - H. Macro Kjeldahl digestion.
1:5 solid / water leach for soluble analytes	EN34	SOIL	10 g of soil is mixed with 50 mL of reagent grade water and tumbled end over end for 1 hour. Water soluble salts are leached from the soil by the continuous suspension. Samples are settled and the water filtered off for analysis.
Extraction for Phenoxy Acid Herbicides in Soils.	EP202-PR	SOIL	In-House: Alkaline extract followed by SPE clean up of acidified portion of the sample extract.

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Project : 754-MELEN224697 JDD PROJECT



Preparation Methods	Method	Matrix	Method Descriptions
Dry and Pulverise (up to 100g)	GEO30	SOIL	#
Methanolic Extraction of Soils for Purge and Trap	ORG16	SOIL	In house: Referenced to USEPA SW 846 - 5030A. 5g of solid is shaken with surrogate and 10mL methanol prior to analysis by Purge and Trap - GC/MS.
Tumbler Extraction of Solids/ Sample Cleanup	ORG17A-UTP	SOIL	In house: Mechanical agitation (tumbler). 20g of sample, Na2SO4 and surrogate are extracted with 150mL 1:1 DCM/Acetone by end over end tumble. Samples are extracted, concentrated (by KD) and exchanged into an appropriate solvent for GPC and florisil cleanup as required.
Tumbler Extraction of Solids for LVI (Non-concentrating)	ORG17D	SOIL	In house: 10g of sample, Na2SO4 and surrogate are extracted with 50mL 1:1 DCM/Acetone by end over end tumbling. An aliquot is concentrated by nitrogen blowdown to a reduced volume for analysis if required.

QUALITY CONTROL REPORT

Work Order : **EB1910136**

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Amendment : **3**

Client : **COFFEY ENVIRONMENTS PTY LTD**

Contact : **MS ERICA COLLEY**

Address : Level 5 12 Creek St
Brisbane QLD, AUSTRALIA 4000

Telephone : +61 07 3608 2500

Project : **754-MELEN224697 JDD PROJECT**

Order number : **BN/065/19**

C-O-C number : ----

Sampler : **E COLLEY**

Site : ----

Quote number : **BN/065/19 V2**

No. of samples received : **45**

No. of samples analysed : **45**

Laboratory : Environmental Division Brisbane

Contact : Andrew Epps

Address : 2 Byth Street Stafford QLD Australia 4053

Telephone : +61 7 3552 8639

Date Samples Received : 17-Apr-2019

Date Analysis Commenced : 18-Apr-2019

Issue Date : 05-Dec-2019



Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Santusha Pandra	Senior Chemist	Brisbane Organics, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high

Key :
 Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
 CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
 LOR = Limit of reporting
 RPD = Relative Percentage Difference
 # = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EA025: Total Suspended Solids dried at 104 ± 2°C (QC Lot: 2304623)									
EB1910136-001	TSS_16 Deep	EA025: Suspended Solids (SS)	----	1	mg/L	<1	1	0.00	No Limit
EB1910136-012	TSS_36 Deep	EA025: Suspended Solids (SS)	----	1	mg/L	2	1	64.9	No Limit
EA025: Total Suspended Solids dried at 104 ± 2°C (QC Lot: 2304624)									
EB1910136-027	TSS_20	EA025: Suspended Solids (SS)	----	1	mg/L	<1	1	0.00	No Limit
EB1910136-037	TSS_11 Deep	EA025: Suspended Solids (SS)	----	1	mg/L	<1	<1	0.00	No Limit
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 2304649)									
EB1910136-002	WQ_16	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	2480	2550	2.97	0% - 20%
EB1910136-020	WQ_06	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	2450	2430	0.877	0% - 20%
EG035F: Dissolved Mercury by FIMS (QC Lot: 2308381)									
EB1910136-002	WQ_16	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EB1910136-020	WQ_06	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 2308642)									
EB1910136-002	WQ_16	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EB1910136-020	WQ_06	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS (QC Lot: 2308346)									
EB1910136-002	WQ_16	EG093A-F: Beryllium	7440-41-7	0.1	µg/L	<0.1	<0.1	0.00	No Limit
		EG093A-F: Molybdenum	7439-98-7	0.1	µg/L	10.1	10.0	0.00	0% - 20%
		EG093A-F: Silver	7440-22-4	0.1	µg/L	<0.1	<0.1	0.00	No Limit
		EG093A-F: Cadmium	7440-43-9	0.2	µg/L	<0.1	<0.1	0.00	No Limit
		EG093A-F: Cobalt	7440-48-4	0.2	µg/L	<0.2	<0.2	0.00	No Limit
		EG093A-F: Lead	7439-92-1	0.2	µg/L	<0.2	<0.2	0.00	No Limit
		EG093A-F: Antimony	7440-36-0	0.5	µg/L	<0.5	<0.5	0.00	No Limit
		EG093A-F: Arsenic	7440-38-2	0.5	µg/L	1.9	1.8	0.00	No Limit
		EG093A-F: Chromium	7440-47-3	0.5	µg/L	<0.5	<0.5	0.00	No Limit



Sub-Matrix: **WATER**

Sub-Matrix: WATER				Laboratory Duplicate (DUP) Report							
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)		
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS (QC Lot: 2308346) - continued											
EB1910136-002	WQ_16	EG093A-F: Manganese	7439-96-5	0.5	µg/L	0.5	0.6	19.0	No Limit		
		EG093A-F: Nickel	7440-02-0	0.5	µg/L	<0.5	<0.5	0.00	No Limit		
		EG093A-F: Vanadium	7440-62-2	0.5	µg/L	2.0	2.1	6.54	No Limit		
		EG093A-F: Barium	7440-39-3	1	µg/L	4	4	0.00	No Limit		
		EG093A-F: Copper	7440-50-8	1	µg/L	<1	<1	0.00	No Limit		
		EG093A-F: Boron	7440-42-8	100	µg/L	4450	4550	2.23	0% - 20%		
		EG093A-F: Aluminium	7429-90-5	5	µg/L	<5	<5	0.00	No Limit		
		EG093A-F: Tin	7440-31-5	5	µg/L	<5	<5	0.00	No Limit		
		EG093A-F: Zinc	7440-66-6	5	µg/L	<5	<5	0.00	No Limit		
EB1910136-019	WQ_14	EG093A-F: Beryllium	7440-41-7	0.1	µg/L	<0.1	<0.1	0.00	No Limit		
		EG093A-F: Molybdenum	7439-98-7	0.1	µg/L	9.4	9.4	0.00	0% - 20%		
		EG093A-F: Silver	7440-22-4	0.1	µg/L	<0.1	<0.1	0.00	No Limit		
		EG093A-F: Cadmium	7440-43-9	0.2	µg/L	<0.1	<0.1	0.00	No Limit		
		EG093A-F: Cobalt	7440-48-4	0.2	µg/L	<0.2	<0.2	0.00	No Limit		
		EG093A-F: Lead	7439-92-1	0.2	µg/L	<0.2	<0.2	0.00	No Limit		
		EG093A-F: Antimony	7440-36-0	0.5	µg/L	<0.5	<0.5	0.00	No Limit		
		EG093A-F: Arsenic	7440-38-2	0.5	µg/L	1.5	1.6	8.16	No Limit		
		EG093A-F: Chromium	7440-47-3	0.5	µg/L	<0.5	<0.5	0.00	No Limit		
		EG093A-F: Manganese	7439-96-5	0.5	µg/L	<0.5	0.6	18.7	No Limit		
		EG093A-F: Nickel	7440-02-0	0.5	µg/L	<0.5	<0.5	0.00	No Limit		
		EG093A-F: Vanadium	7440-62-2	0.5	µg/L	1.9	1.9	0.00	No Limit		
		EG093A-F: Barium	7440-39-3	1	µg/L	6	6	0.00	No Limit		
		EG093A-F: Copper	7440-50-8	1	µg/L	1	1	0.00	No Limit		
		EG093A-F: Boron	7440-42-8	100	µg/L	4170	4280	2.47	0% - 20%		
		EG093A-F: Aluminium	7429-90-5	5	µg/L	<5	<5	0.00	No Limit		
		EG093A-F: Tin	7440-31-5	5	µg/L	<5	<5	0.00	No Limit		
		EG093A-F: Zinc	7440-66-6	5	µg/L	<5	<5	0.00	No Limit		
		EG093F: Dissolved Metals in Saline Water by ORC-ICPMS (QC Lot: 2308347)									
		EB1910136-002	WQ_16	EG093B-F: Selenium	7782-49-2	2	µg/L	10	10	0.00	No Limit
EG093B-F: Iron	7439-89-6			5	µg/L	<5	<5	0.00	No Limit		
EB1910136-019	WQ_14	EG093B-F: Selenium	7782-49-2	2	µg/L	10	10	0.00	No Limit		
		EG093B-F: Iron	7439-89-6	5	µg/L	<5	<5	0.00	No Limit		
EG093T: Total Metals in Saline Water by ORC-ICPMS (QC Lot: 2308351)											
EB1910136-002	WQ_16	EG093A-T: Beryllium	7440-41-7	0.1	µg/L	<0.1	<0.1	0.00	No Limit		
		EG093A-T: Molybdenum	7439-98-7	0.1	µg/L	10.6	10.8	2.44	0% - 20%		
		EG093A-T: Silver	7440-22-4	0.1	µg/L	<0.1	<0.1	0.00	No Limit		
		EG093A-T: Cadmium	7440-43-9	0.2	µg/L	<0.2	<0.2	0.00	No Limit		
		EG093A-T: Cobalt	7440-48-4	0.2	µg/L	<0.2	<0.2	0.00	No Limit		
		EG093A-T: Lead	7439-92-1	0.2	µg/L	<0.2	<0.2	0.00	No Limit		
		EG093A-T: Antimony	7440-36-0	0.5	µg/L	<0.5	<0.5	0.00	No Limit		

Sub-Matrix: WATER				Laboratory Duplicate (DUP) Report							
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)		
EG093T: Total Metals in Saline Water by ORC-ICPMS (QC Lot: 2308351) - continued											
EB1910136-002	WQ_16	EG093A-T: Arsenic	7440-38-2	0.5	µg/L	1.5	1.6	0.00	No Limit		
		EG093A-T: Chromium	7440-47-3	0.5	µg/L	<0.5	<0.5	0.00	No Limit		
		EG093A-T: Manganese	7439-96-5	0.5	µg/L	0.9	0.9	0.00	No Limit		
		EG093A-T: Nickel	7440-02-0	0.5	µg/L	<0.5	<0.5	0.00	No Limit		
		EG093A-T: Vanadium	7440-62-2	0.5	µg/L	1.7	1.7	0.00	No Limit		
		EG093A-T: Barium	7440-39-3	1	µg/L	4	5	0.00	No Limit		
		EG093A-T: Copper	7440-50-8	1	µg/L	<1	<1	0.00	No Limit		
		EG093A-T: Boron	7440-42-8	100	µg/L	4330	3980	8.48	0% - 20%		
		EG093A-T: Tin	7440-31-5	5	µg/L	<5	<5	0.00	No Limit		
		EG093A-T: Zinc	7440-66-6	5	µg/L	<5	<5	0.00	No Limit		
EB1910136-019	WQ_14	EG093A-T: Beryllium	7440-41-7	0.1	µg/L	<0.1	<0.1	0.00	No Limit		
		EG093A-T: Molybdenum	7439-98-7	0.1	µg/L	9.8	9.6	2.27	0% - 20%		
		EG093A-T: Silver	7440-22-4	0.1	µg/L	<0.1	<0.1	0.00	No Limit		
		EG093A-T: Cadmium	7440-43-9	0.2	µg/L	<0.2	<0.2	0.00	No Limit		
		EG093A-T: Cobalt	7440-48-4	0.2	µg/L	<0.2	<0.2	0.00	No Limit		
		EG093A-T: Lead	7439-92-1	0.2	µg/L	<0.2	<0.2	0.00	No Limit		
		EG093A-T: Antimony	7440-36-0	0.5	µg/L	<0.5	<0.5	0.00	No Limit		
		EG093A-T: Arsenic	7440-38-2	0.5	µg/L	1.3	1.4	0.00	No Limit		
		EG093A-T: Chromium	7440-47-3	0.5	µg/L	<0.5	<0.5	0.00	No Limit		
		EG093A-T: Manganese	7439-96-5	0.5	µg/L	<0.5	0.5	0.00	No Limit		
		EG093A-T: Nickel	7440-02-0	0.5	µg/L	<0.5	<0.5	0.00	No Limit		
		EG093A-T: Vanadium	7440-62-2	0.5	µg/L	1.6	1.6	0.00	No Limit		
		EG093A-T: Barium	7440-39-3	1	µg/L	6	6	0.00	No Limit		
		EG093A-T: Copper	7440-50-8	1	µg/L	<1	<1	0.00	No Limit		
		EG093A-T: Boron	7440-42-8	100	µg/L	3500	3460	1.13	0% - 20%		
		EG093A-T: Tin	7440-31-5	5	µg/L	<5	<5	0.00	No Limit		
		EG093A-T: Zinc	7440-66-6	5	µg/L	<5	<5	0.00	No Limit		
		EG093T: Total Metals in Saline Water by ORC-ICPMS (QC Lot: 2308352)									
		EB1910136-002	WQ_16	EG093B-T: Selenium	7782-49-2	2	µg/L	5	4	0.00	No Limit
				EG093B-T: Iron	7439-89-6	5	µg/L	8	8	0.00	No Limit
EB1910136-019	WQ_14	EG093B-T: Selenium	7782-49-2	2	µg/L	4	4	0.00	No Limit		
		EG093B-T: Iron	7439-89-6	5	µg/L	<5	<5	0.00	No Limit		
EK026SF: Total CN by Segmented Flow Analyser (QC Lot: 2308928)											
EB1910136-002	WQ_16	EK026SF: Total Cyanide	57-12-5	0.004	mg/L	<0.004	<0.004	0.00	No Limit		
EB1910136-020	WQ_06	EK026SF: Total Cyanide	57-12-5	0.004	mg/L	<0.004	<0.004	0.00	No Limit		
EK040P: Fluoride by PC Titrator (QC Lot: 2306069)											
EB1910032-011	Anonymous	EK040P: Fluoride	16984-48-8	0.1	mg/L	0.3	0.3	0.00	No Limit		
EB1910136-019	WQ_14	EK040P: Fluoride	16984-48-8	0.1	mg/L	0.9	0.8	0.00	No Limit		
EK085M: Sulfide as S2- (QC Lot: 2307338)											

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 Work Order : EB1910136 Amendment 3
 Client : COFFEY ENVIRONMENTS PTY LTD
 Project : 754-MELEN224697 JDD PROJECT



Sub-Matrix: WATER				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EK085M: Sulfide as S2- (QC Lot: 2307338) - continued									
EB1910097-002	Anonymous	EK085: Sulfide as S2-	18496-25-8	0.1	mg/L	<0.1	<0.1	0.00	No Limit
EB1910100-003	Anonymous	EK085: Sulfide as S2-	18496-25-8	0.1	mg/L	<0.1	<0.1	0.00	No Limit
EK085M: Sulfide as S2- (QC Lot: 2307339)									
EB1910136-015	WQ_05	EK085: Sulfide as S2-	18496-25-8	0.1	mg/L	<0.1	<0.1	0.00	No Limit
EB1910153-001	Anonymous	EK085: Sulfide as S2-	18496-25-8	0.1	mg/L	0.1	0.1	0.00	No Limit
EP080/071: Total Petroleum Hydrocarbons (QC Lot: 2308545)									
EB1910136-007	WQ_10	EP080: C6 - C9 Fraction	----	20	µg/L	<20	<20	0.00	No Limit
EB1910136-020	WQ_06	EP080: C6 - C9 Fraction	----	20	µg/L	<20	<20	0.00	No Limit
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QC Lot: 2308545)									
EB1910136-007	WQ_10	EP080: C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	0.00	No Limit
EB1910136-020	WQ_06	EP080: C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	0.00	No Limit
EP080: BTEXN (QC Lot: 2308545)									
EB1910136-007	WQ_10	EP080: Benzene	71-43-2	1	µg/L	<1	<1	0.00	No Limit
		EP080: Toluene	108-88-3	2	µg/L	<2	<2	0.00	No Limit
		EP080: Ethylbenzene	100-41-4	2	µg/L	<2	<2	0.00	No Limit
		EP080: meta- & para-Xylene	108-38-3	2	µg/L	<2	<2	0.00	No Limit
			106-42-3						
		EP080: ortho-Xylene	95-47-6	2	µg/L	<2	<2	0.00	No Limit
EB1910136-020	WQ_06	EP080: Naphthalene	91-20-3	5	µg/L	<5	<5	0.00	No Limit
		EP080: Benzene	71-43-2	1	µg/L	<1	<1	0.00	No Limit
		EP080: Toluene	108-88-3	2	µg/L	<2	<2	0.00	No Limit
		EP080: Ethylbenzene	100-41-4	2	µg/L	<2	<2	0.00	No Limit
		EP080: meta- & para-Xylene	108-38-3	2	µg/L	<2	<2	0.00	No Limit
			106-42-3						
		EP080: ortho-Xylene	95-47-6	2	µg/L	<2	<2	0.00	No Limit
		EP080: Naphthalene	91-20-3	5	µg/L	<5	<5	0.00	No Limit



Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report Result	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit				Low	High
EA025: Total Suspended Solids dried at 104 ± 2°C (QCLot: 2304623)								
EA025: Suspended Solids (SS)	----	1	mg/L	<1	150 mg/L	102	84	120
				<1	1000 mg/L	92.5	84	120
EA025: Total Suspended Solids dried at 104 ± 2°C (QCLot: 2304624)								
EA025: Suspended Solids (SS)	----	1	mg/L	<1	150 mg/L	96.8	84	120
				<1	1000 mg/L	95.8	84	120
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 2304649)								
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	25 mg/L	104	85	118
				<1	100 mg/L	97.4	85	118
EG035F: Dissolved Mercury by FIMS (QCLot: 2308381)								
EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.01 mg/L	95.8	84	118
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2308642)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.01 mg/L	95.0	84	118
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS (QCLot: 2308346)								
EG093A-F: Aluminium	7429-90-5	5	µg/L	<5	50 µg/L	95.9	85	118
EG093A-F: Antimony	7440-36-0	0.5	µg/L	<0.5	10 µg/L	91.6	87	115
EG093A-F: Arsenic	7440-38-2	0.5	µg/L	<0.5	10 µg/L	103	87	116
EG093A-F: Barium	7440-39-3	1	µg/L	<1	50 µg/L	94.0	87	114
EG093A-F: Beryllium	7440-41-7	0.1	µg/L	<0.1	10 µg/L	98.0	80	120
EG093A-F: Boron	7440-42-8	100	µg/L	<100	500 µg/L	99.5	82	114
EG093A-F: Cadmium	7440-43-9	0.2	µg/L	<0.2	10 µg/L	99.7	88	114
EG093A-F: Chromium	7440-47-3	0.5	µg/L	<0.5	10 µg/L	95.3	83	115
EG093A-F: Cobalt	7440-48-4	0.2	µg/L	<0.2	10 µg/L	98.5	86	116
EG093A-F: Copper	7440-50-8	1	µg/L	<1	20 µg/L	101	81	117
EG093A-F: Lead	7439-92-1	0.2	µg/L	<0.2	10 µg/L	99.4	80	117
EG093A-F: Manganese	7439-96-5	0.5	µg/L	<0.5	10 µg/L	97.8	80	119
EG093A-F: Molybdenum	7439-98-7	0.1	µg/L	<0.1	10 µg/L	100	80	118
EG093A-F: Nickel	7440-02-0	0.5	µg/L	<0.5	10 µg/L	95.8	87	117
EG093A-F: Silver	7440-22-4	0.1	µg/L	<0.1	10 µg/L	95.2	80	127
EG093A-F: Tin	7440-31-5	5	µg/L	<5	10 µg/L	97.3	82	118
EG093A-F: Vanadium	7440-62-2	0.5	µg/L	<0.5	10 µg/L	108	89	117
EG093A-F: Zinc	7440-66-6	5	µg/L	<5	20 µg/L	101	81	120
EG093B-F: Dissolved Metals in Saline Water by ORC-ICPMS (QCLot: 2308347)								
EG093B-F: Iron	7439-89-6	5	µg/L	<5	50 µg/L	87.9	78	123
EG093B-F: Selenium	7782-49-2	2	µg/L	<2	10 µg/L	99.9	87	121



Sub-Matrix: **WATER**

Method: Compound				Method Blank (MB) Report Result	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%)	Recovery Limits (%)	
						LCS	Low	High
CAS Number	LOR	Unit						
EG093T: Total Metals in Saline Water by ORC-ICPMS (QCLot: 2308351)								
EG093A-T: Antimony	7440-36-0	0.5	µg/L	<0.5	10 µg/L	106	83	116
EG093A-T: Arsenic	7440-38-2	0.5	µg/L	<0.5	10 µg/L	104	86	117
EG093A-T: Barium	7440-39-3	1	µg/L	<1	50 µg/L	104	84	118
EG093A-T: Beryllium	7440-41-7	0.1	µg/L	<0.1	10 µg/L	111	87	120
EG093A-T: Boron	7440-42-8	100	µg/L	<105	500 µg/L	108	83	123
EG093A-T: Cadmium	7440-43-9	0.2	µg/L	<0.2	10 µg/L	104	84	115
EG093A-T: Chromium	7440-47-3	0.5	µg/L	<0.5	10 µg/L	104	84	120
EG093A-T: Cobalt	7440-48-4	0.2	µg/L	<0.2	10 µg/L	107	85	116
EG093A-T: Copper	7440-50-8	1	µg/L	<1	20 µg/L	104	84	119
EG093A-T: Lead	7439-92-1	0.2	µg/L	<0.2	10 µg/L	103	84	120
EG093A-T: Manganese	7439-96-5	0.5	µg/L	<0.5	10 µg/L	110	86	124
EG093A-T: Molybdenum	7439-98-7	0.1	µg/L	0.2	10 µg/L	106	84	118
EG093A-T: Nickel	7440-02-0	0.5	µg/L	<0.5	10 µg/L	107	80	120
EG093A-T: Silver	7440-22-4	0.1	µg/L	<0.1	10 µg/L	98.0	80	120
EG093A-T: Tin	7440-31-5	5	µg/L	<5	10 µg/L	105	83	114
EG093A-T: Vanadium	7440-62-2	0.5	µg/L	<0.5	10 µg/L	103	84	120
EG093A-T: Zinc	7440-66-6	5	µg/L	<5	20 µg/L	101	81	124
EG093T: Total Metals in Saline Water by ORC-ICPMS (QCLot: 2308352)								
EG093B-T: Iron	7439-89-6	5	µg/L	<5	50 µg/L	113	80	128
EG093B-T: Selenium	7782-49-2	2	µg/L	<2	10 µg/L	99.4	89	119
EK026SF: Total CN by Segmented Flow Analyser (QCLot: 2308928)								
EK026SF: Total Cyanide	57-12-5	0.004	mg/L	<0.004	0.2 mg/L	103	85	119
EK040P: Fluoride by PC Titrator (QCLot: 2306069)								
EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	5 mg/L	93.6	80	117
EK085M: Sulfide as S2- (QCLot: 2307338)								
EK085: Sulfide as S2-	18496-25-8	0.1	mg/L	<0.1	0.5 mg/L	113	80	123
EK085M: Sulfide as S2- (QCLot: 2307339)								
EK085: Sulfide as S2-	18496-25-8	0.1	mg/L	<0.1	0.5 mg/L	110	80	123
EP075(SIM)A: Phenolic Compounds (QCLot: 2304675)								
EP075(SIM): Phenol	108-95-2	1	µg/L	<1.0	10 µg/L	35.2	20	48
EP075(SIM): 2-Chlorophenol	95-57-8	1	µg/L	<1.0	10 µg/L	83.3	56	110
EP075(SIM): 2-Methylphenol	95-48-7	1	µg/L	<1.0	10 µg/L	67.7	48	99
EP075(SIM): 3- & 4-Methylphenol	1319-77-3	2	µg/L	<2.0	20 µg/L	64.6	43	93
EP075(SIM): 2-Nitrophenol	88-75-5	1	µg/L	<1.0	10 µg/L	85.8	37	130
EP075(SIM): 2,4-Dimethylphenol	105-67-9	1	µg/L	<1.0	10 µg/L	80.9	53	121
EP075(SIM): 2,4-Dichlorophenol	120-83-2	1	µg/L	<1.0	10 µg/L	84.3	56	120
EP075(SIM): 2,6-Dichlorophenol	87-65-0	1	µg/L	<1.0	10 µg/L	93.5	57	117
EP075(SIM): 4-Chloro-3-methylphenol	59-50-7	1	µg/L	<1.0	10 µg/L	82.8	48	116



Sub-Matrix: **WATER**

Sub-Matrix: WATER				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low High	
Method: Compound	CAS Number	LOR	Unit	Result				
EP075(SIM)A: Phenolic Compounds (QCLot: 2304675) - continued								
EP075(SIM): 2.4.6-Trichlorophenol	88-06-2	1	µg/L	<1.0	10 µg/L	103	48	125
EP075(SIM): 2.4.5-Trichlorophenol	95-95-4	1	µg/L	<1.0	10 µg/L	101	45	123
EP075(SIM): Pentachlorophenol	87-86-5	2	µg/L	<2.0	20 µg/L	109	16	130
EP075(SIM): 2.3.4.6-Tetrachlorophenol	58-90-2	1	µg/L	<1.0	10 µg/L	69.8	34	126
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons (QCLot: 2304675)								
EP075(SIM): Naphthalene	91-20-3	1	µg/L	<1.0	10 µg/L	88.5	50	110
EP075(SIM): Acenaphthylene	208-96-8	1	µg/L	<1.0	10 µg/L	78.1	49	124
EP075(SIM): Acenaphthene	83-32-9	1	µg/L	<1.0	10 µg/L	88.5	55	114
EP075(SIM): Fluorene	86-73-7	1	µg/L	<1.0	10 µg/L	85.3	55	119
EP075(SIM): Phenanthrene	85-01-8	1	µg/L	<1.0	10 µg/L	87.8	51	127
EP075(SIM): Anthracene	120-12-7	1	µg/L	<1.0	10 µg/L	84.7	55	127
EP075(SIM): Fluoranthene	206-44-0	1	µg/L	<1.0	10 µg/L	86.2	55	127
EP075(SIM): Pyrene	129-00-0	1	µg/L	<1.0	10 µg/L	87.3	54	126
EP075(SIM): Benz(a)anthracene	56-55-3	1	µg/L	<1.0	10 µg/L	70.2	47	136
EP075(SIM): Chrysene	218-01-9	1	µg/L	<1.0	10 µg/L	81.3	51	129
EP075(SIM): Benzo(b+j)fluoranthene	205-99-2	1	µg/L	<1.0	10 µg/L	78.1	55	132
	205-82-3							
EP075(SIM): Benzo(k)fluoranthene	207-08-9	1	µg/L	<1.0	10 µg/L	76.5	58	128
EP075(SIM): Benzo(a)pyrene	50-32-8	0.5	µg/L	<0.5	10 µg/L	74.0	55	131
EP075(SIM): Indeno(1.2.3.cd)pyrene	193-39-5	1	µg/L	<1.0	10 µg/L	82.7	52	133
EP075(SIM): Dibenz(a,h)anthracene	53-70-3	1	µg/L	<1.0	10 µg/L	84.9	48	137
EP075(SIM): Benzo(g,h,i)perylene	191-24-2	1	µg/L	<1.0	10 µg/L	76.0	53	131
EP080/071: Total Petroleum Hydrocarbons (QCLot: 2304676)								
EP071: C10 - C14 Fraction	----	50	µg/L	<50	1070 µg/L	79.6	65	135
EP071: C15 - C28 Fraction	----	100	µg/L	<100	1770 µg/L	91.4	62	138
EP071: C29 - C36 Fraction	----	50	µg/L	<50	----	----	----	----
EP080/071: Total Petroleum Hydrocarbons (QCLot: 2308545)								
EP080: C6 - C9 Fraction	----	20	µg/L	<20	160 µg/L	108	67	125
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 2304676)								
EP071: >C10 - C16 Fraction	----	100	µg/L	<100	1560 µg/L	87.0	66	134
EP071: >C16 - C34 Fraction	----	100	µg/L	<100	1190 µg/L	98.3	61	139
EP071: >C34 - C40 Fraction	----	100	µg/L	<100	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 2308545)								
EP080: C6 - C10 Fraction	C6_C10	20	µg/L	<20	185 µg/L	107	66	123
EP080: C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTE	20	µg/L	<20	----	----	----	----
	X							
EP080: BTEXN (QCLot: 2308545)								
EP080: Benzene	71-43-2	1	µg/L	<1	10 µg/L	107	73	119



Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low High	
Method: Compound	CAS Number	LOR	Unit	Result				
EP080: BTEXN (QCLot: 2308545) - continued								
EP080: Toluene	108-88-3	2	µg/L	<2	10 µg/L	101	75	119
EP080: Ethylbenzene	100-41-4	2	µg/L	<2	10 µg/L	103	73	118
EP080: meta- & para-Xylene	108-38-3	2	µg/L	<2	20 µg/L	107	77	121
	106-42-3							
EP080: ortho-Xylene	95-47-6	2	µg/L	<2	10 µg/L	103	76	121
EP080: Total Xylenes	----	2	µg/L	<2	----	----	----	----
EP080: Sum of BTEX	----	1	µg/L	<1	----	----	----	----
EP080: Naphthalene	91-20-3	5	µg/L	<5	10 µg/L	100	75	120

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

Sub-Matrix: WATER				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 2304649)							
EB1910136-004	WQ_03	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	20 mg/L	# Not Determined	70	130
EG035F: Dissolved Mercury by FIMS (QCLot: 2308381)							
EB1910136-004	WQ_03	EG035F: Mercury	7439-97-6	0.05 mg/L	81.8	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2308642)							
EB1910136-004	WQ_03	EG035T: Mercury	7439-97-6	0.05 mg/L	73.0	70	130
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS (QCLot: 2308346)							
EB1910136-004	WQ_03	EG093A-F: Arsenic	7440-38-2	50 µg/L	99.5	70	130
		EG093A-F: Barium	7440-39-3	250 µg/L	94.2	70	130
		EG093A-F: Beryllium	7440-41-7	50 µg/L	105	70	130
		EG093A-F: Cadmium	7440-43-9	50 µg/L	92.8	70	130
		EG093A-F: Chromium	7440-47-3	50 µg/L	93.8	70	130
		EG093A-F: Cobalt	7440-48-4	50 µg/L	98.8	70	130
		EG093A-F: Copper	7440-50-8	100 µg/L	96.2	70	130
		EG093A-F: Lead	7439-92-1	50 µg/L	92.0	70	130
		EG093A-F: Manganese	7439-96-5	50 µg/L	101	70	130
		EG093A-F: Nickel	7440-02-0	50 µg/L	103	70	130
		EG093A-F: Vanadium	7440-62-2	50 µg/L	90.5	70	130
		EG093A-F: Zinc	7440-66-6	100 µg/L	97.6	70	130
EG093T: Total Metals in Saline Water by ORC-ICPMS (QCLot: 2308351)							
EB1910136-004	WQ_03	EG093A-T: Arsenic	7440-38-2	50 µg/L	99.9	70	130

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 Work Order : EB1910136 Amendment 3
 Client : COFFEY ENVIRONMENTS PTY LTD
 Project : 754-MELEN224697 JDD PROJECT



Sub-Matrix: **WATER**

Sub-Matrix: WATER				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EG093T: Total Metals in Saline Water by ORC-ICPMS (QCLot: 2308351) - continued							
EB1910136-004	WQ_03	EG093A-T: Barium	7440-39-3	250 µg/L	101	70	130
		EG093A-T: Beryllium	7440-41-7	50 µg/L	92.0	70	130
		EG093A-T: Cadmium	7440-43-9	50 µg/L	96.2	70	130
		EG093A-T: Chromium	7440-47-3	50 µg/L	101	70	130
		EG093A-T: Cobalt	7440-48-4	50 µg/L	98.3	70	130
		EG093A-T: Copper	7440-50-8	100 µg/L	95.6	70	130
		EG093A-T: Lead	7439-92-1	50 µg/L	98.1	70	130
		EG093A-T: Manganese	7439-96-5	50 µg/L	98.0	70	130
		EG093A-T: Nickel	7440-02-0	50 µg/L	95.7	70	130
		EG093A-T: Vanadium	7440-62-2	50 µg/L	100	70	130
		EG093A-T: Zinc	7440-66-6	100 µg/L	95.5	70	130
EK026SF: Total CN by Segmented Flow Analyser (QCLot: 2308928)							
EB1910136-004	WQ_03	EK026SF: Total Cyanide	57-12-5	0.4 mg/L	95.2	70	130
EK040P: Fluoride by PC Titrator (QCLot: 2306069)							
EB1910136-002	WQ_16	EK040P: Fluoride	16984-48-8	10 mg/L	73.6	70	130
EK085M: Sulfide as S2- (QCLot: 2307338)							
EB1910097-003	Anonymous	EK085: Sulfide as S2-	18496-25-8	1.0636 mg/L	79.8	70	130
EK085M: Sulfide as S2- (QCLot: 2307339)							
EB1910136-016	WQ_04	EK085: Sulfide as S2-	18496-25-8	1.0636 mg/L	87.7	70	130
EP080/071: Total Petroleum Hydrocarbons (QCLot: 2308545)							
EB1910136-004	WQ_03	EP080: C6 - C9 Fraction	----	40 µg/L	103	70	130
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 2308545)							
EB1910136-004	WQ_03	EP080: C6 - C10 Fraction	C6_C10	40 µg/L	112	70	130
EP080: BTEXN (QCLot: 2308545)							
EB1910136-004	WQ_03	EP080: Benzene	71-43-2	10 µg/L	110	70	130
		EP080: Toluene	108-88-3	10 µg/L	96.4	70	130

QA/QC Compliance Assessment to assist with Quality Review

Work Order : **EB1910136**

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Amendment : **3**

Client : **COFFEY ENVIRONMENTS PTY LTD**

Laboratory : Environmental Division Brisbane

Contact : MS ERICA COLLEY

Telephone : +61 7 3552 8639

Project : 754-MELEN224697 JDD PROJECT

Date Samples Received : 17-Apr-2019

Site : ----

Issue Date : 05-Dec-2019

Sampler : E COLLEY

No. of samples received : 45

Order number : BN/065/19

No. of samples analysed : 45

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO** Method Blank value outliers occur.
- **NO** Duplicate outliers occur.
- **NO** Laboratory Control outliers occur.
- Matrix Spike outliers exist - please see following pages for full details.
- For all regular sample matrices, **NO** surrogate recovery outliers occur.

Outliers : Analysis Holding Time Compliance

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- Quality Control Sample Frequency Outliers exist - please see following pages for full details.

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries							
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA	EB1910136--004	WQ_03	Sulfate as SO4 - Turbidimetric	14808-79-8	Not Determined	----	MS recovery not determined, background level greater than or equal to 4x spike level.

Method		Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EK085M: Sulfide as S2-							
Clear Plastic Bottle - Zinc Acetate/NaOH							
WQ_03,	WQ_07,	----	----	----	20-Apr-2019	19-Apr-2019	1
WQ_02,	WQ_18,						
WQ_13							

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
Method	QC	Regular	Actual	Expected	
Laboratory Duplicates (DUP)					
PAH/Phenols (GC/MS - SIM)	0	15	0.00	10.00	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	0	15	0.00	10.00	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)					
Suspended Solids	4	39	10.26	15.00	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)					
PAH/Phenols (GC/MS - SIM)	0	15	0.00	5.00	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	0	15	0.00	5.00	NEPM 2013 B3 & ALS QC Standard

Method	Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA025: Total Suspended Solids dried at 104 ± 2°C								
Clear Plastic Bottle - Natural (EA025)	TSS_06, TSS_21, TSS_35, TSS_36 Deep, WQ_02, TSS_40, TSS_39, TSS_38, TSS_11 Deep, TSS_23,	12-Apr-2019	----	----	----	18-Apr-2019	19-Apr-2019	✔
Clear Plastic Bottle - Natural (EA025)	WQ_16, WQ_05, TSS_19, TSS_17 Deep, TSS_18,	13-Apr-2019	----	----	----	18-Apr-2019	20-Apr-2019	✔
Clear Plastic Bottle - Natural (EA025)	WQ_09, TSS_02, TSS_33,	14-Apr-2019	----	----	----	18-Apr-2019	21-Apr-2019	✔
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Clear Plastic Bottle - Natural (ED041G)	WQ_06, WQ_02, WQ_13	12-Apr-2019	----	----	----	18-Apr-2019	10-May-2019	✔
Clear Plastic Bottle - Natural (ED041G)	WQ_15, WQ_08	13-Apr-2019	----	----	----	18-Apr-2019	11-May-2019	✔
Clear Plastic Bottle - Natural (ED041G)	WQ_09, WQ_11,	14-Apr-2019	----	----	----	18-Apr-2019	12-May-2019	✔

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EG035F: Dissolved Mercury by FIMS							
Clear Plastic Bottle - Filtered; Lab-acidified (EG035F) WQ_03, WQ_07, WQ_18, WQ_06, WQ_02, WQ_13	12-Apr-2019	----	----	----	24-Apr-2019	10-May-2019	✓
Clear Plastic Bottle - Filtered; Lab-acidified (EG035F) WQ_16, WQ_05, WQ_15, WQ_08	13-Apr-2019	----	----	----	24-Apr-2019	11-May-2019	✓
Clear Plastic Bottle - Filtered; Lab-acidified (EG035F) WQ_10, WQ_04, WQ_14, WQ_09, WQ_11,	14-Apr-2019	----	----	----	24-Apr-2019	12-May-2019	✓
EG035T: Total Recoverable Mercury by FIMS							
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG035T) WQ_03, WQ_07, WQ_18, WQ_06, WQ_02, WQ_13	12-Apr-2019	----	----	----	24-Apr-2019	10-May-2019	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG035T) WQ_16, WQ_05, WQ_15, WQ_08	13-Apr-2019	----	----	----	24-Apr-2019	11-May-2019	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG035T) WQ_10, WQ_04, WQ_14, WQ_09, WQ_11,	14-Apr-2019	----	----	----	24-Apr-2019	12-May-2019	✓
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS							
Clear Plastic Bottle - Filtered; Lab-acidified (EG093A-F) WQ_03, WQ_07, WQ_18, WQ_06, WQ_02, WQ_13	12-Apr-2019	----	----	----	24-Apr-2019	09-Oct-2019	✓
Clear Plastic Bottle - Filtered; Lab-acidified (EG093A-F) WQ_16, WQ_05, WQ_15, WQ_08	13-Apr-2019	----	----	----	24-Apr-2019	10-Oct-2019	✓
Clear Plastic Bottle - Filtered; Lab-acidified (EG093A-F) WQ_10, WQ_04, WQ_14, WQ_09, WQ_11,	14-Apr-2019	----	----	----	24-Apr-2019	11-Oct-2019	✓



Matrix: **WATER**

Evaluation: * = Holding time breach ; ✓ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EG093T: Total Metals in Saline Water by ORC-ICPMS								
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG093A-T) WQ_03, WQ_07, WQ_18,	WQ_06, WQ_02, WQ_13	12-Apr-2019	23-Apr-2019	09-Oct-2019	✓	23-Apr-2019	09-Oct-2019	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG093A-T) WQ_16, WQ_05,	WQ_15, WQ_08	13-Apr-2019	23-Apr-2019	10-Oct-2019	✓	23-Apr-2019	10-Oct-2019	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG093A-T) WQ_10, WQ_04, WQ_14	WQ_09, WQ_11,	14-Apr-2019	23-Apr-2019	11-Oct-2019	✓	23-Apr-2019	11-Oct-2019	✓
EK026SF: Total CN by Segmented Flow Analyser								
Opaque plastic bottle - NaOH (EK026SF) WQ_03, WQ_07, WQ_18,	WQ_06, WQ_02, WQ_13	12-Apr-2019	----	----	----	23-Apr-2019	26-Apr-2019	✓
Opaque plastic bottle - NaOH (EK026SF) WQ_16, WQ_05,	WQ_15, WQ_08	13-Apr-2019	----	----	----	23-Apr-2019	27-Apr-2019	✓
Opaque plastic bottle - NaOH (EK026SF) WQ_10, WQ_04, WQ_14	WQ_09, WQ_11,	14-Apr-2019	----	----	----	23-Apr-2019	28-Apr-2019	✓
EK040P: Fluoride by PC Titrator								
Clear Plastic Bottle - Natural (EK040P) WQ_03, WQ_07, WQ_18,	WQ_06, WQ_02, WQ_13	12-Apr-2019	----	----	----	18-Apr-2019	10-May-2019	✓
Clear Plastic Bottle - Natural (EK040P) WQ_16, WQ_05,	WQ_15, WQ_08	13-Apr-2019	----	----	----	18-Apr-2019	11-May-2019	✓
Clear Plastic Bottle - Natural (EK040P) WQ_10, WQ_04, WQ_14	WQ_09, WQ_11,	14-Apr-2019	----	----	----	18-Apr-2019	12-May-2019	✓



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EK085M: Sulfide as S2-								
Clear Plastic Bottle - Zinc Acetate/NaOH (EK085) WQ_03, WQ_02, WQ_13	WQ_07, WQ_18,	12-Apr-2019	----	----	----	20-Apr-2019	19-Apr-2019	✖
Clear Plastic Bottle - Zinc Acetate/NaOH (EK085) WQ_16, WQ_05,	WQ_15, WQ_08	13-Apr-2019	----	----	----	20-Apr-2019	20-Apr-2019	✔
Clear Plastic Bottle - Zinc Acetate/NaOH (EK085) WQ_10, WQ_04, WQ_14	WQ_09, WQ_11,	14-Apr-2019	----	----	----	20-Apr-2019	21-Apr-2019	✔
EP075(SIM)A: Phenolic Compounds								
Amber Glass Bottle - Unpreserved (EP075(SIM)) WQ_03, WQ_07, WQ_18,	WQ_06, WQ_02, WQ_13	12-Apr-2019	18-Apr-2019	19-Apr-2019	✔	23-Apr-2019	28-May-2019	✔
Amber Glass Bottle - Unpreserved (EP075(SIM)) WQ_16, WQ_05,	WQ_15, WQ_08	13-Apr-2019	18-Apr-2019	20-Apr-2019	✔	23-Apr-2019	28-May-2019	✔
Amber Glass Bottle - Unpreserved (EP075(SIM)) WQ_10, WQ_04, WQ_14	WQ_09, WQ_11,	14-Apr-2019	18-Apr-2019	21-Apr-2019	✔	23-Apr-2019	28-May-2019	✔
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Amber Glass Bottle - Unpreserved (EP075(SIM)) WQ_03, WQ_07, WQ_18,	WQ_06, WQ_02, WQ_13	12-Apr-2019	18-Apr-2019	19-Apr-2019	✔	23-Apr-2019	28-May-2019	✔
Amber Glass Bottle - Unpreserved (EP075(SIM)) WQ_16, WQ_05,	WQ_15, WQ_08	13-Apr-2019	18-Apr-2019	20-Apr-2019	✔	23-Apr-2019	28-May-2019	✔
Amber Glass Bottle - Unpreserved (EP075(SIM)) WQ_10, WQ_04, WQ_14	WQ_09, WQ_11,	14-Apr-2019	18-Apr-2019	21-Apr-2019	✔	23-Apr-2019	28-May-2019	✔



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis			
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation	
EP080/071: Total Petroleum Hydrocarbons								
Amber Glass Bottle - Unpreserved (EP071) WQ_03, WQ_07, WQ_18,	WQ_06, WQ_02, WQ_13	12-Apr-2019	18-Apr-2019	19-Apr-2019	✔	23-Apr-2019	28-May-2019	✔
Amber Glass Bottle - Unpreserved (EP071) WQ_16, WQ_05,	WQ_15, WQ_08	13-Apr-2019	18-Apr-2019	20-Apr-2019	✔	23-Apr-2019	28-May-2019	✔
Amber Glass Bottle - Unpreserved (EP071) WQ_10, WQ_04, WQ_14	WQ_09, WQ_11,	14-Apr-2019	18-Apr-2019	21-Apr-2019	✔	23-Apr-2019	28-May-2019	✔
Amber VOC Vial - Sulfuric Acid (EP080) WQ_03, WQ_07, WQ_18,	WQ_06, WQ_02, WQ_13	12-Apr-2019	23-Apr-2019	26-Apr-2019	✔	23-Apr-2019	26-Apr-2019	✔
Amber VOC Vial - Sulfuric Acid (EP080) WQ_16, WQ_05,	WQ_15, WQ_08	13-Apr-2019	23-Apr-2019	27-Apr-2019	✔	23-Apr-2019	27-Apr-2019	✔
Amber VOC Vial - Sulfuric Acid (EP080) WQ_10, WQ_04, WQ_14	WQ_09, WQ_11,	14-Apr-2019	23-Apr-2019	28-Apr-2019	✔	23-Apr-2019	28-Apr-2019	✔



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
Amber Glass Bottle - Unpreserved (EP071)								
WQ_03, WQ_07, WQ_18,	WQ_06, WQ_02, WQ_13	12-Apr-2019	18-Apr-2019	19-Apr-2019	✔	23-Apr-2019	28-May-2019	✔
Amber Glass Bottle - Unpreserved (EP071)								
WQ_16, WQ_05,	WQ_15, WQ_08	13-Apr-2019	18-Apr-2019	20-Apr-2019	✔	23-Apr-2019	28-May-2019	✔
Amber Glass Bottle - Unpreserved (EP071)								
WQ_10, WQ_04, WQ_14	WQ_09, WQ_11,	14-Apr-2019	18-Apr-2019	21-Apr-2019	✔	23-Apr-2019	28-May-2019	✔
Amber VOC Vial - Sulfuric Acid (EP080)								
WQ_03, WQ_07, WQ_18,	WQ_06, WQ_02, WQ_13	12-Apr-2019	23-Apr-2019	26-Apr-2019	✔	23-Apr-2019	26-Apr-2019	✔
Amber VOC Vial - Sulfuric Acid (EP080)								
WQ_16, WQ_05,	WQ_15, WQ_08	13-Apr-2019	23-Apr-2019	27-Apr-2019	✔	23-Apr-2019	27-Apr-2019	✔
Amber VOC Vial - Sulfuric Acid (EP080)								
WQ_10, WQ_04, WQ_14	WQ_09, WQ_11,	14-Apr-2019	23-Apr-2019	28-Apr-2019	✔	23-Apr-2019	28-Apr-2019	✔
EP080: BTEXN								
Amber VOC Vial - Sulfuric Acid (EP080)								
WQ_03, WQ_07, WQ_18,	WQ_06, WQ_02, WQ_13	12-Apr-2019	23-Apr-2019	26-Apr-2019	✔	23-Apr-2019	26-Apr-2019	✔
Amber VOC Vial - Sulfuric Acid (EP080)								
WQ_16, WQ_05,	WQ_15, WQ_08	13-Apr-2019	23-Apr-2019	27-Apr-2019	✔	23-Apr-2019	27-Apr-2019	✔
Amber VOC Vial - Sulfuric Acid (EP080)								
WQ_10, WQ_04, WQ_14	WQ_09, WQ_11,	14-Apr-2019	23-Apr-2019	28-Apr-2019	✔	23-Apr-2019	28-Apr-2019	✔



Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)		Quality Control Specification	
Analytical Methods	Method	QC	Regular	Actual	Expected		Evaluation
Laboratory Duplicates (DUP)							
Dissolved Mercury by FIMS	EG035F	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals in Saline Water -Suite A by ORC-ICPMS	EG093A-F	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals in Saline Water -Suite B by ORC-ICPMS	EG093B-F	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	2	16	12.50	10.00	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	0	15	0.00	10.00	✗	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Sulfide as S2-	EK085	4	40	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Suspended Solids	EA025	4	39	10.26	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Cyanide by Segmented Flow Analyser	EK026SF	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Saline Water Suite A by ORC-ICPMS	EG093A-T	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Saline Water -Suite B by ORC-ICPMS	EG093B-T	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	0	15	0.00	10.00	✗	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Dissolved Mercury by FIMS	EG035F	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals in Saline Water -Suite A by ORC-ICPMS	EG093A-F	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals in Saline Water -Suite B by ORC-ICPMS	EG093B-F	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	1	16	6.25	5.00	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Sulfide as S2-	EK085	2	40	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Suspended Solids	EA025	4	39	10.26	15.00	✗	NEPM 2013 B3 & ALS QC Standard
Total Cyanide by Segmented Flow Analyser	EK026SF	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Saline Water Suite A by ORC-ICPMS	EG093A-T	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Saline Water -Suite B by ORC-ICPMS	EG093B-T	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Dissolved Mercury by FIMS	EG035F	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals in Saline Water -Suite A by ORC-ICPMS	EG093A-F	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals in Saline Water -Suite B by ORC-ICPMS	EG093B-F	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	1	16	6.25	5.00	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard



Matrix: **WATER**

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	
Method Blanks (MB) - Continued							
Sulfide as S2-	EK085	2	40	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Suspended Solids	EA025	2	39	5.13	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Cyanide by Segmented Flow Analyser	EK026SF	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Saline Water Suite A by ORC-ICPMS	EG093A-T	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Saline Water -Suite B by ORC-ICPMS	EG093B-T	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Dissolved Mercury by FIMS	EG035F	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals in Saline Water -Suite A by ORC-ICPMS	EG093A-F	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	1	16	6.25	5.00	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	0	15	0.00	5.00	✗	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Sulfide as S2-	EK085	2	40	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Cyanide by Segmented Flow Analyser	EK026SF	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Saline Water Suite A by ORC-ICPMS	EG093A-T	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	0	15	0.00	5.00	✗	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard



Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Suspended Solids	EA025	WATER	In house: Referenced to APHA 2540D. A gravimetric procedure employed to determine the amount of 'non-filterable' residue in a aqueous sample. The prescribed GFC (1.2um) filter is rinsed with deionised water, oven dried and weighed prior to analysis. A well-mixed sample is filtered through a glass fibre filter (1.2um). The residue on the filter paper is dried at 104+/-2C . This method is compliant with NEPM (2013) Schedule B(3)
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	WATER	In house: Referenced to APHA 4500-SO4. Dissolved sulfate is determined in a 0.45um filtered sample. Sulfate ions are converted to a barium sulfate suspension in an acetic acid medium with barium chloride. Light absorbance of the BaSO4 suspension is measured by a photometer and the SO4-2 concentration is determined by comparison of the reading with a standard curve. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Mercury by FIMS	EG035F	WATER	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) Samples are 0.45µm filtered prior to analysis. FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Total Mercury by FIMS	EG035T	WATER	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the unfiltered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Metals in Saline Water -Suite A by ORC-ICPMS	EG093A-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020 Samples are 0.45µm filtered prior to analysis. The ORC-ICPMS technique removes interfering species through a series of chemical reactions prior to ion detection. Ions are passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to measurement by a discrete dynode ion detector. This method is compliant with NEPM (2013) Schedule B(3)
Total Metals in Saline Water Suite A by ORC-ICPMS	EG093A-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020. The ORC-ICPMS technique removes interfering species through a series of chemical reactions prior to ion detection. Ions are passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to measurement by a discrete dynode ion detector. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Metals in Saline Water -Suite B by ORC-ICPMS	EG093B-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020 Samples are 0.45µm filtered prior to analysis. The ORC-ICPMS technique removes interfering species through a series of chemical reactions prior to ion detection. Ions are passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to measurement by a discrete dynode ion detector. This method is compliant with NEPM (2013) Schedule B(3)
Total Metals in Saline Water -Suite B by ORC-ICPMS	EG093B-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020. The ORC-ICPMS technique removes interfering species through a series of chemical reactions prior to ion detection. Ions are passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to measurement by a discrete dynode ion detector. This method is compliant with NEPM (2013) Schedule B(3)



Analytical Methods	Method	Matrix	Method Descriptions
Total Cyanide by Segmented Flow Analyser	EK026SF	WATER	In house: Referenced to APHA 4500-CN C / ASTM D7511. Sodium hydroxide preserved samples are introduced into an automated segmented flow analyser. Complex bound cyanide is decomposed in a continuously flowing stream, at a pH of 3.8, by the effect of UV light. A UV-B lamp (312 nm) and a decomposition spiral of borosilicate glass are used to filter out UV light with a wavelength of less than 290 nm thus preventing the conversion of thiocyanate into cyanide. The hydrogen cyanide present at a pH of 3.8 is separated by gas dialysis. The hydrogen cyanide is then determined photometrically, based on the reaction of cyanide with chloramine-T to form cyanogen chloride. This then reacts with 4-pyridine carboxylic acid and 1,3-dimethylbarbituric acid to give a red colour which is measured at 600 nm. This method is compliant with NEPM (2013) Schedule B(3)
Fluoride by PC Titrator	EK040P	WATER	In house: Referenced to APHA 4500-F C: CDTA is added to the sample to provide a uniform ionic strength background, adjust pH, and break up complexes. Fluoride concentration is determined by either manual or automatic ISE measurement. This method is compliant with NEPM (2013) Schedule B(3)
Sulfide as S2-	EK085	WATER	In house: Referenced to APHA 4500-S2- D. Sulfide species present in water samples are immediately precipitated when collected in pretreated caustic/zinc acetate preserved sample containers. The sulphides are coloured using methylene blue indicator. Non-detects may be screened by comparison against a standard at half-LOR, otherwise samples are measured using UV-VIS detection at 664nm. This method is compliant with NEPM (2013) Schedule B(3)
TRH - Semivolatile Fraction	EP071	WATER	In house: Referenced to USEPA SW 846 - 8015A The sample extract is analysed by Capillary GC/FID and quantification is by comparison against an established 5 point calibration curve of n-Alkane standards. This method is compliant with the QC requirements of NEPM (2013) Schedule B(3)
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	WATER	In house: Referenced to USEPA SW 846 - 8270D Sample extracts are analysed by Capillary GC/MS in SIM Mode and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
TRH Volatiles/BTEX	EP080	WATER	In house: Referenced to USEPA SW 846 - 8260B Water samples are directly purged prior to analysis by Capillary GC/MS and quantification is by comparison against an established 5 point calibration curve. Alternatively, a sample is equilibrated in a headspace vial and a portion of the headspace determined by GCMS analysis. This method is compliant with the QC requirements of NEPM (2013) Schedule B(3)

Preparation Methods	Method	Matrix	Method Descriptions
TKN/TP Digestion	EK061/EK067	WATER	In house: Referenced to APHA 4500 Norg - D; APHA 4500 P - H. This method is compliant with NEPM (2013) Schedule B(3)
Digestion for Total Recoverable Metals - ORC	EN25-ORC	WATER	In house: Referenced to USEPA SW846-3005. This is an Ultrapure Nitric acid digestion procedure used to prepare surface and ground water samples for analysis by ORC- ICPMS. This method is compliant with NEPM (2013) Schedule B(3)
Separatory Funnel Extraction of Liquids	ORG14	WATER	In house: Referenced to USEPA SW 846 - 3510B 100 mL to 1L of sample is transferred to a separatory funnel and serially extracted three times using DCM for each extract. The resultant extracts are combined, dehydrated and concentrated for analysis. This method is compliant with NEPM (2013) Schedule B(3) . ALS default excludes sediment which may be resident in the container.
Volatiles Water Preparation	ORG16-W	WATER	A 5 mL aliquot or 5 mL of a diluted sample is added to a 40 mL VOC vial for sparging.

QUALITY CONTROL REPORT

Work Order : **EB1910136**

Page : 1 of 9

Amendment : **4**

Client : **COFFEY ENVIRONMENTS PTY LTD**

Contact : **MS ERICA COLLEY**

Address : Level 5 12 Creek St
Brisbane QLD, AUSTRALIA 4000

Telephone : +61 07 3608 2500

Project : **754-MELEN224697 JDD PROJECT**

Order number : **BN/065/19**

C-O-C number : ----

Sampler : **E COLLEY**

Site : ----

Quote number : **BN/065/19 V2**

No. of samples received : **45**

No. of samples analysed : **45**

Laboratory : Environmental Division Brisbane

Contact : Andrew Epps

Address : 2 Byth Street Stafford QLD Australia 4053

Telephone : +61 7 3552 8639

Date Samples Received : 17-Apr-2019

Date Analysis Commenced : 18-Apr-2019

Issue Date : 31-Mar-2020



Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high

Key :
 Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
 CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
 LOR = Limit of reporting
 RPD = Relative Percentage Difference
 # = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EA025: Total Suspended Solids dried at 104 ± 2°C (QC Lot: 2304623)									
EB1910136-001	TSS_16 Deep	EA025: Suspended Solids (SS)	----	1	mg/L	<1	1	0.00	No Limit
EB1910136-012	TSS_36 Deep	EA025: Suspended Solids (SS)	----	1	mg/L	2	1	64.9	No Limit
EA025: Total Suspended Solids dried at 104 ± 2°C (QC Lot: 2304624)									
EB1910136-027	TSS_20	EA025: Suspended Solids (SS)	----	1	mg/L	<1	1	0.00	No Limit
EB1910136-037	TSS_11 Deep	EA025: Suspended Solids (SS)	----	1	mg/L	<1	<1	0.00	No Limit
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 2304649)									
EB1910136-002	WQ_16	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	2480	2550	2.97	0% - 20%
EB1910136-020	WQ_06	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	2450	2430	0.877	0% - 20%
EG035F: Dissolved Mercury by FIMS (QC Lot: 2308381)									
EB1910136-002	WQ_16	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EB1910136-020	WQ_06	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 2308642)									
EB1910136-002	WQ_16	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EB1910136-020	WQ_06	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS (QC Lot: 2308346)									
EB1910136-002	WQ_16	EG093A-F: Beryllium	7440-41-7	0.1	µg/L	<0.1	<0.1	0.00	No Limit
		EG093A-F: Molybdenum	7439-98-7	0.1	µg/L	10.1	10.0	0.00	0% - 20%
		EG093A-F: Silver	7440-22-4	0.1	µg/L	<0.1	<0.1	0.00	No Limit
		EG093A-F: Cadmium	7440-43-9	0.2	µg/L	<0.1	<0.1	0.00	No Limit
		EG093A-F: Cobalt	7440-48-4	0.2	µg/L	<0.2	<0.2	0.00	No Limit
		EG093A-F: Lead	7439-92-1	0.2	µg/L	<0.2	<0.2	0.00	No Limit
		EG093A-F: Antimony	7440-36-0	0.5	µg/L	<0.5	<0.5	0.00	No Limit
		EG093A-F: Arsenic	7440-38-2	0.5	µg/L	1.9	1.8	0.00	No Limit
		EG093A-F: Chromium	7440-47-3	0.5	µg/L	<0.5	<0.5	0.00	No Limit



Sub-Matrix: **WATER**

Sub-Matrix: WATER				Laboratory Duplicate (DUP) Report							
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)		
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS (QC Lot: 2308346) - continued											
EB1910136-002	WQ_16	EG093A-F: Manganese	7439-96-5	0.5	µg/L	0.5	0.6	19.0	No Limit		
		EG093A-F: Nickel	7440-02-0	0.5	µg/L	<0.5	<0.5	0.00	No Limit		
		EG093A-F: Vanadium	7440-62-2	0.5	µg/L	2.0	2.1	6.54	No Limit		
		EG093A-F: Barium	7440-39-3	1	µg/L	4	4	0.00	No Limit		
		EG093A-F: Copper	7440-50-8	1	µg/L	<1	<1	0.00	No Limit		
		EG093A-F: Boron	7440-42-8	100	µg/L	4450	4550	2.23	0% - 20%		
		EG093A-F: Aluminium	7429-90-5	5	µg/L	<5	<5	0.00	No Limit		
		EG093A-F: Tin	7440-31-5	5	µg/L	<5	<5	0.00	No Limit		
		EG093A-F: Zinc	7440-66-6	5	µg/L	<5	<5	0.00	No Limit		
EB1910136-019	WQ_14	EG093A-F: Beryllium	7440-41-7	0.1	µg/L	<0.1	<0.1	0.00	No Limit		
		EG093A-F: Molybdenum	7439-98-7	0.1	µg/L	9.4	9.4	0.00	0% - 20%		
		EG093A-F: Silver	7440-22-4	0.1	µg/L	<0.1	<0.1	0.00	No Limit		
		EG093A-F: Cadmium	7440-43-9	0.2	µg/L	<0.1	<0.1	0.00	No Limit		
		EG093A-F: Cobalt	7440-48-4	0.2	µg/L	<0.2	<0.2	0.00	No Limit		
		EG093A-F: Lead	7439-92-1	0.2	µg/L	<0.2	<0.2	0.00	No Limit		
		EG093A-F: Antimony	7440-36-0	0.5	µg/L	<0.5	<0.5	0.00	No Limit		
		EG093A-F: Arsenic	7440-38-2	0.5	µg/L	1.5	1.6	8.16	No Limit		
		EG093A-F: Chromium	7440-47-3	0.5	µg/L	<0.5	<0.5	0.00	No Limit		
		EG093A-F: Manganese	7439-96-5	0.5	µg/L	<0.5	0.6	18.7	No Limit		
		EG093A-F: Nickel	7440-02-0	0.5	µg/L	<0.5	<0.5	0.00	No Limit		
		EG093A-F: Vanadium	7440-62-2	0.5	µg/L	1.9	1.9	0.00	No Limit		
		EG093A-F: Barium	7440-39-3	1	µg/L	6	6	0.00	No Limit		
		EG093A-F: Copper	7440-50-8	1	µg/L	1	1	0.00	No Limit		
		EG093A-F: Boron	7440-42-8	100	µg/L	4170	4280	2.47	0% - 20%		
		EG093A-F: Aluminium	7429-90-5	5	µg/L	<5	<5	0.00	No Limit		
		EG093A-F: Tin	7440-31-5	5	µg/L	<5	<5	0.00	No Limit		
		EG093A-F: Zinc	7440-66-6	5	µg/L	<5	<5	0.00	No Limit		
		EG093F: Dissolved Metals in Saline Water by ORC-ICPMS (QC Lot: 2308347)									
		EB1910136-002	WQ_16	EG093B-F: Selenium	7782-49-2	2	µg/L	10	10	0.00	No Limit
EG093B-F: Iron	7439-89-6			5	µg/L	<5	<5	0.00	No Limit		
EB1910136-019	WQ_14	EG093B-F: Selenium	7782-49-2	2	µg/L	10	10	0.00	No Limit		
		EG093B-F: Iron	7439-89-6	5	µg/L	<5	<5	0.00	No Limit		
EG093T: Total Metals in Saline Water by ORC-ICPMS (QC Lot: 2308351)											
EB1910136-002	WQ_16	EG093A-T: Beryllium	7440-41-7	0.1	µg/L	<0.1	<0.1	0.00	No Limit		
		EG093A-T: Molybdenum	7439-98-7	0.1	µg/L	10.6	10.8	2.44	0% - 20%		
		EG093A-T: Silver	7440-22-4	0.1	µg/L	<0.1	<0.1	0.00	No Limit		
		EG093A-T: Cadmium	7440-43-9	0.2	µg/L	<0.2	<0.2	0.00	No Limit		
		EG093A-T: Cobalt	7440-48-4	0.2	µg/L	<0.2	<0.2	0.00	No Limit		
		EG093A-T: Lead	7439-92-1	0.2	µg/L	<0.2	<0.2	0.00	No Limit		
		EG093A-T: Antimony	7440-36-0	0.5	µg/L	<0.5	<0.5	0.00	No Limit		

Sub-Matrix: WATER				Laboratory Duplicate (DUP) Report							
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)		
EG093T: Total Metals in Saline Water by ORC-ICPMS (QC Lot: 2308351) - continued											
EB1910136-002	WQ_16	EG093A-T: Arsenic	7440-38-2	0.5	µg/L	1.5	1.6	0.00	No Limit		
		EG093A-T: Chromium	7440-47-3	0.5	µg/L	<0.5	<0.5	0.00	No Limit		
		EG093A-T: Manganese	7439-96-5	0.5	µg/L	0.9	0.9	0.00	No Limit		
		EG093A-T: Nickel	7440-02-0	0.5	µg/L	<0.5	<0.5	0.00	No Limit		
		EG093A-T: Vanadium	7440-62-2	0.5	µg/L	1.7	1.7	0.00	No Limit		
		EG093A-T: Barium	7440-39-3	1	µg/L	4	5	0.00	No Limit		
		EG093A-T: Copper	7440-50-8	1	µg/L	<1	<1	0.00	No Limit		
		EG093A-T: Boron	7440-42-8	100	µg/L	4330	3980	8.48	0% - 20%		
		EG093A-T: Tin	7440-31-5	5	µg/L	<5	<5	0.00	No Limit		
		EG093A-T: Zinc	7440-66-6	5	µg/L	<5	<5	0.00	No Limit		
EB1910136-019	WQ_14	EG093A-T: Beryllium	7440-41-7	0.1	µg/L	<0.1	<0.1	0.00	No Limit		
		EG093A-T: Molybdenum	7439-98-7	0.1	µg/L	9.8	9.6	2.27	0% - 20%		
		EG093A-T: Silver	7440-22-4	0.1	µg/L	<0.1	<0.1	0.00	No Limit		
		EG093A-T: Cadmium	7440-43-9	0.2	µg/L	<0.2	<0.2	0.00	No Limit		
		EG093A-T: Cobalt	7440-48-4	0.2	µg/L	<0.2	<0.2	0.00	No Limit		
		EG093A-T: Lead	7439-92-1	0.2	µg/L	<0.2	<0.2	0.00	No Limit		
		EG093A-T: Antimony	7440-36-0	0.5	µg/L	<0.5	<0.5	0.00	No Limit		
		EG093A-T: Arsenic	7440-38-2	0.5	µg/L	1.3	1.4	0.00	No Limit		
		EG093A-T: Chromium	7440-47-3	0.5	µg/L	<0.5	<0.5	0.00	No Limit		
		EG093A-T: Manganese	7439-96-5	0.5	µg/L	<0.5	0.5	0.00	No Limit		
		EG093A-T: Nickel	7440-02-0	0.5	µg/L	<0.5	<0.5	0.00	No Limit		
		EG093A-T: Vanadium	7440-62-2	0.5	µg/L	1.6	1.6	0.00	No Limit		
		EG093A-T: Barium	7440-39-3	1	µg/L	6	6	0.00	No Limit		
		EG093A-T: Copper	7440-50-8	1	µg/L	<1	<1	0.00	No Limit		
		EG093A-T: Boron	7440-42-8	100	µg/L	3500	3460	1.13	0% - 20%		
		EG093A-T: Tin	7440-31-5	5	µg/L	<5	<5	0.00	No Limit		
		EG093A-T: Zinc	7440-66-6	5	µg/L	<5	<5	0.00	No Limit		
		EG093T: Total Metals in Saline Water by ORC-ICPMS (QC Lot: 2308352)									
		EB1910136-002	WQ_16	EG093B-T: Selenium	7782-49-2	2	µg/L	5	4	0.00	No Limit
				EG093B-T: Iron	7439-89-6	5	µg/L	8	8	0.00	No Limit
EB1910136-019	WQ_14	EG093B-T: Selenium	7782-49-2	2	µg/L	4	4	0.00	No Limit		
		EG093B-T: Iron	7439-89-6	5	µg/L	<5	<5	0.00	No Limit		
EK026SF: Total CN by Segmented Flow Analyser (QC Lot: 2308928)											
EB1910136-002	WQ_16	EK026SF: Total Cyanide	57-12-5	0.004	mg/L	<0.004	<0.004	0.00	No Limit		
EB1910136-020	WQ_06	EK026SF: Total Cyanide	57-12-5	0.004	mg/L	<0.004	<0.004	0.00	No Limit		
EK040P: Fluoride by PC Titrator (QC Lot: 2306069)											
EB1910032-011	Anonymous	EK040P: Fluoride	16984-48-8	0.1	mg/L	0.3	0.3	0.00	No Limit		
EB1910136-019	WQ_14	EK040P: Fluoride	16984-48-8	0.1	mg/L	0.9	0.8	0.00	No Limit		
EK085M: Sulfide as S2- (QC Lot: 2307338)											



Sub-Matrix: WATER				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EK085M: Sulfide as S2- (QC Lot: 2307338) - continued									
EB1910097-002	Anonymous	EK085: Sulfide as S2-	18496-25-8	0.1	mg/L	<0.1	<0.1	0.00	No Limit
EB1910100-003	Anonymous	EK085: Sulfide as S2-	18496-25-8	0.1	mg/L	<0.1	<0.1	0.00	No Limit
EK085M: Sulfide as S2- (QC Lot: 2307339)									
EB1910136-015	WQ_05	EK085: Sulfide as S2-	18496-25-8	0.1	mg/L	<0.1	<0.1	0.00	No Limit
EB1910153-001	Anonymous	EK085: Sulfide as S2-	18496-25-8	0.1	mg/L	0.1	0.1	0.00	No Limit



Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

Sub-Matrix: WATER				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result		LCS	Low	High
EA025: Total Suspended Solids dried at 104 ± 2°C (QCLot: 2304623)								
EA025: Suspended Solids (SS)	----	1	mg/L	<1	150 mg/L	102	84	120
				<1	1000 mg/L	92.5	84	120
EA025: Total Suspended Solids dried at 104 ± 2°C (QCLot: 2304624)								
EA025: Suspended Solids (SS)	----	1	mg/L	<1	150 mg/L	96.8	84	120
				<1	1000 mg/L	95.8	84	120
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 2304649)								
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	25 mg/L	104	85	118
				<1	100 mg/L	97.4	85	118
EG035F: Dissolved Mercury by FIMS (QCLot: 2308381)								
EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.01 mg/L	95.8	84	118
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2308642)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.01 mg/L	95.0	84	118
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS (QCLot: 2308346)								
EG093A-F: Aluminium	7429-90-5	5	µg/L	<5	50 µg/L	95.9	85	118
EG093A-F: Antimony	7440-36-0	0.5	µg/L	<0.5	10 µg/L	91.6	87	115
EG093A-F: Arsenic	7440-38-2	0.5	µg/L	<0.5	10 µg/L	103	87	116
EG093A-F: Barium	7440-39-3	1	µg/L	<1	50 µg/L	94.0	87	114
EG093A-F: Beryllium	7440-41-7	0.1	µg/L	<0.1	10 µg/L	98.0	80	120
EG093A-F: Boron	7440-42-8	100	µg/L	<100	500 µg/L	99.5	82	114
EG093A-F: Cadmium	7440-43-9	0.2	µg/L	<0.2	10 µg/L	99.7	88	114
EG093A-F: Chromium	7440-47-3	0.5	µg/L	<0.5	10 µg/L	95.3	83	115
EG093A-F: Cobalt	7440-48-4	0.2	µg/L	<0.2	10 µg/L	98.5	86	116
EG093A-F: Copper	7440-50-8	1	µg/L	<1	20 µg/L	101	81	117
EG093A-F: Lead	7439-92-1	0.2	µg/L	<0.2	10 µg/L	99.4	80	117
EG093A-F: Manganese	7439-96-5	0.5	µg/L	<0.5	10 µg/L	97.8	80	119
EG093A-F: Molybdenum	7439-98-7	0.1	µg/L	<0.1	10 µg/L	100	80	118
EG093A-F: Nickel	7440-02-0	0.5	µg/L	<0.5	10 µg/L	95.8	87	117
EG093A-F: Silver	7440-22-4	0.1	µg/L	<0.1	10 µg/L	95.2	80	127
EG093A-F: Tin	7440-31-5	5	µg/L	<5	10 µg/L	97.3	82	118
EG093A-F: Vanadium	7440-62-2	0.5	µg/L	<0.5	10 µg/L	108	89	117
EG093A-F: Zinc	7440-66-6	5	µg/L	<5	20 µg/L	101	81	120
EG093B-F: Dissolved Metals in Saline Water by ORC-ICPMS (QCLot: 2308347)								
EG093B-F: Iron	7439-89-6	5	µg/L	<5	50 µg/L	87.9	78	123
EG093B-F: Selenium	7782-49-2	2	µg/L	<2	10 µg/L	99.9	87	121



Sub-Matrix: **WATER**

Sub-Matrix: WATER				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low High	
Method: Compound	CAS Number	LOR	Unit	Result				
EG093T: Total Metals in Saline Water by ORC-ICPMS (QCLot: 2308351)								
EG093A-T: Antimony	7440-36-0	0.5	µg/L	<0.5	10 µg/L	106	83	116
EG093A-T: Arsenic	7440-38-2	0.5	µg/L	<0.5	10 µg/L	104	86	117
EG093A-T: Barium	7440-39-3	1	µg/L	<1	50 µg/L	104	84	118
EG093A-T: Beryllium	7440-41-7	0.1	µg/L	<0.1	10 µg/L	111	87	120
EG093A-T: Boron	7440-42-8	100	µg/L	<105	500 µg/L	108	83	123
EG093A-T: Cadmium	7440-43-9	0.2	µg/L	<0.2	10 µg/L	104	84	115
EG093A-T: Chromium	7440-47-3	0.5	µg/L	<0.5	10 µg/L	104	84	120
EG093A-T: Cobalt	7440-48-4	0.2	µg/L	<0.2	10 µg/L	107	85	116
EG093A-T: Copper	7440-50-8	1	µg/L	<1	20 µg/L	104	84	119
EG093A-T: Lead	7439-92-1	0.2	µg/L	<0.2	10 µg/L	103	84	120
EG093A-T: Manganese	7439-96-5	0.5	µg/L	<0.5	10 µg/L	110	86	124
EG093A-T: Molybdenum	7439-98-7	0.1	µg/L	0.2	10 µg/L	106	84	118
EG093A-T: Nickel	7440-02-0	0.5	µg/L	<0.5	10 µg/L	107	80	120
EG093A-T: Silver	7440-22-4	0.1	µg/L	<0.1	10 µg/L	98.0	80	120
EG093A-T: Tin	7440-31-5	5	µg/L	<5	10 µg/L	105	83	114
EG093A-T: Vanadium	7440-62-2	0.5	µg/L	<0.5	10 µg/L	103	84	120
EG093A-T: Zinc	7440-66-6	5	µg/L	<5	20 µg/L	101	81	124
EG093T: Total Metals in Saline Water by ORC-ICPMS (QCLot: 2308352)								
EG093B-T: Iron	7439-89-6	5	µg/L	<5	50 µg/L	113	80	128
EG093B-T: Selenium	7782-49-2	2	µg/L	<2	10 µg/L	99.4	89	119
EK026SF: Total CN by Segmented Flow Analyser (QCLot: 2308928)								
EK026SF: Total Cyanide	57-12-5	0.004	mg/L	<0.004	0.2 mg/L	103	85	119
EK040P: Fluoride by PC Titrator (QCLot: 2306069)								
EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	5 mg/L	93.6	80	117
EK085M: Sulfide as S2- (QCLot: 2307338)								
EK085: Sulfide as S2-	18496-25-8	0.1	mg/L	<0.1	0.5 mg/L	113	80	123
EK085M: Sulfide as S2- (QCLot: 2307339)								
EK085: Sulfide as S2-	18496-25-8	0.1	mg/L	<0.1	0.5 mg/L	110	80	123

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

Sub-Matrix: WATER				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
				Concentration	MS	Low	High
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number				
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 2304649)							
EB1910136-004	WQ_03						

Sub-Matrix: WATER				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 2304649) - continued							
EB1910136-004	WQ_03	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	20 mg/L	# Not Determined	70	130
EG035F: Dissolved Mercury by FIMS (QCLot: 2308381)							
EB1910136-004	WQ_03	EG035F: Mercury	7439-97-6	0.05 mg/L	81.8	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2308642)							
EB1910136-004	WQ_03	EG035T: Mercury	7439-97-6	0.05 mg/L	73.0	70	130
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS (QCLot: 2308346)							
EB1910136-004	WQ_03	EG093A-F: Arsenic	7440-38-2	50 µg/L	99.5	70	130
		EG093A-F: Barium	7440-39-3	250 µg/L	94.2	70	130
		EG093A-F: Beryllium	7440-41-7	50 µg/L	105	70	130
		EG093A-F: Cadmium	7440-43-9	50 µg/L	92.8	70	130
		EG093A-F: Chromium	7440-47-3	50 µg/L	93.8	70	130
		EG093A-F: Cobalt	7440-48-4	50 µg/L	98.8	70	130
		EG093A-F: Copper	7440-50-8	100 µg/L	96.2	70	130
		EG093A-F: Lead	7439-92-1	50 µg/L	92.0	70	130
		EG093A-F: Manganese	7439-96-5	50 µg/L	101	70	130
		EG093A-F: Nickel	7440-02-0	50 µg/L	103	70	130
		EG093A-F: Vanadium	7440-62-2	50 µg/L	90.5	70	130
		EG093A-F: Zinc	7440-66-6	100 µg/L	97.6	70	130
EG093T: Total Metals in Saline Water by ORC-ICPMS (QCLot: 2308351)							
EB1910136-004	WQ_03	EG093A-T: Arsenic	7440-38-2	50 µg/L	99.9	70	130
		EG093A-T: Barium	7440-39-3	250 µg/L	101	70	130
		EG093A-T: Beryllium	7440-41-7	50 µg/L	92.0	70	130
		EG093A-T: Cadmium	7440-43-9	50 µg/L	96.2	70	130
		EG093A-T: Chromium	7440-47-3	50 µg/L	101	70	130
		EG093A-T: Cobalt	7440-48-4	50 µg/L	98.3	70	130
		EG093A-T: Copper	7440-50-8	100 µg/L	95.6	70	130
		EG093A-T: Lead	7439-92-1	50 µg/L	98.1	70	130
		EG093A-T: Manganese	7439-96-5	50 µg/L	98.0	70	130
		EG093A-T: Nickel	7440-02-0	50 µg/L	95.7	70	130
		EG093A-T: Vanadium	7440-62-2	50 µg/L	100	70	130
		EG093A-T: Zinc	7440-66-6	100 µg/L	95.5	70	130
EK026SF: Total CN by Segmented Flow Analyser (QCLot: 2308928)							
EB1910136-004	WQ_03	EK026SF: Total Cyanide	57-12-5	0.4 mg/L	95.2	70	130
EK040P: Fluoride by PC Titrator (QCLot: 2306069)							
EB1910136-002	WQ_16	EK040P: Fluoride	16984-48-8	10 mg/L	73.6	70	130
EK085M: Sulfide as S2- (QCLot: 2307338)							



Sub-Matrix: WATER

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EK085M: Sulfide as S2- (QCLot: 2307338) - continued							
EB1910097-003	Anonymous	EK085: Sulfide as S2-	18496-25-8	1.0636 mg/L	79.8	70	130
EK085M: Sulfide as S2- (QCLot: 2307339)							
EB1910136-016	WQ_04	EK085: Sulfide as S2-	18496-25-8	1.0636 mg/L	87.7	70	130

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: EB1910136	Page	: 1 of 10
Amendment	: 4		
Client	: COFFEY ENVIRONMENTS PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MS ERICA COLLEY	Telephone	: +61 7 3552 8639
Project	: 754-MELEN224697 JDD PROJECT	Date Samples Received	: 17-Apr-2019
Site	: ----	Issue Date	: 31-Mar-2020
Sampler	: E COLLEY	No. of samples received	: 45
Order number	: BN/065/19	No. of samples analysed	: 45

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO** Method Blank value outliers occur.
- **NO** Duplicate outliers occur.
- **NO** Laboratory Control outliers occur.
- Matrix Spike outliers exist - please see following pages for full details.
- For all regular sample matrices, **NO** surrogate recovery outliers occur.

Outliers : Analysis Holding Time Compliance

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- Quality Control Sample Frequency Outliers exist - please see following pages for full details.



Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries							
ED041G: Sulfate (Turbidimetric) as SO ₄ 2- by DA	EB1910136--004	WQ_03	Sulfate as SO ₄ - Turbidimetric	14808-79-8	Not Determined	----	MS recovery not determined, background level greater than or equal to 4x spike level.

Outliers : Analysis Holding Time Compliance

Matrix: **WATER**

Method		Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EK085M: Sulfide as S²⁻							
Clear Plastic Bottle - Zinc Acetate/NaOH							
WQ_03,	WQ_07,	----	----	----	20-Apr-2019	19-Apr-2019	1
WQ_02,	WQ_18,						
WQ_13							

Outliers : Frequency of Quality Control Samples

Matrix: **WATER**

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
Method	QC	Regular	Actual	Expected	
Laboratory Control Samples (LCS)					
Suspended Solids	4	39	10.26	15.00	NEPM 2013 B3 & ALS QC Standard

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for VOC in soils vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA025: Total Suspended Solids dried at 104 ± 2°C								
Clear Plastic Bottle - Natural (EA025)	TSS_06, TSS_21, TSS_35, TSS_36 Deep, WQ_02, TSS_40, TSS_39, TSS_38, TSS_11 Deep, TSS_23,	12-Apr-2019	----	----	----	18-Apr-2019	19-Apr-2019	✔
Clear Plastic Bottle - Natural (EA025)	WQ_16, WQ_05, TSS_19, TSS_17 Deep, TSS_18,	13-Apr-2019	----	----	----	18-Apr-2019	20-Apr-2019	✔
Clear Plastic Bottle - Natural (EA025)	WQ_09, TSS_02, TSS_33,	14-Apr-2019	----	----	----	18-Apr-2019	21-Apr-2019	✔
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Clear Plastic Bottle - Natural (ED041G)	WQ_06, WQ_02, WQ_13	12-Apr-2019	----	----	----	18-Apr-2019	10-May-2019	✔
Clear Plastic Bottle - Natural (ED041G)	WQ_15, WQ_08	13-Apr-2019	----	----	----	18-Apr-2019	11-May-2019	✔
Clear Plastic Bottle - Natural (ED041G)	WQ_09, WQ_11,	14-Apr-2019	----	----	----	18-Apr-2019	12-May-2019	✔



Matrix: **WATER**

Evaluation: * = Holding time breach ; ✓ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EG035F: Dissolved Mercury by FIMS								
Clear Plastic Bottle - Filtered; Lab-acidified (EG035F) WQ_03, WQ_07, WQ_18,	WQ_06, WQ_02, WQ_13	12-Apr-2019	----	----	----	24-Apr-2019	10-May-2019	✓
Clear Plastic Bottle - Filtered; Lab-acidified (EG035F) WQ_16, WQ_05,	WQ_15, WQ_08	13-Apr-2019	----	----	----	24-Apr-2019	11-May-2019	✓
Clear Plastic Bottle - Filtered; Lab-acidified (EG035F) WQ_10, WQ_04, WQ_14	WQ_09, WQ_11,	14-Apr-2019	----	----	----	24-Apr-2019	12-May-2019	✓
EG035T: Total Recoverable Mercury by FIMS								
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG035T) WQ_03, WQ_07, WQ_18,	WQ_06, WQ_02, WQ_13	12-Apr-2019	----	----	----	24-Apr-2019	10-May-2019	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG035T) WQ_16, WQ_05,	WQ_15, WQ_08	13-Apr-2019	----	----	----	24-Apr-2019	11-May-2019	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG035T) WQ_10, WQ_04, WQ_14	WQ_09, WQ_11,	14-Apr-2019	----	----	----	24-Apr-2019	12-May-2019	✓
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS								
Clear Plastic Bottle - Filtered; Lab-acidified (EG093A-F) WQ_03, WQ_07, WQ_18,	WQ_06, WQ_02, WQ_13	12-Apr-2019	----	----	----	24-Apr-2019	09-Oct-2019	✓
Clear Plastic Bottle - Filtered; Lab-acidified (EG093A-F) WQ_16, WQ_05,	WQ_15, WQ_08	13-Apr-2019	----	----	----	24-Apr-2019	10-Oct-2019	✓
Clear Plastic Bottle - Filtered; Lab-acidified (EG093A-F) WQ_10, WQ_04, WQ_14	WQ_09, WQ_11,	14-Apr-2019	----	----	----	24-Apr-2019	11-Oct-2019	✓



Matrix: **WATER**

Evaluation: * = Holding time breach ; ✓ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EG093T: Total Metals in Saline Water by ORC-ICPMS								
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG093A-T) WQ_03, WQ_07, WQ_18,	WQ_06, WQ_02, WQ_13	12-Apr-2019	23-Apr-2019	09-Oct-2019	✓	23-Apr-2019	09-Oct-2019	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG093A-T) WQ_16, WQ_05,	WQ_15, WQ_08	13-Apr-2019	23-Apr-2019	10-Oct-2019	✓	23-Apr-2019	10-Oct-2019	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG093A-T) WQ_10, WQ_04, WQ_14	WQ_09, WQ_11,	14-Apr-2019	23-Apr-2019	11-Oct-2019	✓	23-Apr-2019	11-Oct-2019	✓
EK026SF: Total CN by Segmented Flow Analyser								
Opaque plastic bottle - NaOH (EK026SF) WQ_03, WQ_07, WQ_18,	WQ_06, WQ_02, WQ_13	12-Apr-2019	----	----	----	23-Apr-2019	26-Apr-2019	✓
Opaque plastic bottle - NaOH (EK026SF) WQ_16, WQ_05,	WQ_15, WQ_08	13-Apr-2019	----	----	----	23-Apr-2019	27-Apr-2019	✓
Opaque plastic bottle - NaOH (EK026SF) WQ_10, WQ_04, WQ_14	WQ_09, WQ_11,	14-Apr-2019	----	----	----	23-Apr-2019	28-Apr-2019	✓
EK040P: Fluoride by PC Titrator								
Clear Plastic Bottle - Natural (EK040P) WQ_03, WQ_07, WQ_18,	WQ_06, WQ_02, WQ_13	12-Apr-2019	----	----	----	18-Apr-2019	10-May-2019	✓
Clear Plastic Bottle - Natural (EK040P) WQ_16, WQ_05,	WQ_15, WQ_08	13-Apr-2019	----	----	----	18-Apr-2019	11-May-2019	✓
Clear Plastic Bottle - Natural (EK040P) WQ_10, WQ_04, WQ_14	WQ_09, WQ_11,	14-Apr-2019	----	----	----	18-Apr-2019	12-May-2019	✓

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EK085M: Sulfide as S2-								
Clear Plastic Bottle - Zinc Acetate/NaOH (EK085)								
WQ_03, WQ_02, WQ_13	WQ_07, WQ_18,	12-Apr-2019	----	----	----	20-Apr-2019	19-Apr-2019	✘
Clear Plastic Bottle - Zinc Acetate/NaOH (EK085)								
WQ_16, WQ_05,	WQ_15, WQ_08	13-Apr-2019	----	----	----	20-Apr-2019	20-Apr-2019	✔
Clear Plastic Bottle - Zinc Acetate/NaOH (EK085)								
WQ_10, WQ_04, WQ_14	WQ_09, WQ_11,	14-Apr-2019	----	----	----	20-Apr-2019	21-Apr-2019	✔

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)		Quality Control Specification	
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	
Laboratory Duplicates (DUP)							
Dissolved Mercury by FIMS	EG035F	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals in Saline Water -Suite A by ORC-ICPMS	EG093A-F	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals in Saline Water -Suite B by ORC-ICPMS	EG093B-F	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	2	16	12.50	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Sulfide as S2-	EK085	4	40	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Suspended Solids	EA025	4	39	10.26	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Cyanide by Segmented Flow Analyser	EK026SF	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Saline Water Suite A by ORC-ICPMS	EG093A-T	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Saline Water -Suite B by ORC-ICPMS	EG093B-T	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Dissolved Mercury by FIMS	EG035F	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals in Saline Water -Suite A by ORC-ICPMS	EG093A-F	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals in Saline Water -Suite B by ORC-ICPMS	EG093B-F	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	1	16	6.25	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Sulfide as S2-	EK085	2	40	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Suspended Solids	EA025	4	39	10.26	15.00	✗	NEPM 2013 B3 & ALS QC Standard
Total Cyanide by Segmented Flow Analyser	EK026SF	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Saline Water Suite A by ORC-ICPMS	EG093A-T	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Saline Water -Suite B by ORC-ICPMS	EG093B-T	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Dissolved Mercury by FIMS	EG035F	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals in Saline Water -Suite A by ORC-ICPMS	EG093A-F	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals in Saline Water -Suite B by ORC-ICPMS	EG093B-F	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	1	16	6.25	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Sulfide as S2-	EK085	2	40	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Suspended Solids	EA025	2	39	5.13	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Cyanide by Segmented Flow Analyser	EK026SF	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Saline Water Suite A by ORC-ICPMS	EG093A-T	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Saline Water -Suite B by ORC-ICPMS	EG093B-T	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							



Matrix: **WATER**

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	
Matrix Spikes (MS) - Continued							
Dissolved Mercury by FIMS	EG035F	1	15	6.67	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals in Saline Water -Suite A by ORC-ICPMS	EG093A-F	1	15	6.67	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	1	16	6.25	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	15	6.67	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Sulfide as S2-	EK085	2	40	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Cyanide by Segmented Flow Analyser	EK026SF	1	15	6.67	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	15	6.67	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Metals in Saline Water Suite A by ORC-ICPMS	EG093A-T	1	15	6.67	5.00	✔	NEPM 2013 B3 & ALS QC Standard



Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Suspended Solids	EA025	WATER	In house: Referenced to APHA 2540D. A gravimetric procedure employed to determine the amount of 'non-filterable' residue in a aqueous sample. The prescribed GFC (1.2um) filter is rinsed with deionised water, oven dried and weighed prior to analysis. A well-mixed sample is filtered through a glass fibre filter (1.2um). The residue on the filter paper is dried at 104+/-2C . This method is compliant with NEPM (2013) Schedule B(3)
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	WATER	In house: Referenced to APHA 4500-SO4. Dissolved sulfate is determined in a 0.45um filtered sample. Sulfate ions are converted to a barium sulfate suspension in an acetic acid medium with barium chloride. Light absorbance of the BaSO4 suspension is measured by a photometer and the SO4-2 concentration is determined by comparison of the reading with a standard curve. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Mercury by FIMS	EG035F	WATER	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) Samples are 0.45µm filtered prior to analysis. FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Total Mercury by FIMS	EG035T	WATER	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the unfiltered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Metals in Saline Water -Suite A by ORC-ICPMS	EG093A-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020 Samples are 0.45µm filtered prior to analysis. The ORC-ICPMS technique removes interfering species through a series of chemical reactions prior to ion detection. Ions are passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to measurement by a discrete dynode ion detector. This method is compliant with NEPM (2013) Schedule B(3)
Total Metals in Saline Water Suite A by ORC-ICPMS	EG093A-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020. The ORC-ICPMS technique removes interfering species through a series of chemical reactions prior to ion detection. Ions are passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to measurement by a discrete dynode ion detector. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Metals in Saline Water -Suite B by ORC-ICPMS	EG093B-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020 Samples are 0.45µm filtered prior to analysis. The ORC-ICPMS technique removes interfering species through a series of chemical reactions prior to ion detection. Ions are passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to measurement by a discrete dynode ion detector. This method is compliant with NEPM (2013) Schedule B(3)
Total Metals in Saline Water -Suite B by ORC-ICPMS	EG093B-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020. The ORC-ICPMS technique removes interfering species through a series of chemical reactions prior to ion detection. Ions are passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to measurement by a discrete dynode ion detector. This method is compliant with NEPM (2013) Schedule B(3)



Analytical Methods	Method	Matrix	Method Descriptions
Total Cyanide by Segmented Flow Analyser	EK026SF	WATER	In house: Referenced to APHA 4500-CN C / ASTM D7511. Sodium hydroxide preserved samples are introduced into an automated segmented flow analyser. Complex bound cyanide is decomposed in a continuously flowing stream, at a pH of 3.8, by the effect of UV light. A UV-B lamp (312 nm) and a decomposition spiral of borosilicate glass are used to filter out UV light with a wavelength of less than 290 nm thus preventing the conversion of thiocyanate into cyanide. The hydrogen cyanide present at a pH of 3.8 is separated by gas dialysis. The hydrogen cyanide is then determined photometrically, based on the reaction of cyanide with chloramine-T to form cyanogen chloride. This then reacts with 4-pyridine carboxylic acid and 1,3-dimethylbarbituric acid to give a red colour which is measured at 600 nm. This method is compliant with NEPM (2013) Schedule B(3)
Fluoride by PC Titrator	EK040P	WATER	In house: Referenced to APHA 4500-F C: CDTA is added to the sample to provide a uniform ionic strength background, adjust pH, and break up complexes. Fluoride concentration is determined by either manual or automatic ISE measurement. This method is compliant with NEPM (2013) Schedule B(3)
Sulfide as S2-	EK085	WATER	In house: Referenced to APHA 4500-S2- D. Sulfide species present in water samples are immediately precipitated when collected in pretreated caustic/zinc acetate preserved sample containers. The sulphides are coloured using methylene blue indicator. Non-detects may be screened by comparison against a standard at half-LOR, otherwise samples are measured using UV-VIS detection at 664nm. This method is compliant with NEPM (2013) Schedule B(3)

Preparation Methods	Method	Matrix	Method Descriptions
TKN/TP Digestion	EK061/EK067	WATER	In house: Referenced to APHA 4500 Norg - D; APHA 4500 P - H. This method is compliant with NEPM (2013) Schedule B(3)
Digestion for Total Recoverable Metals - ORC	EN25-ORC	WATER	In house: Referenced to USEPA SW846-3005. This is an Ultrapure Nitric acid digestion procedure used to prepare surface and ground water samples for analysis by ORC- ICPMS. This method is compliant with NEPM (2013) Schedule B(3)
Separatory Funnel Extraction of Liquids	ORG14	WATER	In house: Referenced to USEPA SW 846 - 3510B 100 mL to 1L of sample is transferred to a separatory funnel and serially extracted three times using DCM for each extract. The resultant extracts are combined, dehydrated and concentrated for analysis. This method is compliant with NEPM (2013) Schedule B(3) . ALS default excludes sediment which may be resident in the container.
Volatiles Water Preparation	ORG16-W	WATER	A 5 mL aliquot or 5 mL of a diluted sample is added to a 40 mL VOC vial for sparging.

QUALITY CONTROL REPORT

Work Order	: EB1910444	Page	: 1 of 11
Amendment	: 1		
Client	: COFFEY ENVIRONMENTS PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: ERICA COLLEY	Contact	: Andrew Epps
Address	: LEVEL WORKPLES BUILDING SAVANNAH HEIGHTS SECTION 531, LOT 12 WAIGANI DRIVE HOHOLA, NCD PNG	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: 64277004057	Telephone	: +61 7 3552 8639
Project	: 754-MELEN224697 JDD PROJECT	Date Samples Received	: 23-Apr-2019
Order number	: BN/065/19	Date Analysis Commenced	: 30-Apr-2019
C-O-C number	: ----	Issue Date	: 05-Dec-2019
Sampler	: ERICA COLLEY		
Site	:		
Quote number	: BN/065/19 V2		
No. of samples received	: 50		
No. of samples analysed	: 49		



Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics, Smithfield, NSW
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high

Key :
 Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
 CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
 LOR = Limit of reporting
 RPD = Relative Percentage Difference
 # = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **SOIL**

Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES (QC Lot: 2346167)									
EB1910444-019	SED 12 <2000µm Fraction	EG005-SDH: Cadmium	7440-43-9	0.1	mg/kg	<0.2	<0.2	0.00	No Limit
		EG005-SDH: Cobalt	7440-48-4	0.5	mg/kg	1.9	1.2	46.0	No Limit
		EG005-SDH: Antimony	7440-36-0	1	mg/kg	4.3	1.6	92.7	No Limit
		EG005-SDH: Arsenic	7440-38-2	1	mg/kg	6.7	7.9	16.5	No Limit
		EG005-SDH: Barium	7440-39-3	1	mg/kg	38.7	36.8	5.03	0% - 20%
		EG005-SDH: Beryllium	7440-41-7	1	mg/kg	<1.0	<1.0	0.00	No Limit
		EG005-SDH: Chromium	7440-47-3	1	mg/kg	9.2	8.4	8.28	No Limit
		EG005-SDH: Copper	7440-50-8	1	mg/kg	3.2	2.9	7.76	No Limit
		EG005-SDH: Lead	7439-92-1	1	mg/kg	6.5	6.3	4.12	No Limit
		EG005-SDH: Nickel	7440-02-0	1	mg/kg	2.7	2.7	0.00	No Limit
		EG005-SDH: Zinc	7440-66-6	1	mg/kg	5.1	4.4	16.5	No Limit
		EG005-SDH: Manganese	7439-96-5	10	mg/kg	361	373	3.44	0% - 20%
		EG005-SDH: Vanadium	7440-62-2	2	mg/kg	2.9	2.2	29.2	No Limit
		EG005-SDH: Aluminium	7429-90-5	50	mg/kg	1190	990	18.4	0% - 20%
		EG005-SDH: Iron	7439-89-6	50	mg/kg	3250	2680	19.2	0% - 20%
EB1910444-030	SED 11 <2000µm Fraction	EG005-SDH: Cadmium	7440-43-9	0.1	mg/kg	<0.2	0.4	36.4	No Limit
		EG005-SDH: Cobalt	7440-48-4	0.5	mg/kg	3.6	4.4	18.7	No Limit
		EG005-SDH: Antimony	7440-36-0	1	mg/kg	1.4	<1.0	36.9	No Limit
		EG005-SDH: Arsenic	7440-38-2	1	mg/kg	6.2	6.0	4.08	No Limit
		EG005-SDH: Barium	7440-39-3	1	mg/kg	43.4	43.2	0.523	0% - 20%
		EG005-SDH: Beryllium	7440-41-7	1	mg/kg	<1.0	<1.0	0.00	No Limit
		EG005-SDH: Chromium	7440-47-3	1	mg/kg	27.4	27.9	1.87	0% - 20%
		EG005-SDH: Copper	7440-50-8	1	mg/kg	5.9	5.9	0.00	No Limit
		EG005-SDH: Lead	7439-92-1	1	mg/kg	12.7	15.9	22.8	0% - 50%
		EG005-SDH: Nickel	7440-02-0	1	mg/kg	7.7	6.7	14.0	No Limit



Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES (QC Lot: 2346167) - continued									
EB1910444-030	SED 11 <2000µm Fraction	EG005-SDH: Zinc	7440-66-6	1	mg/kg	14.4	14.4	0.00	0% - 50%
		EG005-SDH: Manganese	7439-96-5	10	mg/kg	595	555	6.99	0% - 20%
		EG005-SDH: Vanadium	7440-62-2	2	mg/kg	10.6	10.4	2.18	No Limit
		EG005-SDH: Aluminium	7429-90-5	50	mg/kg	4920	4950	0.668	0% - 20%
		EG005-SDH: Iron	7439-89-6	50	mg/kg	13300	13400	1.13	0% - 20%
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES (QC Lot: 2346170)									
EB1910444-041	SED 17 <63µm Fraction	EG005-SDH: Cadmium	7440-43-9	0.1	mg/kg	0.4	0.4	0.00	No Limit
		EG005-SDH: Cobalt	7440-48-4	0.5	mg/kg	11.1	11.1	0.00	0% - 20%
		EG005-SDH: Antimony	7440-36-0	1	mg/kg	<1.0	<1.0	0.00	No Limit
		EG005-SDH: Arsenic	7440-38-2	1	mg/kg	7.0	8.3	16.8	No Limit
		EG005-SDH: Barium	7440-39-3	1	mg/kg	63.5	64.6	1.66	0% - 20%
		EG005-SDH: Beryllium	7440-41-7	1	mg/kg	1.1	1.1	0.00	No Limit
		EG005-SDH: Chromium	7440-47-3	1	mg/kg	71.9	72.0	0.00	0% - 20%
		EG005-SDH: Copper	7440-50-8	1	mg/kg	25.3	25.3	0.00	0% - 20%
		EG005-SDH: Lead	7439-92-1	1	mg/kg	50.7	49.8	1.89	0% - 20%
		EG005-SDH: Nickel	7440-02-0	1	mg/kg	15.4	15.7	1.73	0% - 50%
		EG005-SDH: Zinc	7440-66-6	1	mg/kg	47.5	47.3	0.431	0% - 20%
		EG005-SDH: Manganese	7439-96-5	10	mg/kg	934	933	0.157	0% - 20%
		EG005-SDH: Vanadium	7440-62-2	2	mg/kg	23.3	23.8	2.20	0% - 50%
		EG005-SDH: Aluminium	7429-90-5	50	mg/kg	12300	12400	0.554	0% - 20%
		EG005-SDH: Iron	7439-89-6	50	mg/kg	28700	28900	0.612	0% - 20%
EB1910444-051	SED 21 <63µm Fraction	EG005-SDH: Cadmium	7440-43-9	0.1	mg/kg	<0.2	<0.2	0.00	No Limit
		EG005-SDH: Cobalt	7440-48-4	0.5	mg/kg	24.0	23.5	2.09	0% - 20%
		EG005-SDH: Antimony	7440-36-0	1	mg/kg	<1.0	5.5	138	No Limit
		EG005-SDH: Arsenic	7440-38-2	1	mg/kg	11.3	12.8	12.5	0% - 50%
		EG005-SDH: Barium	7440-39-3	1	mg/kg	65.8	65.9	0.187	0% - 20%
		EG005-SDH: Beryllium	7440-41-7	1	mg/kg	1.9	1.9	0.00	No Limit
		EG005-SDH: Chromium	7440-47-3	1	mg/kg	58.6	58.6	0.00	0% - 20%
		EG005-SDH: Copper	7440-50-8	1	mg/kg	35.3	35.3	0.00	0% - 20%
		EG005-SDH: Lead	7439-92-1	1	mg/kg	61.7	62.7	1.59	0% - 20%
		EG005-SDH: Nickel	7440-02-0	1	mg/kg	31.6	30.8	2.41	0% - 20%
		EG005-SDH: Zinc	7440-66-6	1	mg/kg	73.6	73.6	0.00	0% - 20%
		EG005-SDH: Manganese	7439-96-5	10	mg/kg	1840	1850	0.132	0% - 20%
		EG005-SDH: Vanadium	7440-62-2	2	mg/kg	62.4	62.1	0.589	0% - 20%
		EG005-SDH: Aluminium	7429-90-5	50	mg/kg	23400	23300	0.326	0% - 20%
		EG005-SDH: Iron	7439-89-6	50	mg/kg	54000	54000	0.113	0% - 20%
EG005(ED093)T: Total Metals by ICP-AES (QC Lot: 2346171)									
EB1910444-019	SED 12 <2000µm Fraction	EG005T: Beryllium	7440-41-7	1	mg/kg	<1	<1	0.00	No Limit
		EG005T: Cadmium	7440-43-9	1	mg/kg	<1	<1	0.00	No Limit
		EG005T: Barium	7440-39-3	10	mg/kg	<10	<10	0.00	No Limit



Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EG005(ED093)T: Total Metals by ICP-AES (QC Lot: 2346171) - continued									
EB1910444-019	SED 12 <2000µm Fraction	EG005T: Chromium	7440-47-3	2	mg/kg	3	3	0.00	No Limit
		EG005T: Cobalt	7440-48-4	2	mg/kg	<2	<2	0.00	No Limit
		EG005T: Nickel	7440-02-0	2	mg/kg	<2	<2	0.00	No Limit
		EG005T: Silver	7440-22-4	2	mg/kg	<2	<2	0.00	No Limit
		EG005T: Arsenic	7440-38-2	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Copper	7440-50-8	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Lead	7439-92-1	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Manganese	7439-96-5	5	mg/kg	76	73	3.40	0% - 50%
		EG005T: Selenium	7782-49-2	5	mg/kg	6	<5	20.8	No Limit
		EG005T: Tin	7440-31-5	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Vanadium	7440-62-2	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Zinc	7440-66-6	5	mg/kg	12	12	0.00	No Limit
		EG005T: Boron	7440-42-8	50	mg/kg	<50	<50	0.00	No Limit
		EG005T: Iron	7439-89-6	50	mg/kg	1930	1730	10.9	0% - 20%
EB1910444-030	SED 11 <2000µm Fraction	EG005T: Beryllium	7440-41-7	1	mg/kg	<1	<1	0.00	No Limit
		EG005T: Cadmium	7440-43-9	1	mg/kg	<1	<1	0.00	No Limit
		EG005T: Barium	7440-39-3	10	mg/kg	10	10	0.00	No Limit
		EG005T: Chromium	7440-47-3	2	mg/kg	11	11	0.00	No Limit
		EG005T: Cobalt	7440-48-4	2	mg/kg	2	2	0.00	No Limit
		EG005T: Nickel	7440-02-0	2	mg/kg	5	5	0.00	No Limit
		EG005T: Silver	7440-22-4	2	mg/kg	<2	<2	0.00	No Limit
		EG005T: Arsenic	7440-38-2	5	mg/kg	5	6	0.00	No Limit
		EG005T: Copper	7440-50-8	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Lead	7439-92-1	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Manganese	7439-96-5	5	mg/kg	142	146	2.52	0% - 20%
		EG005T: Selenium	7782-49-2	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Tin	7440-31-5	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Vanadium	7440-62-2	5	mg/kg	6	6	0.00	No Limit
		EG005T: Zinc	7440-66-6	5	mg/kg	17	17	0.00	No Limit
		EG005T: Boron	7440-42-8	50	mg/kg	<50	<50	0.00	No Limit
		EG005T: Iron	7439-89-6	50	mg/kg	8140	8260	1.56	0% - 20%
		EG005(ED093)T: Total Metals by ICP-AES (QC Lot: 2346174)							
EB1910444-041	SED 17 <63µm Fraction	EG005T: Beryllium	7440-41-7	1	mg/kg	<1	<1	0.00	No Limit
		EG005T: Cadmium	7440-43-9	1	mg/kg	<1	<1	0.00	No Limit
		EG005T: Barium	7440-39-3	10	mg/kg	20	20	0.00	No Limit
		EG005T: Chromium	7440-47-3	2	mg/kg	27	27	0.00	0% - 50%
		EG005T: Cobalt	7440-48-4	2	mg/kg	5	5	0.00	No Limit
		EG005T: Nickel	7440-02-0	2	mg/kg	12	11	0.00	No Limit
		EG005T: Silver	7440-22-4	2	mg/kg	<2	<2	0.00	No Limit
		EG005T: Arsenic	7440-38-2	5	mg/kg	6	5	18.1	No Limit

Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report							
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)		
EG005(ED093)T: Total Metals by ICP-AES (QC Lot: 2346174) - continued											
EB1910444-041	SED 17 <63µm Fraction	EG005T: Copper	7440-50-8	5	mg/kg	12	12	0.00	No Limit		
		EG005T: Lead	7439-92-1	5	mg/kg	13	13	0.00	No Limit		
		EG005T: Manganese	7439-96-5	5	mg/kg	277	275	0.707	0% - 20%		
		EG005T: Selenium	7782-49-2	5	mg/kg	<5	<5	0.00	No Limit		
		EG005T: Tin	7440-31-5	5	mg/kg	<5	<5	0.00	No Limit		
		EG005T: Vanadium	7440-62-2	5	mg/kg	17	17	0.00	No Limit		
		EG005T: Zinc	7440-66-6	5	mg/kg	33	33	0.00	No Limit		
		EG005T: Boron	7440-42-8	50	mg/kg	<50	<50	0.00	No Limit		
		EG005T: Iron	7439-89-6	50	mg/kg	17000	17000	0.0757	0% - 20%		
EB1910444-051	SED 21 <63µm Fraction	EG005T: Beryllium	7440-41-7	1	mg/kg	<1	<1	0.00	No Limit		
		EG005T: Cadmium	7440-43-9	1	mg/kg	<1	<1	0.00	No Limit		
		EG005T: Barium	7440-39-3	10	mg/kg	30	30	0.00	No Limit		
		EG005T: Chromium	7440-47-3	2	mg/kg	39	38	0.00	0% - 50%		
		EG005T: Cobalt	7440-48-4	2	mg/kg	12	11	0.00	No Limit		
		EG005T: Nickel	7440-02-0	2	mg/kg	23	23	0.00	0% - 50%		
		EG005T: Silver	7440-22-4	2	mg/kg	<2	<2	0.00	No Limit		
		EG005T: Arsenic	7440-38-2	5	mg/kg	9	8	21.4	No Limit		
		EG005T: Copper	7440-50-8	5	mg/kg	25	25	0.00	No Limit		
		EG005T: Lead	7439-92-1	5	mg/kg	18	17	0.00	No Limit		
		EG005T: Manganese	7439-96-5	5	mg/kg	618	606	1.81	0% - 20%		
		EG005T: Selenium	7782-49-2	5	mg/kg	<5	<5	0.00	No Limit		
		EG005T: Tin	7440-31-5	5	mg/kg	<5	<5	0.00	No Limit		
		EG005T: Vanadium	7440-62-2	5	mg/kg	42	42	0.00	No Limit		
		EG005T: Zinc	7440-66-6	5	mg/kg	61	60	0.00	0% - 50%		
		EG005T: Boron	7440-42-8	50	mg/kg	<50	<50	0.00	No Limit		
		EG005T: Iron	7439-89-6	50	mg/kg	35000	34400	1.95	0% - 20%		
		EA002: pH 1:5 (Soils) (QC Lot: 2336340)									
		EB1910444-011	SED 7	EA002: pH Value	----	0.1	pH Unit	8.6	8.7	0.00	0% - 20%
EB1910444-001	SED 12	EA002: pH Value	----	0.1	pH Unit	8.6	8.6	0.00	0% - 20%		
EA055: Moisture Content (Dried @ 105-110°C) (QC Lot: 2323423)											
EB1910444-004	SED 24	EA055: Moisture Content	----	0.1	%	47.6	48.6	2.00	0% - 20%		
EB1910444-016	SED 21	EA055: Moisture Content	----	0.1	%	54.9	53.9	1.83	0% - 20%		
EG035-SDH: 1M HCl extractable Mercury by FIMS (QC Lot: 2346168)											
EB1910444-019	SED 12 <2000µm Fraction	EG035-SDH: Mercury	7439-97-6	0.1	mg/kg	<0.10	<0.10	0.00	No Limit		
EB1910444-030	SED 11 <2000µm Fraction	EG035-SDH: Mercury	7439-97-6	0.1	mg/kg	<0.10	<0.10	0.00	No Limit		
EG035-SDH: 1M HCl extractable Mercury by FIMS (QC Lot: 2346169)											
EB1910444-041	SED 17 <63µm Fraction	EG035-SDH: Mercury	7439-97-6	0.1	mg/kg	<0.10	<0.10	0.00	No Limit		
EB1910444-051	SED 21 <63µm Fraction	EG035-SDH: Mercury	7439-97-6	0.1	mg/kg	<0.10	<0.10	0.00	No Limit		
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 2346172)											

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 Project : 754-MELEN224697 JDD PROJECT



Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 2346172) - continued									
EB1910444-019	SED 12 <2000µm Fraction	EG035T: Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
EB1910444-030	SED 11 <2000µm Fraction	EG035T: Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 2346173)									
EB1910444-041	SED 17 <63µm Fraction	EG035T: Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
EB1910444-051	SED 21 <63µm Fraction	EG035T: Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 2336341)									
EB1910444-011	SED 7	EK059G: Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.4	0.4	0.00	No Limit
EB1910444-001	SED 12	EK059G: Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.7	0.6	0.00	No Limit
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QC Lot: 2325723)									
EB1910444-001	SED 12	EK061G: Total Kjeldahl Nitrogen as N	----	20	mg/kg	380	290	25.8	0% - 50%
EB1910444-010	SED 23	EK061G: Total Kjeldahl Nitrogen as N	----	20	mg/kg	1060	1060	0.00	0% - 20%
EP003: Total Organic Carbon (TOC) in Soil (QC Lot: 2335104)									
EB1910444-001	SED 12	EP003: Total Organic Carbon	----	0.02	%	0.16	0.17	0.00	No Limit
EB1910444-011	SED 7	EP003: Total Organic Carbon	----	0.02	%	0.26	0.26	0.00	0% - 50%
EP003TC: Total Carbon (TC) in Soil (QC Lot: 2335105)									
EB1910444-001	SED 12	EP003TC: Total Carbon	TC	0.02	%	11.2	10.9	2.21	0% - 20%
EB1910444-011	SED 7	EP003TC: Total Carbon	TC	0.02	%	9.17	9.24	0.678	0% - 20%



Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

Sub-Matrix: SOIL				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low High	
Method: Compound	CAS Number	LOR	Unit	Result				
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES (QCLot: 2346167)								
EG005-SDH: Aluminium	7429-90-5	50	mg/kg	<50	5020 mg/kg	107	86	130
EG005-SDH: Antimony	7440-36-0	1	mg/kg	<1.0	----	----	----	----
EG005-SDH: Arsenic	7440-38-2	1	mg/kg	<1.0	9.35 mg/kg	107	73	116
EG005-SDH: Barium	7440-39-3	1	mg/kg	<1.0	64.2 mg/kg	110	70	130
EG005-SDH: Beryllium	7440-41-7	1	mg/kg	<1.0	----	----	----	----
EG005-SDH: Cadmium	7440-43-9	0.1	mg/kg	<0.1	0.155 mg/kg	114	70	130
EG005-SDH: Cobalt	7440-48-4	0.5	mg/kg	<0.5	2.47 mg/kg	117	70	130
EG005-SDH: Chromium	7440-47-3	1	mg/kg	<1.0	5.62 mg/kg	109	70	124
EG005-SDH: Copper	7440-50-8	1	mg/kg	<1.0	10.7 mg/kg	101	75	113
EG005-SDH: Iron	7439-89-6	50	mg/kg	<50	7120 mg/kg	99.4	71	123
EG005-SDH: Lead	7439-92-1	1	mg/kg	<1.0	20.4 mg/kg	114	87	130
EG005-SDH: Manganese	7439-96-5	10	mg/kg	<10	223 mg/kg	107	70	130
EG005-SDH: Nickel	7440-02-0	1	mg/kg	<1.0	4.29 mg/kg	109	70	128
EG005-SDH: Vanadium	7440-62-2	2	mg/kg	<2.0	10.6 mg/kg	106	70	130
EG005-SDH: Zinc	7440-66-6	1	mg/kg	<1.0	36.3 mg/kg	113	70	117
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES (QCLot: 2346170)								
EG005-SDH: Aluminium	7429-90-5	50	mg/kg	<50	5020 mg/kg	105	86	130
EG005-SDH: Antimony	7440-36-0	1	mg/kg	<1.0	----	----	----	----
EG005-SDH: Arsenic	7440-38-2	1	mg/kg	<1.0	9.35 mg/kg	109	73	116
EG005-SDH: Barium	7440-39-3	1	mg/kg	<1.0	64.2 mg/kg	108	70	130
EG005-SDH: Beryllium	7440-41-7	1	mg/kg	<1.0	----	----	----	----
EG005-SDH: Cadmium	7440-43-9	0.1	mg/kg	<0.1	0.155 mg/kg	129	70	130
EG005-SDH: Cobalt	7440-48-4	0.5	mg/kg	<0.5	2.47 mg/kg	115	70	130
EG005-SDH: Chromium	7440-47-3	1	mg/kg	<1.0	5.62 mg/kg	106	70	124
EG005-SDH: Copper	7440-50-8	1	mg/kg	<1.0	10.7 mg/kg	99.1	75	113
EG005-SDH: Iron	7439-89-6	50	mg/kg	<50	7120 mg/kg	97.8	71	123
EG005-SDH: Lead	7439-92-1	1	mg/kg	<1.0	20.4 mg/kg	112	87	130
EG005-SDH: Manganese	7439-96-5	10	mg/kg	<10	223 mg/kg	105	70	130
EG005-SDH: Nickel	7440-02-0	1	mg/kg	<1.0	4.29 mg/kg	107	70	128
EG005-SDH: Vanadium	7440-62-2	2	mg/kg	<2.0	10.6 mg/kg	104	70	130
EG005-SDH: Zinc	7440-66-6	1	mg/kg	<1.0	36.3 mg/kg	110	70	117
EG005(ED093)T: Total Metals by ICP-AES (QCLot: 2346171)								
EG005T: Arsenic	7440-38-2	5	mg/kg	<5	100 mg/kg	95.9	84	123
EG005T: Barium	7440-39-3	10	mg/kg	<10	85.6 mg/kg	108	89	129



Sub-Matrix: SOIL				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low High	
Method: Compound	CAS Number	LOR	Unit	Result				
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2346172) - continued								
EG035T: Mercury	7439-97-6	0.1	mg/kg	<0.1	0.0847 mg/kg	85.0	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2346173)								
EG035T: Mercury	7439-97-6	0.1	mg/kg	<0.1	0.0847 mg/kg	89.1	70	130
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2336341)								
EK059G: Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	<0.1	2.5 mg/kg	103	88	118
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2325723)								
EK061G: Total Kjeldahl Nitrogen as N	----	20	mg/kg	<20	1000 mg/kg	100	72	106
				<20	100 mg/kg	107	70	122
				<20	500 mg/kg	97.0	74	118
EP003: Total Organic Carbon (TOC) in Soil (QCLot: 2335104)								
EP003: Total Organic Carbon	----	0.02	%	<0.02	0.44 %	105	70	130
EP003TC: Total Carbon (TC) in Soil (QCLot: 2335105)								
EP003TC: Total Carbon	TC	0.02	%	<0.02	8.4 %	107	70	130

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: SOIL				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES (QCLot: 2346167)							
EB1910444-020	SED 9 <2000µm Fraction	EG005-SDH: Arsenic	7440-38-2	125 mg/kg	# 68.8	70	130
		EG005-SDH: Barium	7440-39-3	125 mg/kg	97.2	70	130
		EG005-SDH: Cadmium	7440-43-9	65 mg/kg	80.3	70	130
		EG005-SDH: Cobalt	7440-48-4	125 mg/kg	84.2	70	130
		EG005-SDH: Chromium	7440-47-3	125 mg/kg	85.1	70	130
		EG005-SDH: Copper	7440-50-8	125 mg/kg	90.1	70	130
		EG005-SDH: Lead	7439-92-1	125 mg/kg	81.6	70	130
		EG005-SDH: Manganese	7439-96-5	125 mg/kg	# Not Determined	70	130
		EG005-SDH: Nickel	7440-02-0	125 mg/kg	85.5	70	130
		EG005-SDH: Vanadium	7440-62-2	125 mg/kg	90.2	70	130
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES (QCLot: 2346170)							
EB1910444-042	SED 2 <63µm Fraction	EG005-SDH: Arsenic	7440-38-2	25 mg/kg	87.0	70	130
EB1910444-042	SED 2 <63µm Fraction	EG005-SDH: Barium	7440-39-3	125 mg/kg	96.8	70	130
		EG005-SDH: Cadmium	7440-43-9	12.5 mg/kg	74.9	70	130



Sub-Matrix: **SOIL**

Sub-Matrix: SOIL				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES (QCLot: 2346170) - continued							
EB1910444-042	SED 2 <63µm Fraction	EG005-SDH: Cobalt	7440-48-4	125 mg/kg	82.3	70	130
		EG005-SDH: Chromium	7440-47-3	125 mg/kg	80.4	70	130
		EG005-SDH: Copper	7440-50-8	125 mg/kg	89.8	70	130
		EG005-SDH: Lead	7439-92-1	125 mg/kg	80.4	70	130
		EG005-SDH: Manganese	7439-96-5	125 mg/kg	# Not Determined	70	130
		EG005-SDH: Nickel	7440-02-0	125 mg/kg	83.3	70	130
		EG005-SDH: Vanadium	7440-62-2	125 mg/kg	88.3	70	130
		EG005-SDH: Zinc	7440-66-6	125 mg/kg	76.5	70	130
EG005(ED093)T: Total Metals by ICP-AES (QCLot: 2346171)							
EB1910444-020	SED 9 <2000µm Fraction	EG005T: Arsenic	7440-38-2	50 mg/kg	90.0	70	130
		EG005T: Barium	7440-39-3	50 mg/kg	100	70	130
		EG005T: Beryllium	7440-41-7	5 mg/kg	100	70	130
		EG005T: Cadmium	7440-43-9	25 mg/kg	84.4	70	130
		EG005T: Chromium	7440-47-3	50 mg/kg	90.2	70	130
		EG005T: Cobalt	7440-48-4	50 mg/kg	84.2	70	130
		EG005T: Copper	7440-50-8	50 mg/kg	96.0	70	130
		EG005T: Lead	7439-92-1	50 mg/kg	85.3	70	130
		EG005T: Manganese	7439-96-5	50 mg/kg	# Not Determined	70	130
		EG005T: Nickel	7440-02-0	50 mg/kg	85.1	70	130
		EG005T: Vanadium	7440-62-2	50 mg/kg	95.0	70	130
		EG005T: Zinc	7440-66-6	50 mg/kg	78.2	70	130
EG005(ED093)T: Total Metals by ICP-AES (QCLot: 2346174)							
EB1910444-042	SED 2 <63µm Fraction	EG005T: Arsenic	7440-38-2	50 mg/kg	83.3	70	130
		EG005T: Barium	7440-39-3	50 mg/kg	100	70	130
		EG005T: Beryllium	7440-41-7	5 mg/kg	96.6	70	130
		EG005T: Cadmium	7440-43-9	25 mg/kg	85.4	70	130
		EG005T: Chromium	7440-47-3	50 mg/kg	88.6	70	130
		EG005T: Cobalt	7440-48-4	50 mg/kg	83.2	70	130
		EG005T: Copper	7440-50-8	50 mg/kg	91.5	70	130
		EG005T: Lead	7439-92-1	50 mg/kg	86.8	70	130
		EG005T: Manganese	7439-96-5	50 mg/kg	# Not Determined	70	130
		EG005T: Nickel	7440-02-0	50 mg/kg	89.2	70	130
		EG005T: Vanadium	7440-62-2	50 mg/kg	89.5	70	130
		EG005T: Zinc	7440-66-6	50 mg/kg	81.0	70	130
EG035-SDH: 1M HCl extractable Mercury by FIMS (QCLot: 2346168)							
EB1910444-020	SED 9 <2000µm Fraction						

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Sub-Matrix: **SOIL**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EG035-SDH: 1M HCl extractable Mercury by FIMS (QCLot: 2346168) - continued							
EB1910444-020	SED 9 <2000µm Fraction	EG035-SDH: Mercury	7439-97-6	2.5 mg/kg	75.5	70	130
EG035-SDH: 1M HCl extractable Mercury by FIMS (QCLot: 2346169)							
EB1910444-042	SED 2 <63µm Fraction	EG035-SDH: Mercury	7439-97-6	2.5 mg/kg	73.3	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2346172)							
EB1910444-020	SED 9 <2000µm Fraction	EG035T: Mercury	7439-97-6	5 mg/kg	83.5	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2346173)							
EB1910444-042	SED 2 <63µm Fraction	EG035T: Mercury	7439-97-6	5 mg/kg	90.3	70	130
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2336341)							
EB1910444-001	SED 12	EK059G: Nitrite + Nitrate as N (Sol.)	----	2.5 mg/kg	103	70	130
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2325723)							
EB1910444-001	SED 12	EK061G: Total Kjeldahl Nitrogen as N	----	500 mg/kg	92.1	70	130

QA/QC Compliance Assessment to assist with Quality Review

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Amendment	: 1		
Client	: COFFEY ENVIRONMENTS PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: ERICA COLLEY	Telephone	: +61 7 3552 8639
Project	: 754-MELEN224697 JDD PROJECT	Date Samples Received	: 23-Apr-2019
Site	:	Issue Date	: 05-Dec-2019
Sampler	: ERICA COLLEY	No. of samples received	: 50
Order number	: BN/065/19	No. of samples analysed	: 49

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO** Method Blank value outliers occur.
- **NO** Duplicate outliers occur.
- **NO** Laboratory Control outliers occur.
- Matrix Spike outliers exist - please see following pages for full details.
- For all regular sample matrices, **NO** surrogate recovery outliers occur.

Outliers : Analysis Holding Time Compliance

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- Quality Control Sample Frequency Outliers exist - please see following pages for full details.



Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **SOIL**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries							
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICP	EB1910444--020	SED 9 <2000µm Fraction	Arsenic	7440-38-2	68.8 %	70-130%	Recovery less than lower data quality objective
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICP	EB1910444--020	SED 9 <2000µm Fraction	Manganese	7439-96-5	Not Determined	----	MS recovery not determined, background level greater than or equal to 4x spike level.
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICP	EB1910444--042	SED 2 <63µm Fraction	Manganese	7439-96-5	Not Determined	----	MS recovery not determined, background level greater than or equal to 4x spike level.
EG005(ED093)T: Total Metals by ICP-AES	EB1910444--020	SED 9 <2000µm Fraction	Manganese	7439-96-5	Not Determined	----	MS recovery not determined, background level greater than or equal to 4x spike level.
EG005(ED093)T: Total Metals by ICP-AES	EB1910444--042	SED 2 <63µm Fraction	Manganese	7439-96-5	Not Determined	----	MS recovery not determined, background level greater than or equal to 4x spike level.

Outliers : Analysis Holding Time Compliance

Matrix: **SOIL**

Method		Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EA002: pH 1:5 (Soils)							
Soil Glass Jar - Unpreserved SED 11		09-May-2019	22-Apr-2019	17	----	----	----
Soil Glass Jar - Unpreserved SED 3, SED 25, SED 1, SED 23, SED 20, SED 22		09-May-2019	23-Apr-2019	16	----	----	----
Soil Glass Jar - Unpreserved SED 12, SED 17, SED 18		09-May-2019	24-Apr-2019	15	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)							
Soil Glass Jar - Unpreserved SED 11		----	----	----	02-May-2019	29-Apr-2019	3



Matrix: **SOIL**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA002: pH 1:5 (Soils)								
Soil Glass Jar - Unpreserved (EA002) SED 11		15-Apr-2019	09-May-2019	22-Apr-2019	✖	09-May-2019	09-May-2019	✓
Soil Glass Jar - Unpreserved (EA002) SED 3, SED 25, SED 1, SED 23, SED 20, SED 22	SED 24, SED 2, SED 13, SED 10, SED 21,	16-Apr-2019	09-May-2019	23-Apr-2019	✖	09-May-2019	09-May-2019	✓
Soil Glass Jar - Unpreserved (EA002) SED 12, SED 17, SED 18	SED 9, SED 7,	17-Apr-2019	09-May-2019	24-Apr-2019	✖	09-May-2019	09-May-2019	✓
EA055: Moisture Content (Dried @ 105-110°C)								
Soil Glass Jar - Unpreserved (EA055) SED 11		15-Apr-2019	----	----	----	02-May-2019	29-Apr-2019	✖
Soil Glass Jar - Unpreserved (EA055) SED 3, SED 25, SED 1, SED 23, SED 20, SED 22	SED 24, SED 2, SED 13, SED 10, SED 21,	16-Apr-2019	----	----	----	02-May-2019	30-Apr-2019	✖
Soil Glass Jar - Unpreserved (EA055) SED 12		17-Apr-2019	----	----	----	01-May-2019	01-May-2019	✓
Soil Glass Jar - Unpreserved (EA055) SED 9,	SED 17	17-Apr-2019	----	----	----	02-May-2019	01-May-2019	✖
Soil Glass Jar - Unpreserved (EA055) SED 7		17-Apr-2019	----	----	----	01-May-2019	01-May-2019	✓
Soil Glass Jar - Unpreserved (EA055) SED 18		17-Apr-2019	----	----	----	02-May-2019	01-May-2019	✖



Matrix: **SOIL**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA150: Particle Sizing								
Snap Lock Bag (EA150H) SED 11		15-Apr-2019	----	----	----	15-May-2019	12-Oct-2019	✓
Snap Lock Bag (EA150H) SED 3, SED 2, SED 13, SED 10, SED 21,	SED 24, SED 1, SED 23, SED 20, SED 22	16-Apr-2019	----	----	----	15-May-2019	13-Oct-2019	✓
Snap Lock Bag (EA150H) SED 12, SED 17, SED 18	SED 9, SED 7,	17-Apr-2019	----	----	----	15-May-2019	14-Oct-2019	✓
EA150: Soil Classification based on Particle Size								
Snap Lock Bag (EA150H) SED 11		15-Apr-2019	----	----	----	15-May-2019	12-Oct-2019	✓
Snap Lock Bag (EA150H) SED 3, SED 2, SED 13, SED 10, SED 21,	SED 24, SED 1, SED 23, SED 20, SED 22	16-Apr-2019	----	----	----	15-May-2019	13-Oct-2019	✓
Snap Lock Bag (EA150H) SED 12, SED 17, SED 18	SED 9, SED 7,	17-Apr-2019	----	----	----	15-May-2019	14-Oct-2019	✓
EA152: Soil Particle Density								
Snap Lock Bag (EA152) SED 11		15-Apr-2019	----	----	----	15-May-2019	12-Oct-2019	✓
Snap Lock Bag (EA152) SED 3, SED 2, SED 13, SED 10, SED 21,	SED 24, SED 1, SED 23, SED 20, SED 22	16-Apr-2019	----	----	----	15-May-2019	13-Oct-2019	✓
Snap Lock Bag (EA152) SED 12, SED 17, SED 18	SED 9, SED 7,	17-Apr-2019	----	----	----	15-May-2019	14-Oct-2019	✓



Matrix: **SOIL**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES								
Pulp Bag (-2000µm) (EG005-SDH) SED 12 - <2000µm Fraction, SED 3 - <2000µm Fraction, SED 17 - <2000µm Fraction, SED 1 - <2000µm Fraction, SED 23 - <2000µm Fraction, SED 11 - <2000µm Fraction, SED 18 - <2000µm Fraction, SED 21 - <2000µm Fraction,	SED 9 - <2000µm Fraction, SED 24 - <2000µm Fraction, SED 2 - <2000µm Fraction, SED 13 - <2000µm Fraction, SED 7 - <2000µm Fraction, SED 10 - <2000µm Fraction, SED 20 - <2000µm Fraction, SED 22 - <2000µm Fraction	14-May-2019	15-May-2019	10-Nov-2019	✔	16-May-2019	10-Nov-2019	✔
Pulp Bag (-63µm) (EG005-SDH) SED 12 - <63µm Fraction, SED 3 - <63µm Fraction, SED 17 - <63µm Fraction, SED 1 - <63µm Fraction, SED 23 - <63µm Fraction, SED 11 - <63µm Fraction, SED 18 - <63µm Fraction, SED 21 - <63µm Fraction,	SED 9 - <63µm Fraction, SED 24 - <63µm Fraction, SED 2 - <63µm Fraction, SED 13 - <63µm Fraction, SED 7 - <63µm Fraction, SED 10 - <63µm Fraction, SED 20 - <63µm Fraction, SED 22 - <63µm Fraction	14-May-2019	15-May-2019	10-Nov-2019	✔	16-May-2019	10-Nov-2019	✔
EG005(ED093)T: Total Metals by ICP-AES								
Pulp Bag (-2000µm) (EG005T) SED 12 - <2000µm Fraction, SED 3 - <2000µm Fraction, SED 17 - <2000µm Fraction, SED 1 - <2000µm Fraction, SED 23 - <2000µm Fraction, SED 11 - <2000µm Fraction, SED 18 - <2000µm Fraction, SED 21 - <2000µm Fraction,	SED 9 - <2000µm Fraction, SED 24 - <2000µm Fraction, SED 2 - <2000µm Fraction, SED 13 - <2000µm Fraction, SED 7 - <2000µm Fraction, SED 10 - <2000µm Fraction, SED 20 - <2000µm Fraction, SED 22 - <2000µm Fraction	14-May-2019	15-May-2019	10-Nov-2019	✔	15-May-2019	10-Nov-2019	✔
Pulp Bag (-63µm) (EG005T) SED 12 - <63µm Fraction, SED 3 - <63µm Fraction, SED 17 - <63µm Fraction, SED 1 - <63µm Fraction, SED 23 - <63µm Fraction, SED 11 - <63µm Fraction, SED 18 - <63µm Fraction, SED 21 - <63µm Fraction,	SED 9 - <63µm Fraction, SED 24 - <63µm Fraction, SED 2 - <63µm Fraction, SED 13 - <63µm Fraction, SED 7 - <63µm Fraction, SED 10 - <63µm Fraction, SED 20 - <63µm Fraction, SED 22 - <63µm Fraction	14-May-2019	15-May-2019	10-Nov-2019	✔	15-May-2019	10-Nov-2019	✔



Matrix: **SOIL**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EG035-SDH: 1M HCl extractable Mercury by FIMS								
Pulp Bag (-2000µm) (EG035-SDH) SED 12 - <2000µm Fraction, SED 3 - <2000µm Fraction, SED 17 - <2000µm Fraction, SED 1 - <2000µm Fraction, SED 23 - <2000µm Fraction, SED 11 - <2000µm Fraction, SED 18 - <2000µm Fraction, SED 21 - <2000µm Fraction,	SED 9 - <2000µm Fraction, SED 24 - <2000µm Fraction, SED 2 - <2000µm Fraction, SED 13 - <2000µm Fraction, SED 7 - <2000µm Fraction, SED 10 - <2000µm Fraction, SED 20 - <2000µm Fraction, SED 22 - <2000µm Fraction	14-May-2019	15-May-2019	11-Jun-2019	✔	16-May-2019	11-Jun-2019	✔
Pulp Bag (-63µm) (EG035-SDH) SED 12 - <63µm Fraction, SED 3 - <63µm Fraction, SED 17 - <63µm Fraction, SED 1 - <63µm Fraction, SED 23 - <63µm Fraction, SED 11 - <63µm Fraction, SED 18 - <63µm Fraction, SED 21 - <63µm Fraction,	SED 9 - <63µm Fraction, SED 24 - <63µm Fraction, SED 2 - <63µm Fraction, SED 13 - <63µm Fraction, SED 7 - <63µm Fraction, SED 10 - <63µm Fraction, SED 20 - <63µm Fraction, SED 22 - <63µm Fraction	14-May-2019	15-May-2019	11-Jun-2019	✔	16-May-2019	11-Jun-2019	✔
EG035T: Total Recoverable Mercury by FIMS								
Pulp Bag (-2000µm) (EG035T) SED 12 - <2000µm Fraction, SED 3 - <2000µm Fraction, SED 17 - <2000µm Fraction, SED 1 - <2000µm Fraction, SED 23 - <2000µm Fraction, SED 11 - <2000µm Fraction, SED 18 - <2000µm Fraction, SED 21 - <2000µm Fraction,	SED 9 - <2000µm Fraction, SED 24 - <2000µm Fraction, SED 2 - <2000µm Fraction, SED 13 - <2000µm Fraction, SED 7 - <2000µm Fraction, SED 10 - <2000µm Fraction, SED 20 - <2000µm Fraction, SED 22 - <2000µm Fraction	14-May-2019	15-May-2019	11-Jun-2019	✔	15-May-2019	11-Jun-2019	✔
Pulp Bag (-63µm) (EG035T) SED 12 - <63µm Fraction, SED 3 - <63µm Fraction, SED 17 - <63µm Fraction, SED 1 - <63µm Fraction, SED 23 - <63µm Fraction, SED 11 - <63µm Fraction, SED 18 - <63µm Fraction, SED 21 - <63µm Fraction,	SED 9 - <63µm Fraction, SED 24 - <63µm Fraction, SED 2 - <63µm Fraction, SED 13 - <63µm Fraction, SED 7 - <63µm Fraction, SED 10 - <63µm Fraction, SED 20 - <63µm Fraction, SED 22 - <63µm Fraction	14-May-2019	15-May-2019	11-Jun-2019	✔	15-May-2019	11-Jun-2019	✔



Matrix: **SOIL**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Soil Glass Jar - Unpreserved (EK059G) SED 11		15-Apr-2019	09-May-2019	12-Oct-2019	✓	09-May-2019	12-Oct-2019	✓
Soil Glass Jar - Unpreserved (EK059G) SED 3, SED 24, SED 25, SED 2, SED 1, SED 13, SED 23, SED 10, SED 20, SED 21, SED 22		16-Apr-2019	09-May-2019	13-Oct-2019	✓	09-May-2019	13-Oct-2019	✓
Soil Glass Jar - Unpreserved (EK059G) SED 12, SED 9, SED 17, SED 7, SED 18		17-Apr-2019	09-May-2019	14-Oct-2019	✓	09-May-2019	14-Oct-2019	✓
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Soil Glass Jar - Unpreserved (EK061G) SED 11		15-Apr-2019	03-May-2019	12-Oct-2019	✓	03-May-2019	12-Oct-2019	✓
Soil Glass Jar - Unpreserved (EK061G) SED 3, SED 24, SED 25, SED 2, SED 1, SED 13, SED 23, SED 10, SED 20, SED 21, SED 22		16-Apr-2019	03-May-2019	13-Oct-2019	✓	03-May-2019	13-Oct-2019	✓
Soil Glass Jar - Unpreserved (EK061G) SED 12, SED 9, SED 17, SED 7, SED 18		17-Apr-2019	03-May-2019	14-Oct-2019	✓	03-May-2019	14-Oct-2019	✓
EP003: Total Organic Carbon (TOC) in Soil								
Snap Lock Bag (EP003) SED 11		15-Apr-2019	08-May-2019	13-May-2019	✓	08-May-2019	13-May-2019	✓
Snap Lock Bag (EP003) SED 3, SED 24, SED 25, SED 2, SED 1, SED 13, SED 23, SED 10, SED 20, SED 21, SED 22		16-Apr-2019	08-May-2019	14-May-2019	✓	08-May-2019	14-May-2019	✓
Snap Lock Bag (EP003) SED 12, SED 9, SED 17, SED 7, SED 18		17-Apr-2019	08-May-2019	15-May-2019	✓	08-May-2019	15-May-2019	✓



Matrix: **SOIL**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EP003TC: Total Carbon (TC) in Soil								
Snap Lock Bag (EP003TC) SED 11		15-Apr-2019	08-May-2019	13-May-2019	✔	08-May-2019	13-May-2019	✔
Snap Lock Bag (EP003TC) SED 3, SED 24, SED 25, SED 2, SED 1, SED 13, SED 23, SED 10, SED 20, SED 21, SED 22		16-Apr-2019	08-May-2019	14-May-2019	✔	08-May-2019	14-May-2019	✔
Snap Lock Bag (EP003TC) SED 12, SED 9, SED 17, SED 7, SED 18		17-Apr-2019	08-May-2019	15-May-2019	✔	08-May-2019	15-May-2019	✔
GEO26: Sieving								
Snap Lock Bag (GEO26C) SED 11 - <2000µm Fraction, SED 11 - <63µm Fraction		15-Apr-2019	14-May-2019	12-Oct-2019	✔	----	----	----
Snap Lock Bag (GEO26C) SED 3 - <2000µm Fraction, SED 24 - <2000µm Fraction, SED 17 - <2000µm Fraction, SED 13 - <2000µm Fraction, SED 23 - <2000µm Fraction, SED 10 - <2000µm Fraction, SED 20 - <2000µm Fraction, SED 21 - <2000µm Fraction, SED 22 - <2000µm Fraction, SED 3 - <63µm Fraction, SED 24 - <63µm Fraction, SED 2 - <63µm Fraction, SED 1 - <63µm Fraction, SED 13 - <63µm Fraction, SED 23 - <63µm Fraction, SED 10 - <63µm Fraction, SED 20 - <63µm Fraction, SED 21 - <63µm Fraction, SED 22 - <63µm Fraction		16-Apr-2019	14-May-2019	13-Oct-2019	✔	----	----	----
Snap Lock Bag (GEO26C) SED 12 - <2000µm Fraction, SED 9 - <2000µm Fraction, SED 7 - <2000µm Fraction, SED 18 - <2000µm Fraction, SED 12 - <63µm Fraction, SED 9 - <63µm Fraction, SED 17 - <63µm Fraction, SED 7 - <63µm Fraction, SED 18 - <63µm Fraction		17-Apr-2019	14-May-2019	14-Oct-2019	✔	----	----	----
Snap Lock Bag (GEO26) SED 2 - <2000µm Fraction, SED 1 - <2000µm Fraction		26-Apr-2019	14-May-2019	23-Oct-2019	✔	----	----	----



Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)		Quality Control Specification	
Analytical Methods	Method	QC	Regular	Actual	Expected		Evaluation
Laboratory Duplicates (DUP)							
1M HCl Extractable Mercury by FIMS	EG035-SDH	4	32	12.50	10.00	✓	NEPM 2013 B3 & ALS QC Standard
1M HCl Extractable Metals	EG005-SDH	4	32	12.50	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Moisture Content	EA055	2	17	11.76	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	2	17	11.76	10.00	✓	NEPM 2013 B3 & ALS QC Standard
pH (1:5)	EA002	2	17	11.76	10.00	✓	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	2	21	9.52	9.52	✓	NEPM 2013 B3 & ALS QC Standard
Total Carbon	EP003TC	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	4	32	12.50	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-AES	EG005T	4	32	12.50	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP003	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
1M HCl Extractable Mercury by FIMS	EG035-SDH	2	32	6.25	5.00	✓	NEPM 2013 B3 & ALS QC Standard
1M HCl Extractable Metals	EG005-SDH	2	32	6.25	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	1	17	5.88	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	3	21	14.29	14.29	✓	NEPM 2013 B3 & ALS QC Standard
Total Carbon	EP003TC	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	2	32	6.25	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-AES	EG005T	2	32	6.25	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP003	1	20	5.00	10.00	✗	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
1M HCl Extractable Mercury by FIMS	EG035-SDH	2	32	6.25	5.00	✓	NEPM 2013 B3 & ALS QC Standard
1M HCl Extractable Metals	EG005-SDH	2	32	6.25	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	1	17	5.88	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	1	21	4.76	4.76	✓	NEPM 2013 B3 & ALS QC Standard
Total Carbon	EP003TC	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	2	32	6.25	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-AES	EG005T	2	32	6.25	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP003	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
1M HCl Extractable Mercury by FIMS	EG035-SDH	2	32	6.25	5.00	✓	NEPM 2013 B3 & ALS QC Standard
1M HCl Extractable Metals	EG005-SDH	3	32	9.38	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	1	17	5.88	5.00	✓	NEPM 2013 B3 & ALS QC Standard

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 Work Order : EB1910444 Amendment 1
 Client : COFFEY ENVIRONMENTS PTY LTD
 Project : 754-MELEN224697 JDD PROJECT



Matrix: **SOIL**
Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	
Matrix Spikes (MS) - Continued							
TKN as N By Discrete Analyser	EK061G	1	21	4.76	4.76	✔	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	2	32	6.25	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-AES	EG005T	2	32	6.25	5.00	✔	NEPM 2013 B3 & ALS QC Standard



Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
pH (1:5)	EA002	SOIL	In house: Referenced to Rayment and Lyons 4A1 and APHA 4500H+. pH is determined on soil samples after a 1:5 soil/water leach. This method is compliant with NEPM (2013) Schedule B(3)
Moisture Content	EA055	SOIL	In house: A gravimetric procedure based on weight loss over a 12 hour drying period at 105-110 degrees C. This method is compliant with NEPM (2013) Schedule B(3) Section 6.1 and Table 1 (14 day holding time).
Particle Size Analysis by Hydrometer	EA150H	SOIL	Particle Size Analysis by Hydrometer according to AS1289.3.6.3 - 2003
Soil Particle Density	EA152	SOIL	Soil Particle Density by AS 1289.3.5.1-2006 : Methods of testing soils for engineering purposes - Soil classification tests - Determination of the soil particle density of a soil - Standard method
1M HCl Extractable Metals	EG005-SDH	SOIL	In house: Referenced to APHA 3120; USEPA SW 846 - 6010. Metals are determined via ICPAES following weak acid extraction. The ICPAES technique ionises samples in a plasma, emitting a characteristic spectrum based on metals present. Intensities at selected wavelengths are compared against those of matrix matched standards. This method is compliant with NEPM (2013) Schedule B(3). LORs per NAGD. ALS is not NATA accredited for the analysis of Barium, Boron, Molybdenum and Strontium by this method.
Total Metals by ICP-AES	EG005T	SOIL	In house: Referenced to APHA 3120; USEPA SW 846 - 6010. Metals are determined following an appropriate acid digestion of the soil. The ICPAES technique ionises samples in a plasma, emitting a characteristic spectrum based on metals present. Intensities at selected wavelengths are compared against those of matrix matched standards. This method is compliant with NEPM (2013) Schedule B(3)
1M HCl Extractable Mercury by FIMS	EG035-SDH	SOIL	In house: Referenced to AS 3550, APHA 3112 Hg - B. Mercury is determined via FIMS following weak acid extraction. FIM-AAS is an automated flameless atomic absorption technique. Mercury in solids are determined following an appropriate acid digestion. Ionic mercury is reduced online to atomic mercury vapour by SnCl ₂ which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Total Mercury by FIMS	EG035T	SOIL	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl ₂) (Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. Mercury in solids are determined following an appropriate acid digestion. Ionic mercury is reduced online to atomic mercury vapour by SnCl ₂ which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Nitrite and Nitrate as N (NO _x)- Soluble by Discrete Analyser	EK059G	SOIL	In house: Thermo Scientific Method D08727 and NEMI (National Environmental Method Index) Method ID: 9171. This method covers the determination of total oxidised nitrogen (NO _x -N) and nitrate (NO ₃ -N) by calculation, Combined oxidised Nitrogen (NO ₂ +NO ₃) in a water extract is determined by direct colourimetry by Discrete Analyser.
TKN as N By Discrete Analyser	EK061G	SOIL	In house: Referenced to APHA 4500-Norg-D Soil samples are digested using Kjeldahl digestion followed by determination by Discrete Analyser.
Total Nitrogen as N (TKN + NO _x) By Discrete Analyser	EK062G	SOIL	In house: Referenced to APHA 4500 Norg/NO ₃ - Total Nitrogen is determined as the sum of TKN and Oxidised Nitrogen, each determined separately as N.
Total Organic Carbon	EP003	SOIL	In house C-IR17. Dried and pulverised sample is reacted with acid to remove inorganic Carbonates, then combusted in a furnace in the presence of strong oxidants / catalysts. The evolved (Organic) Carbon (as CO ₂) is automatically measured by infra-red detector.



Analytical Methods	Method	Matrix	Method Descriptions
Total Carbon	EP003TC	SOIL	In house C-IR07. Dried and pulverised sample is combusted in a LECO furnace in the presence of strong oxidants / catalysts. The evolved Carbon (as CO ₂) is measured by infra-red detector
Total Inorganic Carbon	EP003TIC	SOIL	In house C-CAL15. Determined as the difference between Total Carbon and Organic Carbon.
Preparation Methods	Method	Matrix	Method Descriptions
TKN/TP Digestion	EK061/EK067	SOIL	In house: Referenced to APHA 4500 Norg- D; APHA 4500 P - H. Macro Kjeldahl digestion.
1:5 solid / water leach for soluble analytes	EN34	SOIL	10 g of soil is mixed with 50 mL of reagent grade water and tumbled end over end for 1 hour. Water soluble salts are leached from the soil by the continuous suspension. Samples are settled and the water filtered off for analysis.
Hot Block Digest for metals in soils sediments and sludges	EN69	SOIL	In house: Referenced to USEPA 200.2. Hot Block Acid Digestion 1.0g of sample is heated with Nitric and Hydrochloric acids, then cooled. Peroxide is added and samples heated and cooled again before being filtered and bulked to volume for analysis. Digest is appropriate for determination of selected metals in sludge, sediments, and soils. This method is compliant with NEPM (2013) Schedule B(3) (Method 202)
1M HCl Extraction for Metals in Sediments (1 hour)	EN71	SOIL	In house: Referenced to In house, Allen (1993). 1g of sample is leached at room temperature for 1 hour in 10% hydrochloric acid. The resultant extract is filtered and bulked for analysis of extracted metals.
Extraction for Phenoxy Acid Herbicides in Soils.	EP202-PR	SOIL	In-House: Alkaline extract followed by SPE clean up of acidified portion of the sample extract.
Sieving (fine to -2mm)	GEO26	SOIL	In house: The dried sample is sieved to 2mm and the fines are then analysed per the client's request.
Sieving (fine to -63µm)	GEO26C	SOIL	In house: The sample is sieved to -63µm and the fines are then analysed per the client's request.
Dry and Pulverise (up to 100g)	GEO30	SOIL	#
Methanolic Extraction of Soils for Purge and Trap	ORG16	SOIL	In house: Referenced to USEPA SW 846 - 5030A. 5g of solid is shaken with surrogate and 10mL methanol prior to analysis by Purge and Trap - GC/MS.
Tumbler Extraction of Solids/ Sample Cleanup	ORG17A-UTP	SOIL	In house: Mechanical agitation (tumbler). 20g of sample, Na ₂ SO ₄ and surrogate are extracted with 150mL 1:1 DCM/Acetone by end over end tumble. Samples are extracted, concentrated (by KD) and exchanged into an appropriate solvent for GPC and florisil cleanup as required.
Tumbler Extraction of Solids for LVI (Non-concentrating)	ORG17D	SOIL	In house: 10g of sample, Na ₂ SO ₄ and surrogate are extracted with 50mL 1:1 DCM/Acetone by end over end tumbling. An aliquot is concentrated by nitrogen blowdown to a reduced volume for analysis if required.

QUALITY CONTROL REPORT

Work Order	: EB1910671	Page	: 1 of 5
Amendment	: 3		
Client	: COFFEY ENVIRONMENTS PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: ERICA COLLEY	Contact	: Andrew Epps
Address	: LEVEL WORKPLES BUILDING SAVANNAH HEIGHTS SECTION 531, LOT 12 WAIGANI DRIVE HOHOLA, NCD PNG	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: 64277004057	Telephone	: +61 7 3552 8639
Project	: 754-MELEN224697 JDD PROJECT	Date Samples Received	: 23-Apr-2019
Order number	:	Date Analysis Commenced	: 26-Apr-2019
C-O-C number	: ----	Issue Date	: 05-Dec-2019
Sampler	: ERICA COLLEY		
Site	: ----		
Quote number	: BN/065/19 V2		
No. of samples received	: 8		
No. of samples analysed	: 1		



Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
 CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
 LOR = Limit of reporting
 RPD = Relative Percentage Difference
 # = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **WATER**

Sub-Matrix: WATER				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 2316236)									
EB1910681-002	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	57	57	0.00	0% - 20%
EB1910150-002	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	2	<1	72.2	No Limit
EG035F: Dissolved Mercury by FIMS (QC Lot: 2317120)									
EB1910668-001	Anonymous	EG035F: Mercury	7439-97-6	0.0001	mg/L	0.0004	0.0004	0.00	No Limit
EB1910705-001	Anonymous	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 2317244)									
EB1910631-001	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS (QC Lot: 2326655)									
EB1910671-001	WQ 19	EG094B-F: Selenium	7782-49-2	0.2	µg/L	<0.2	<0.2	0.00	No Limit
		EG094B-F: Iron	7439-89-6	2	µg/L	<2	<2	0.00	No Limit
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS (QC Lot: 2326656)									
EB1910671-001	WQ 19	EG094A-F: Cadmium	7440-43-9	0.05	µg/L	<0.05	<0.05	0.00	No Limit
		EG094A-F: Beryllium	7440-41-7	0.1	µg/L	<0.1	<0.1	0.00	No Limit
		EG094A-F: Cobalt	7440-48-4	0.1	µg/L	<0.1	<0.1	0.00	No Limit
		EG094A-F: Lead	7439-92-1	0.1	µg/L	<0.1	<0.1	0.00	No Limit
		EG094A-F: Molybdenum	7439-98-7	0.1	µg/L	<0.1	<0.1	0.00	No Limit
		EG094A-F: Silver	7440-22-4	0.1	µg/L	<0.1	<0.1	0.00	No Limit
		EG094A-F: Antimony	7440-36-0	0.2	µg/L	<0.2	<0.2	0.00	No Limit
		EG094A-F: Arsenic	7440-38-2	0.2	µg/L	<0.2	<0.2	0.00	No Limit
		EG094A-F: Chromium	7440-47-3	0.2	µg/L	<0.2	<0.2	0.00	No Limit
		EG094A-F: Tin	7440-31-5	0.2	µg/L	<0.2	<0.2	0.00	No Limit
		EG094A-F: Vanadium	7440-62-2	0.2	µg/L	<0.2	<0.2	0.00	No Limit
		EG094A-F: Barium	7440-39-3	0.5	µg/L	0.9	0.7	32.7	No Limit
		EG094A-F: Copper	7440-50-8	0.5	µg/L	<0.5	<0.5	0.00	No Limit



Sub-Matrix: WATER				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS (QC Lot: 2326656) - continued									
EB1910671-001	WQ 19	EG094A-F: Manganese	7439-96-5	0.5	µg/L	0.6	0.6	0.00	No Limit
		EG094A-F: Nickel	7440-02-0	0.5	µg/L	<0.5	<0.5	0.00	No Limit
		EG094A-F: Zinc	7440-66-6	1	µg/L	9	9	0.00	No Limit
		EG094A-F: Boron	7440-42-8	5	µg/L	<5	<5	0.00	No Limit
EG094T: Total metals in Fresh water by ORC-ICPMS (QC Lot: 2326661)									
EB1910671-001	WQ 19	EG094B-T: Selenium	7782-49-2	0.2	µg/L	<0.2	<0.2	0.00	No Limit
EG094T: Total metals in Fresh water by ORC-ICPMS (QC Lot: 2326662)									
EB1910671-001	WQ 19	EG094A-T: Cadmium	7440-43-9	0.05	µg/L	<0.05	<0.05	0.00	No Limit
		EG094A-T: Beryllium	7440-41-7	0.1	µg/L	<0.1	<0.1	0.00	No Limit
		EG094A-T: Cobalt	7440-48-4	0.1	µg/L	<0.1	<0.1	0.00	No Limit
		EG094A-T: Lead	7439-92-1	0.1	µg/L	<0.1	<0.1	0.00	No Limit
		EG094A-T: Molybdenum	7439-98-7	0.1	µg/L	<0.1	<0.1	0.00	No Limit
		EG094A-T: Silver	7440-22-4	0.1	µg/L	<0.1	<0.1	0.00	No Limit
		EG094A-T: Antimony	7440-36-0	0.2	µg/L	<0.2	<0.2	0.00	No Limit
		EG094A-T: Arsenic	7440-38-2	0.2	µg/L	<0.2	<0.2	0.00	No Limit
		EG094A-T: Chromium	7440-47-3	0.2	µg/L	<0.2	0.5	85.3	No Limit
		EG094A-T: Tin	7440-31-5	0.2	µg/L	<0.2	<0.2	0.00	No Limit
		EG094A-T: Vanadium	7440-62-2	0.2	µg/L	<0.2	<0.2	0.00	No Limit
		EG094A-T: Barium	7440-39-3	0.5	µg/L	0.8	1.2	35.5	No Limit
		EG094A-T: Copper	7440-50-8	0.5	µg/L	<0.5	<0.5	0.00	No Limit
		EG094A-T: Manganese	7439-96-5	0.5	µg/L	0.6	0.8	36.7	No Limit
		EG094A-T: Nickel	7440-02-0	0.5	µg/L	<0.5	<0.5	0.00	No Limit
		EG094A-T: Zinc	7440-66-6	1	µg/L	7	12	47.4	0% - 50%
		EG094A-T: Aluminium	7429-90-5	5	µg/L	<5	<5	0.00	No Limit
		EG094A-T: Boron	7440-42-8	5	µg/L	<5	<5	0.00	No Limit
EK026SF: Total CN by Segmented Flow Analyser (QC Lot: 2320180)									
EB1910692-001	Anonymous	EK026SF: Total Cyanide	57-12-5	0.004	mg/L	<0.004	<0.004	0.00	No Limit
EB1910788-016	Anonymous	EK026SF: Total Cyanide	57-12-5	0.004	mg/L	<0.004	<0.004	0.00	No Limit
EK040P: Fluoride by PC Titrator (QC Lot: 2320881)									
EB1910581-001	Anonymous	EK040P: Fluoride	16984-48-8	0.1	mg/L	174	168	3.51	No Limit



Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

Sub-Matrix: WATER				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low High	
Method: Compound	CAS Number	LOR	Unit	Result				
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 2316236)								
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	25 mg/L	104	85	118
				<1	100 mg/L	105	85	118
EG035F: Dissolved Mercury by FIMS (QCLot: 2317120)								
EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.01 mg/L	101	84	118
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2317244)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.01 mg/L	99.5	84	118
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS (QCLot: 2326655)								
EG094B-F: Iron	7439-89-6	2	µg/L	<2	50 µg/L	100	80	120
EG094B-F: Selenium	7782-49-2	0.2	µg/L	<0.2	10 µg/L	92.6	80	120
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS (QCLot: 2326656)								
EG094A-F: Antimony	7440-36-0	0.2	µg/L	<0.2	10 µg/L	89.9	80	120
EG094A-F: Arsenic	7440-38-2	0.2	µg/L	<0.2	10 µg/L	101	80	120
EG094A-F: Barium	7440-39-3	0.5	µg/L	<0.5	50 µg/L	98.2	80	120
EG094A-F: Beryllium	7440-41-7	0.1	µg/L	<0.1	10 µg/L	97.9	80	120
EG094A-F: Boron	7440-42-8	5	µg/L	<5	50 µg/L	88.5	80	120
EG094A-F: Cadmium	7440-43-9	0.05	µg/L	<0.05	10 µg/L	97.8	80	120
EG094A-F: Chromium	7440-47-3	0.2	µg/L	<0.2	10 µg/L	97.4	80	120
EG094A-F: Cobalt	7440-48-4	0.1	µg/L	<0.1	10 µg/L	106	80	120
EG094A-F: Copper	7440-50-8	0.5	µg/L	<0.5	20 µg/L	95.5	80	120
EG094A-F: Lead	7439-92-1	0.1	µg/L	<0.1	10 µg/L	103	80	120
EG094A-F: Manganese	7439-96-5	0.5	µg/L	<0.5	10 µg/L	102	80	120
EG094A-F: Molybdenum	7439-98-7	0.1	µg/L	<0.1	10 µg/L	94.4	80	120
EG094A-F: Nickel	7440-02-0	0.5	µg/L	<0.5	10 µg/L	103	80	120
EG094A-F: Silver	7440-22-4	0.1	µg/L	<0.1	10 µg/L	90.2	80	120
EG094A-F: Tin	7440-31-5	0.2	µg/L	<0.2	10 µg/L	88.2	80	120
EG094A-F: Vanadium	7440-62-2	0.2	µg/L	<0.2	10 µg/L	98.4	80	120
EG094A-F: Zinc	7440-66-6	1	µg/L	<1	20 µg/L	95.1	80	120
EG094T: Total metals in Fresh water by ORC-ICPMS (QCLot: 2326661)								
EG094B-T: Selenium	7782-49-2	0.2	µg/L	<0.2	10 µg/L	106	80	120
EG094T: Total metals in Fresh water by ORC-ICPMS (QCLot: 2326662)								
EG094A-T: Aluminium	7429-90-5	5	µg/L	<5	50 µg/L	101	80	120
EG094A-T: Antimony	7440-36-0	0.2	µg/L	<0.2	10 µg/L	94.0	80	120
EG094A-T: Arsenic	7440-38-2	0.2	µg/L	<0.2	10 µg/L	104	80	120
EG094A-T: Barium	7440-39-3	0.5	µg/L	<0.5	50 µg/L	104	80	120



Sub-Matrix: **WATER**

Sub-Matrix: WATER				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low High	
Method: Compound	CAS Number	LOR	Unit	Result				
EG094T: Total metals in Fresh water by ORC-ICPMS (QCLot: 2326662) - continued								
EG094A-T: Beryllium	7440-41-7	0.1	µg/L	<0.1	10 µg/L	102	80	120
EG094A-T: Boron	7440-42-8	5	µg/L	<5	50 µg/L	91.7	80	120
EG094A-T: Cadmium	7440-43-9	0.05	µg/L	<0.05	10 µg/L	104	80	120
EG094A-T: Chromium	7440-47-3	0.2	µg/L	<0.2	10 µg/L	106	80	120
EG094A-T: Cobalt	7440-48-4	0.1	µg/L	<0.1	10 µg/L	107	80	120
EG094A-T: Copper	7440-50-8	0.5	µg/L	<0.5	20 µg/L	101	80	120
EG094A-T: Lead	7439-92-1	0.1	µg/L	<0.1	10 µg/L	107	80	120
EG094A-T: Manganese	7439-96-5	0.5	µg/L	<0.5	10 µg/L	109	80	120
EG094A-T: Molybdenum	7439-98-7	0.1	µg/L	<0.1	10 µg/L	103	80	120
EG094A-T: Nickel	7440-02-0	0.5	µg/L	<0.5	10 µg/L	103	80	120
EG094A-T: Silver	7440-22-4	0.1	µg/L	<0.1	10 µg/L	94.3	80	120
EG094A-T: Tin	7440-31-5	0.2	µg/L	<0.2	10 µg/L	94.7	80	120
EG094A-T: Vanadium	7440-62-2	0.2	µg/L	<0.2	10 µg/L	102	80	120
EG094A-T: Zinc	7440-66-6	1	µg/L	<1	20 µg/L	101	80	120
EK026SF: Total CN by Segmented Flow Analyser (QCLot: 2320180)								
EK026SF: Total Cyanide	57-12-5	0.004	mg/L	<0.004	0.2 mg/L	100	85	119
EK040P: Fluoride by PC Titrator (QCLot: 2320881)								
EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	0.5 mg/L	100	80	117

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

Sub-Matrix: WATER				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 2316236)							
EB1910150-003	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	20 mg/L	96.2	70	130
EG035F: Dissolved Mercury by FIMS (QCLot: 2317120)							
EB1910671-001	WQ 19	EG035F: Mercury	7439-97-6	0.01 mg/L	92.3	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2317244)							
EB1910631-002	Anonymous	EG035T: Mercury	7439-97-6	0.01 mg/L	90.7	70	130
EK026SF: Total CN by Segmented Flow Analyser (QCLot: 2320180)							
EB1910692-002	Anonymous	EK026SF: Total Cyanide	57-12-5	0.4 mg/L	93.8	70	130
EK040P: Fluoride by PC Titrator (QCLot: 2320881)							
EB1910581-002	Anonymous	EK040P: Fluoride	16984-48-8	5 mg/L	93.0	70	130

QA/QC Compliance Assessment to assist with Quality Review

Work Order : **EB1910671**

Page : 1 of 6

Amendment : **3**

Client : **COFFEY ENVIRONMENTS PTY LTD**

Laboratory : Environmental Division Brisbane

Contact : **ERICA COLLEY**

Telephone : +61 7 3552 8639

Project : **754-MELEN224697 JDD PROJECT**

Date Samples Received : 23-Apr-2019

Site : ----

Issue Date : 05-Dec-2019

Sampler : **ERICA COLLEY**

No. of samples received : 8

Order number :

No. of samples analysed : 1

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **NO Matrix Spike outliers occur.**
- For all regular sample matrices, **NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **NO Analysis Holding Time Outliers exist.**

Outliers : Frequency of Quality Control Samples

- Quality Control Sample Frequency Outliers exist - please see following pages for full details.



Outliers : Frequency of Quality Control Samples

Matrix: **WATER**

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
Method	QC	Regular	Actual	Expected	
Matrix Spikes (MS)					
Dissolved Metals in Fresh Water -Suite A by ORC-ICPMS	0	1	0.00	5.00	NEPM 2013 B3 & ALS QC Standard
Total Metals in Fresh Water -Suite A by ORC-ICPMS	0	1	0.00	5.00	NEPM 2013 B3 & ALS QC Standard

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for VOC in soils vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA							
Clear Plastic Bottle - Natural (ED041G) WQ 19	17-Apr-2019	----	----	----	26-Apr-2019	15-May-2019	✓
EG035F: Dissolved Mercury by FIMS							
Clear Plastic Bottle - Filtered; Lab-acidified (EG035F) WQ 19	17-Apr-2019	----	----	----	01-May-2019	15-May-2019	✓
EG035T: Total Recoverable Mercury by FIMS							
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG035T) WQ 19	17-Apr-2019	----	----	----	01-May-2019	15-May-2019	✓
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS							
Clear Plastic Bottle - Filtered; Lab-acidified (EG094B-F) WQ 19	17-Apr-2019	----	----	----	03-May-2019	14-Oct-2019	✓
EG094T: Total metals in Fresh water by ORC-ICPMS							
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG094B-T) WQ 19	17-Apr-2019	03-May-2019	14-Oct-2019	✓	03-May-2019	14-Oct-2019	✓
EK026SF: Total CN by Segmented Flow Analyser							
White Plastic Bottle-NaOH (EK026SF) WQ 19	17-Apr-2019	----	----	----	30-Apr-2019	01-May-2019	✓
EK040P: Fluoride by PC Titrator							
Clear Plastic Bottle - Natural (EK040P) WQ 19	17-Apr-2019	----	----	----	30-Apr-2019	15-May-2019	✓



Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	
Laboratory Duplicates (DUP)							
Dissolved Mercury by FIMS	EG035F	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals in Fresh Water -Suite A by ORC-ICPMS	EG094A-F	1	1	100.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals in Fresh Water -Suite B by ORC-ICPMS	EG094B-F	1	1	100.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	1	9	11.11	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	12	16.67	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Cyanide by Segmented Flow Analyser	EK026SF	2	13	15.38	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	8	12.50	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Fresh Water -Suite A by ORC-ICPMS	EG094A-T	1	1	100.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Fresh Water -Suite B by ORC-ICPMS	EG094B-T	1	1	100.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Dissolved Mercury by FIMS	EG035F	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals in Fresh Water -Suite A by ORC-ICPMS	EG094A-F	1	1	100.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals in Fresh Water -Suite B by ORC-ICPMS	EG094B-F	1	1	100.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	1	9	11.11	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	12	16.67	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Cyanide by Segmented Flow Analyser	EK026SF	1	13	7.69	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	8	12.50	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Fresh Water -Suite A by ORC-ICPMS	EG094A-T	1	1	100.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Fresh Water -Suite B by ORC-ICPMS	EG094B-T	1	1	100.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Dissolved Mercury by FIMS	EG035F	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals in Fresh Water -Suite A by ORC-ICPMS	EG094A-F	1	1	100.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals in Fresh Water -Suite B by ORC-ICPMS	EG094B-F	1	1	100.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	1	9	11.11	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	12	8.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Cyanide by Segmented Flow Analyser	EK026SF	1	13	7.69	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	8	12.50	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Fresh Water -Suite A by ORC-ICPMS	EG094A-T	1	1	100.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Fresh Water -Suite B by ORC-ICPMS	EG094B-T	1	1	100.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Dissolved Mercury by FIMS	EG035F	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals in Fresh Water -Suite A by ORC-ICPMS	EG094A-F	0	1	0.00	5.00	✗	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	1	9	11.11	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	12	8.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Cyanide by Segmented Flow Analyser	EK026SF	1	13	7.69	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	8	12.50	5.00	✓	NEPM 2013 B3 & ALS QC Standard



Matrix: **WATER**

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	
Matrix Spikes (MS) - Continued							
Total Metals in Fresh Water -Suite A by ORC-ICPMS	EG094A-T	0	1	0.00	5.00	✖	NEPM 2013 B3 & ALS QC Standard



Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Sulfate (Turbidimetric) as SO ₄ 2- by Discrete Analyser	ED041G	WATER	In house: Referenced to APHA 4500-SO ₄ . Dissolved sulfate is determined in a 0.45µm filtered sample. Sulfate ions are converted to a barium sulfate suspension in an acetic acid medium with barium chloride. Light absorbance of the BaSO ₄ suspension is measured by a photometer and the SO ₄ -2 concentration is determined by comparison of the reading with a standard curve. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Mercury by FIMS	EG035F	WATER	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl ₂)(Cold Vapour generation) AAS) Samples are 0.45µm filtered prior to analysis. FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl ₂ which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Total Mercury by FIMS	EG035T	WATER	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl ₂)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the unfiltered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl ₂ which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Metals in Fresh Water -Suite A by ORC-ICPMS	EG094A-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020 Samples are 0.45µm filtered prior to analysis. The ORC-ICPMS technique removes interfering species through a series of chemical reactions prior to ion detection. Ions are passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to measurement by a discrete dynode ion detector. This method is compliant with NEPM (2013) Schedule B(3)
Total Metals in Fresh Water -Suite A by ORC-ICPMS	EG094A-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020. The ORC-ICPMS technique removes interfering species through a series of chemical reactions prior to ion detection. Ions are passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to measurement by a discrete dynode ion detector. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Metals in Fresh Water -Suite B by ORC-ICPMS	EG094B-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020 Samples are 0.45µm filtered prior to analysis. The ORC-ICPMS technique removes interfering species through a series of chemical reactions prior to ion detection. Ions are passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to measurement by a discrete dynode ion detector. This method is compliant with NEPM (2013) Schedule B(3)
Total Metals in Fresh Water -Suite B by ORC-ICPMS	EG094B-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020. The ORC-ICPMS technique removes interfering species through a series of chemical reactions prior to ion detection. Ions are passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to measurement by a discrete dynode ion detector. This method is compliant with NEPM (2013) Schedule B(3)



Analytical Methods	Method	Matrix	Method Descriptions
Total Cyanide by Segmented Flow Analyser	EK026SF	WATER	In house: Referenced to APHA 4500-CN C / ASTM D7511. Sodium hydroxide preserved samples are introduced into an automated segmented flow analyser. Complex bound cyanide is decomposed in a continuously flowing stream, at a pH of 3.8, by the effect of UV light. A UV-B lamp (312 nm) and a decomposition spiral of borosilicate glass are used to filter out UV light with a wavelength of less than 290 nm thus preventing the conversion of thiocyanate into cyanide. The hydrogen cyanide present at a pH of 3.8 is separated by gas dialysis. The hydrogen cyanide is then determined photometrically, based on the reaction of cyanide with chloramine-T to form cyanogen chloride. This then reacts with 4-pyridine carboxylic acid and 1,3-dimethylbarbituric acid to give a red colour which is measured at 600 nm. This method is compliant with NEPM (2013) Schedule B(3)
Fluoride by PC Titrator	EK040P	WATER	In house: Referenced to APHA 4500-F C: CDTA is added to the sample to provide a uniform ionic strength background, adjust pH, and break up complexes. Fluoride concentration is determined by either manual or automatic ISE measurement. This method is compliant with NEPM (2013) Schedule B(3)

Preparation Methods	Method	Matrix	Method Descriptions
TKN/TP Digestion	EK061/EK067	WATER	In house: Referenced to APHA 4500 Norg - D; APHA 4500 P - H. This method is compliant with NEPM (2013) Schedule B(3)
Digestion for Total Recoverable Metals - ORC	EN25-ORC	WATER	In house: Referenced to USEPA SW846-3005. This is an Ultrapure Nitric acid digestion procedure used to prepare surface and ground water samples for analysis by ORC- ICPMS. This method is compliant with NEPM (2013) Schedule B(3)
Separatory Funnel Extraction of Liquids	ORG14	WATER	In house: Referenced to USEPA SW 846 - 3510B 100 mL to 1L of sample is transferred to a separatory funnel and serially extracted three times using DCM for each extract. The resultant extracts are combined, dehydrated and concentrated for analysis. This method is compliant with NEPM (2013) Schedule B(3) . ALS default excludes sediment which may be resident in the container.
Volatiles Water Preparation	ORG16-W	WATER	A 5 mL aliquot or 5 mL of a diluted sample is added to a 40 mL VOC vial for sparging.

QUALITY CONTROL REPORT

Work Order	: EB1912881	Page	: 1 of 6
Client	: COFFEY ENVIRONMENTS PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: ERICA COLLEY	Contact	: Andrew Epps
Address	: LEVEL WORKPLES BUILDING SAVANNAH HEIGHTS SECTION 531, LOT 12 WAIGANI DRIVE HOHOLA, NCD PNG	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: 64277004057	Telephone	: +61 7 3552 8639
Project	: 754-MELEN224697 JDD PROJECT	Date Samples Received	: 21-May-2019
Order number	: BN/065/19	Date Analysis Commenced	: 04-Jun-2019
C-O-C number	: ----	Issue Date	: 07-Jun-2019
Sampler	: ERICA COLLEY		
Site	: ----		
Quote number	: BN/065/19 V2		
No. of samples received	: 9		
No. of samples analysed	: 6		



Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high

Key :
 Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
 CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
 LOR = Limit of reporting
 RPD = Relative Percentage Difference
 # = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **SOIL**

Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES (QC Lot: 2384848)									
EB1912881-004	SED 14 <2mm Fraction	EG005-SDH: Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
		EG005-SDH: Cobalt	7440-48-4	0.5	mg/kg	3.8	3.8	0.00	No Limit
		EG005-SDH: Antimony	7440-36-0	1	mg/kg	<1.0	<1.0	0.00	No Limit
		EG005-SDH: Arsenic	7440-38-2	1	mg/kg	<1.0	1.2	14.7	No Limit
		EG005-SDH: Barium	7440-39-3	1	mg/kg	5.9	5.9	0.00	No Limit
		EG005-SDH: Beryllium	7440-41-7	1	mg/kg	<1.0	<1.0	0.00	No Limit
		EG005-SDH: Chromium	7440-47-3	1	mg/kg	7.2	7.2	0.00	No Limit
		EG005-SDH: Copper	7440-50-8	1	mg/kg	10.0	10.0	0.00	0% - 50%
		EG005-SDH: Lead	7439-92-1	1	mg/kg	8.4	8.4	0.00	No Limit
		EG005-SDH: Nickel	7440-02-0	1	mg/kg	4.0	3.9	3.68	No Limit
		EG005-SDH: Zinc	7440-66-6	1	mg/kg	9.9	10.0	0.00	No Limit
		EG005-SDH: Manganese	7439-96-5	10	mg/kg	250	250	0.00	0% - 20%
		EG005-SDH: Vanadium	7440-62-2	2	mg/kg	11.8	12.0	1.12	No Limit
		EG005-SDH: Aluminium	7429-90-5	50	mg/kg	2550	2540	0.00	0% - 20%
		EG005-SDH: Iron	7439-89-6	50	mg/kg	8350	8440	1.00	0% - 20%
EG005(ED093)T: Total Metals by ICP-AES (QC Lot: 2384846)									
EB1912881-004	SED 14 <2mm Fraction	EG005T: Beryllium	7440-41-7	1	mg/kg	<1	<1	0.00	No Limit
		EG005T: Cadmium	7440-43-9	1	mg/kg	<1	<1	0.00	No Limit
		EG005T: Barium	7440-39-3	10	mg/kg	20	20	0.00	No Limit
		EG005T: Chromium	7440-47-3	2	mg/kg	29	32	9.28	0% - 50%
		EG005T: Cobalt	7440-48-4	2	mg/kg	10	10	0.00	No Limit
		EG005T: Nickel	7440-02-0	2	mg/kg	17	19	10.8	No Limit
		EG005T: Silver	7440-22-4	2	mg/kg	<2	<2	0.00	No Limit
		EG005T: Arsenic	7440-38-2	5	mg/kg	10	11	11.2	No Limit
EG005T: Copper	7440-50-8	5	mg/kg	25	27	7.64	No Limit		

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 Work Order : EB1912881
 Client : COFFEY ENVIRONMENTS PTY LTD
 Project : 754-MELEN224697 JDD PROJECT



Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EG005(ED093)T: Total Metals by ICP-AES (QC Lot: 2384846) - continued									
EB1912881-004	SED 14 <2mm Fraction	EG005T: Lead	7439-92-1	5	mg/kg	13	13	0.00	No Limit
		EG005T: Manganese	7439-96-5	5	mg/kg	446	482	7.76	0% - 20%
		EG005T: Selenium	7782-49-2	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Tin	7440-31-5	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Vanadium	7440-62-2	5	mg/kg	35	39	9.39	No Limit
		EG005T: Zinc	7440-66-6	5	mg/kg	52	56	8.32	0% - 50%
		EG005T: Boron	7440-42-8	50	mg/kg	<50	<50	0.00	No Limit
		EG005T: Iron	7439-89-6	50	mg/kg	30400	33400	9.33	0% - 20%
EG035-SDH: 1M HCl extractable Mercury by FIMS (QC Lot: 2384849)									
EB1912881-004	SED 14 <2mm Fraction	EG035-SDH: Mercury	7439-97-6	0.1	mg/kg	<0.10	<0.10	0.00	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 2384847)									
EB1912881-004	SED 14 <2mm Fraction	EG035T: Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	0.00	No Limit

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
	Spike Concentration	Spike Recovery (%)	Recovery Limits (%)	
		LCS	Low	High
<50	5020 mg/kg	101	86	130
<1.0	----	----	----	----
<1.0	9.35 mg/kg	90.9	73	116
<1.0	64.2 mg/kg	99.2	70	130
<1.0	----	----	----	----
<0.1	----	----	----	----
<0.5	2.47 mg/kg	111	70	130
<1.0	5.62 mg/kg	101	70	124
<1.0	10.7 mg/kg	101	75	113
<50	7120 mg/kg	95.9	71	123
<1.0	20.4 mg/kg	106	87	130
<10	223 mg/kg	102	70	130
<1.0	4.29 mg/kg	106	70	128
<2.0	10.6 mg/kg	98.7	70	130
<1.0	36.3 mg/kg	104	70	117
<5	98 mg/kg	97.7	84	123
<10	79.4 mg/kg	98.2	89	129
<1	----	----	----	----
<50	----	----	----	----
<1	----	----	----	----
<2	15.4 mg/kg	96.7	83	125
<2	9.8 mg/kg	99.2	89	125
<5	48 mg/kg	92.3	86	122
<50	27922 mg/kg	96.3	70	120
<5	50 mg/kg	97.8	84	119
<5	482 mg/kg	99.0	84	113
<2	12.4 mg/kg	98.6	89	126
<5	----	----	----	----
<2	2.4 mg/kg	89.6	70	130
<5	----	----	----	----
<5	42 mg/kg	93.5	91	127
<5	115 mg/kg	101	87	127



Sub-Matrix: SOIL				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low High	
Method: Compound	CAS Number	LOR	Unit	Result				
EG035-SDH: 1M HCl extractable Mercury by FIMS (QCLot: 2384849) - continued								
EG035-SDH: Mercury	7439-97-6	0.1	mg/kg	<0.10	0.5 mg/kg	106	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2384847)								
EG035T: Mercury	7439-97-6	0.1	mg/kg	<0.1	0.0847 mg/kg	73.9	70	130

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: SOIL				Matrix Spike (MS) Report			
				Spike Concentration	SpikeRecovery(%) MS	Recovery Limits (%) Low High	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number				
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES (QCLot: 2384848)							
EB1912881-005	SED 23 <2mm Fraction	EG005-SDH: Arsenic	7440-38-2	25 mg/kg	# 48.5	70	130
EB1912881-005	SED 23 <2mm Fraction	EG005-SDH: Barium	7440-39-3	25 mg/kg	95.3	70	130
		EG005-SDH: Cadmium	7440-43-9	12.5 mg/kg	83.4	70	130
		EG005-SDH: Cobalt	7440-48-4	25 mg/kg	83.0	70	130
		EG005-SDH: Chromium	7440-47-3	25 mg/kg	86.0	70	130
		EG005-SDH: Copper	7440-50-8	25 mg/kg	91.6	70	130
		EG005-SDH: Lead	7439-92-1	25 mg/kg	82.0	70	130
		EG005-SDH: Manganese	7439-96-5	25 mg/kg	# Not Determined	70	130
		EG005-SDH: Nickel	7440-02-0	25 mg/kg	85.2	70	130
		EG005-SDH: Vanadium	7440-62-2	25 mg/kg	89.1	70	130
		EG005-SDH: Zinc	7440-66-6	25 mg/kg	78.8	70	130
EG005(ED093)T: Total Metals by ICP-AES (QCLot: 2384846)							
EB1912881-005	SED 23 <2mm Fraction	EG005T: Arsenic	7440-38-2	50 mg/kg	89.2	70	130
		EG005T: Barium	7440-39-3	50 mg/kg	90.5	70	130
		EG005T: Beryllium	7440-41-7	5 mg/kg	98.4	70	130
		EG005T: Cadmium	7440-43-9	25 mg/kg	84.8	70	130
		EG005T: Chromium	7440-47-3	50 mg/kg	87.2	70	130
		EG005T: Cobalt	7440-48-4	50 mg/kg	87.2	70	130
		EG005T: Copper	7440-50-8	50 mg/kg	94.4	70	130
		EG005T: Lead	7439-92-1	50 mg/kg	84.0	70	130
		EG005T: Manganese	7439-96-5	50 mg/kg	# Not Determined	70	130
		EG005T: Nickel	7440-02-0	50 mg/kg	81.3	70	130
		EG005T: Vanadium	7440-62-2	50 mg/kg	92.0	70	130
		EG005T: Zinc	7440-66-6	50 mg/kg	76.6	70	130



Sub-Matrix: SOIL

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EG035-SDH: 1M HCl extractable Mercury by FIMS (QCLot: 2384849)							
EB1912881-005	SED 23 <2mm Fraction	EG035-SDH: Mercury	7439-97-6	2.5 mg/kg	# 61.8	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2384847)							
EB1912881-005	SED 23 <2mm Fraction	EG035T: Mercury	7439-97-6	5 mg/kg	93.2	70	130

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: EB1912881	Page	: 1 of 5
Client	: COFFEY ENVIRONMENTS PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: ERICA COLLEY	Telephone	: +61 7 3552 8639
Project	: 754-MELEN224697 JDD PROJECT	Date Samples Received	: 21-May-2019
Site	: ----	Issue Date	: 07-Jun-2019
Sampler	: ERICA COLLEY	No. of samples received	: 9
Order number	: BN/065/19	No. of samples analysed	: 6

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO** Method Blank value outliers occur.
- **NO** Duplicate outliers occur.
- **NO** Laboratory Control outliers occur.
- Matrix Spike outliers exist - please see following pages for full details.
- For all regular sample matrices, **NO** surrogate recovery outliers occur.

Outliers : Analysis Holding Time Compliance

- **NO** Analysis Holding Time Outliers exist.

Outliers : Frequency of Quality Control Samples

- **NO** Quality Control Sample Frequency Outliers exist.

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries							
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICP	EB1912881--005	SED 23 <2mm Fraction	Arsenic	7440-38-2	48.5 %	70-130%	Recovery less than lower data quality objective
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICP	EB1912881--005	SED 23 <2mm Fraction	Manganese	7439-96-5	Not Determined	----	MS recovery not determined, background level greater than or equal to 4x spike level.
EG005(ED093)T: Total Metals by ICP-AES	EB1912881--005	SED 23 <2mm Fraction	Manganese	7439-96-5	Not Determined	----	MS recovery not determined, background level greater than or equal to 4x spike level.
EG035-SDH: 1M HCl extractable Mercury by FIMS	EB1912881--005	SED 23 <2mm Fraction	Mercury	7439-97-6	61.8 %	70-130%	Recovery less than lower data quality objective

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results. This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein. Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters. Holding times for VOC in soils vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES							
Pulp Bag (-2000µm) (EG005-SDH) SED 14 - <2mm Fraction, SED 23 - <2mm Fraction	04-Jun-2019	04-Jun-2019	01-Dec-2019	✓	04-Jun-2019	01-Dec-2019	✓
Pulp Bag (-63µm) (EG005-SDH) SED 14 - <63µm Fraction, SED 23 - <63µm Fraction	04-Jun-2019	04-Jun-2019	01-Dec-2019	✓	04-Jun-2019	01-Dec-2019	✓
EG005(ED093)T: Total Metals by ICP-AES							
Pulp Bag (-2000µm) (EG005T) SED 14 - <2mm Fraction, SED 15 - <2mm Fraction	04-Jun-2019	04-Jun-2019	01-Dec-2019	✓	04-Jun-2019	01-Dec-2019	✓
Pulp Bag (-63µm) (EG005T) SED 14 - <63µm Fraction, SED 15 - <63µm Fraction	04-Jun-2019	04-Jun-2019	01-Dec-2019	✓	04-Jun-2019	01-Dec-2019	✓



Matrix: **SOIL**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EG035-SDH: 1M HCl extractable Mercury by FIMS								
Pulp Bag (-2000µm) (EG035-SDH)								
SED 14 - <2mm Fraction,	SED 23 - <2mm Fraction,	04-Jun-2019	04-Jun-2019	02-Jul-2019	✓	04-Jun-2019	02-Jul-2019	✓
SED 15 - <2mm Fraction								
Pulp Bag (-63µm) (EG035-SDH)								
SED 14 - <63µm Fraction,	SED 23 - <63µm Fraction	04-Jun-2019	04-Jun-2019	02-Jul-2019	✓	04-Jun-2019	02-Jul-2019	✓
EG035T: Total Recoverable Mercury by FIMS								
Pulp Bag (-2000µm) (EG035T)								
SED 14 - <2mm Fraction,	SED 23 - <2mm Fraction,	04-Jun-2019	04-Jun-2019	02-Jul-2019	✓	04-Jun-2019	02-Jul-2019	✓
SED 15 - <2mm Fraction								
Pulp Bag (-63µm) (EG035T)								
SED 14 - <63µm Fraction,	SED 23 - <63µm Fraction,	04-Jun-2019	04-Jun-2019	02-Jul-2019	✓	04-Jun-2019	02-Jul-2019	✓
SED 15 - <63µm Fraction								
GEO26: Sieving								
Snap Lock Bag (GEO26C)								
SED 14 - <2mm Fraction,	SED 23 - <2mm Fraction,	06-Apr-2019	04-Jun-2019	03-Oct-2019	✓	----	----	----
SED 14 - <63µm Fraction,	SED 23 - <63µm Fraction							
Snap Lock Bag (GEO26C)								
SED 15 - <2mm Fraction,	SED 15 - <63µm Fraction	08-Apr-2019	04-Jun-2019	05-Oct-2019	✓	----	----	----



Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)		Quality Control Specification	
Analytical Methods	Method	QC	Regular	Actual	Expected		Evaluation
Laboratory Duplicates (DUP)							
1M HCl Extractable Mercury by FIMS	EG035-SDH	1	5	20.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
1M HCl Extractable Metals	EG005-SDH	1	5	20.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	6	16.67	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-AES	EG005T	1	6	16.67	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
1M HCl Extractable Mercury by FIMS	EG035-SDH	1	5	20.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
1M HCl Extractable Metals	EG005-SDH	1	5	20.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	6	16.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-AES	EG005T	1	6	16.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
1M HCl Extractable Mercury by FIMS	EG035-SDH	1	5	20.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
1M HCl Extractable Metals	EG005-SDH	1	5	20.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	6	16.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-AES	EG005T	1	6	16.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
1M HCl Extractable Mercury by FIMS	EG035-SDH	1	5	20.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
1M HCl Extractable Metals	EG005-SDH	2	5	40.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	6	16.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-AES	EG005T	1	6	16.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard



Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
1M HCl Extractable Metals	EG005-SDH	SOIL	In house: Referenced to APHA 3120; USEPA SW 846 - 6010. Metals are determined via ICPAES following weak acid extraction. The ICPAES technique ionises samples in a plasma, emitting a characteristic spectrum based on metals present. Intensities at selected wavelengths are compared against those of matrix matched standards. This method is compliant with NEPM (2013) Schedule B(3). LORs per NAGD. ALS is not NATA accredited for the analysis of Barium, Boron, Molybdenum and Strontium by this method.
Total Metals by ICP-AES	EG005T	SOIL	In house: Referenced to APHA 3120; USEPA SW 846 - 6010. Metals are determined following an appropriate acid digestion of the soil. The ICPAES technique ionises samples in a plasma, emitting a characteristic spectrum based on metals present. Intensities at selected wavelengths are compared against those of matrix matched standards. This method is compliant with NEPM (2013) Schedule B(3)
1M HCl Extractable Mercury by FIMS	EG035-SDH	SOIL	In house: Referenced to AS 3550, APHA 3112 Hg - B. Mercury is determined via FIMS following weak acid extraction. FIM-AAS is an automated flameless atomic absorption technique. Mercury in solids are determined following an appropriate acid digestion. Ionic mercury is reduced online to atomic mercury vapour by SnCl ₂ which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Total Mercury by FIMS	EG035T	SOIL	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl ₂) (Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. Mercury in solids are determined following an appropriate acid digestion. Ionic mercury is reduced online to atomic mercury vapour by SnCl ₂ which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Preparation Methods	Method	Matrix	Method Descriptions
Hot Block Digest for metals in soils sediments and sludges	EN69	SOIL	In house: Referenced to USEPA 200.2. Hot Block Acid Digestion 1.0g of sample is heated with Nitric and Hydrochloric acids, then cooled. Peroxide is added and samples heated and cooled again before being filtered and bulked to volume for analysis. Digest is appropriate for determination of selected metals in sludge, sediments, and soils. This method is compliant with NEPM (2013) Schedule B(3) (Method 202)
1M HCl Extraction for Metals in Sediments (1 hour)	EN71	SOIL	In house: Referenced to In house, Allen (1993). 1g of sample is leached at room temperature for 1 hour in 10% hydrochloric acid. The resultant extract is filtered and bulked for analysis of extracted metals.
Sieving (fine to -2mm)	GEO26	SOIL	In house: The dried sample is sieved to 2mm and the fines are then analysed per the client's request.
Sieving (fine to -63µm)	GEO26C	SOIL	In house: The sample is sieved to -63µm and the fines are then analysed per the client's request.

QUALITY CONTROL REPORT

Work Order	: EB1922738	Page	: 1 of 6
Client	: COFFEY ENVIRONMENTS PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: ERICA COLLEY	Contact	: Andrew Epps
Address	: Level 5 12 Creek St Brisbane QLD, AUSTRALIA 4000	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: 64277004057	Telephone	: +61 7 3552 8639
Project	: JDD PROJECT	Date Samples Received	: 29-Aug-2019
Order number	:	Date Analysis Commenced	: 30-Aug-2019
C-O-C number	: ----	Issue Date	: 06-Sep-2019
Sampler	: ERICA COLLEY		
Site	:		
Quote number	: EN/222		
No. of samples received	: 14		
No. of samples analysed	: 14		



This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Sarah Ashworth	Laboratory Manager - Brisbane	Brisbane Organics, Stafford, QLD

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
= Indicates failed QC

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: WATER				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EA025: Total Suspended Solids dried at 104 ± 2°C (QC Lot: 2556235)									
EB1922738-001	WQ-01	EA025H: Suspended Solids (SS)	----	5	mg/L	<5	<5	0.00	No Limit
EB1922751-003	Anonymous	EA025H: Suspended Solids (SS)	----	5	mg/L	6310	6330	0.253	0% - 20%
EK055G: Ammonia as N by Discrete Analyser (QC Lot: 2562369)									
EB1922738-001	WQ-01	EK055G: Ammonia as N	7664-41-7	0.01	mg/L	0.01	0.01	0.00	No Limit
EB1922738-013	WQ-24	EK055G: Ammonia as N	7664-41-7	0.01	mg/L	<0.01	0.02	0.00	No Limit
EK057G: Nitrite as N by Discrete Analyser (QC Lot: 2556206)									
EB1922738-001	WQ-01	EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	0.00	No Limit
EB1922686-003	Anonymous	EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	0.00	No Limit
EK057G: Nitrite as N by Discrete Analyser (QC Lot: 2556210)									
EB1922738-013	WQ-24	EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	0.00	No Limit
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 2562370)									
EB1922738-001	WQ-01	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	<0.01	0.00	No Limit
EB1922738-013	WQ-24	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	<0.01	0.00	No Limit
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QC Lot: 2554900)									
EB1922523-001	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	20.2	20.0	0.825	0% - 20%
EB1922738-008	WQ-11	EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	<1.0	<1.0	0.00	No Limit
EK067G: Total Phosphorus as P by Discrete Analyser (QC Lot: 2554901)									
EB1922523-001	Anonymous	EK067G: Total Phosphorus as P	----	0.01	mg/L	0.01	0.01	0.00	No Limit
EB1922738-008	WQ-11	EK067G: Total Phosphorus as P	----	0.01	mg/L	<0.10	<0.10	0.00	No Limit
EK071G: Reactive Phosphorus as P by discrete analyser (QC Lot: 2556208)									
EB1922589-001	Anonymous	EK071G: Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
EB1922738-013	WQ-24	EK071G: Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
EK085M: Sulfide as S2- (QC Lot: 2554877)									

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 Work Order : EB1922738
 Client : COFFEY ENVIRONMENTS PTY LTD
 Project : JDD PROJECT



Sub-Matrix: WATER				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EK085M: Sulfide as S2- (QC Lot: 2554877) - continued									
EB1922738-002	WQ-02	EK085: Sulfide as S2-	18496-25-8	0.1	mg/L	<0.1	<0.1	0.00	No Limit
EP026SP: Chemical Oxygen Demand (Spectrophotometric) (QC Lot: 2562689)									
EB1922738-003	WQ-03	EP026SP: Chemical Oxygen Demand	----	10	mg/L	430	460	6.74	No Limit
EB1922751-016	Anonymous	EP026SP: Chemical Oxygen Demand	----	10	mg/L	12	14	13.9	No Limit
EP030: Biochemical Oxygen Demand (BOD) (QC Lot: 2555995)									
EB1922540-002	Anonymous	EP030: Biochemical Oxygen Demand	----	2	mg/L	<2	<2	0.00	No Limit
EB1922547-001	Anonymous	EP030: Biochemical Oxygen Demand	----	2	mg/L	385	443	14.0	0% - 20%
EP080/071: Total Petroleum Hydrocarbons (QC Lot: 2560151)									
EB1922604-021	Anonymous	EP080: C6 - C9 Fraction	----	20	µg/L	<20	<20	0.00	No Limit
EB1922738-014	WQ-25	EP080: C6 - C9 Fraction	----	20	µg/L	<20	<20	0.00	No Limit
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QC Lot: 2560151)									
EB1922604-021	Anonymous	EP080: C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	0.00	No Limit
EB1922738-014	WQ-25	EP080: C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	0.00	No Limit
EP080: BTEXN (QC Lot: 2560151)									
EB1922604-021	Anonymous	EP080: Benzene	71-43-2	1	µg/L	<1	<1	0.00	No Limit
		EP080: Toluene	108-88-3	2	µg/L	<2	<2	0.00	No Limit
		EP080: Ethylbenzene	100-41-4	2	µg/L	<2	<2	0.00	No Limit
		EP080: meta- & para-Xylene	108-38-3	2	µg/L	<2	<2	0.00	No Limit
			106-42-3						
		EP080: ortho-Xylene	95-47-6	2	µg/L	<2	<2	0.00	No Limit
EB1922738-014	WQ-25	EP080: Naphthalene	91-20-3	5	µg/L	<5	<5	0.00	No Limit
		EP080: Benzene	71-43-2	1	µg/L	<1	<1	0.00	No Limit
		EP080: Toluene	108-88-3	2	µg/L	<2	<2	0.00	No Limit
		EP080: Ethylbenzene	100-41-4	2	µg/L	<2	<2	0.00	No Limit
		EP080: meta- & para-Xylene	108-38-3	2	µg/L	<2	<2	0.00	No Limit
			106-42-3						
		EP080: ortho-Xylene	95-47-6	2	µg/L	<2	<2	0.00	No Limit
		EP080: Naphthalene	91-20-3	5	µg/L	<5	<5	0.00	No Limit

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: WATER				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low High	
Method: Compound	CAS Number	LOR	Unit	Result				
EA025: Total Suspended Solids dried at 104 ± 2°C (QCLot: 2556235)								
EA025H: Suspended Solids (SS)	----	5	mg/L	<5	150 mg/L	103	88	112
				<5	1000 mg/L	103	88	112
				<5	951 mg/L	106	88	116
EK055G: Ammonia as N by Discrete Analyser (QCLot: 2562369)								
EK055G: Ammonia as N	7664-41-7	0.01	mg/L	<0.01	0.5 mg/L	90.1	84	114
EK057G: Nitrite as N by Discrete Analyser (QCLot: 2556206)								
EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	0.5 mg/L	103	90	110
EK057G: Nitrite as N by Discrete Analyser (QCLot: 2556210)								
EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	0.5 mg/L	103	90	110
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2562370)								
EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	0.5 mg/L	92.1	86	111
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2554900)								
EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	<0.1	10 mg/L	86.9	70	108
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2554901)								
EK067G: Total Phosphorus as P	----	0.01	mg/L	<0.01	4.42 mg/L	94.3	79	105
EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 2556208)								
EK071G: Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	0.5 mg/L	101	82	117
EK085M: Sulfide as S2- (QCLot: 2554877)								
EK085: Sulfide as S2-	18496-25-8	0.1	mg/L	<0.1	0.5 mg/L	115	80	123
EP020: Oil and Grease (O&G) (QCLot: 2559054)								
EP020: Oil & Grease	----	5	mg/L	<5	5000 mg/L	101	88	112
EP026SP: Chemical Oxygen Demand (Spectrophotometric) (QCLot: 2562689)								
EP026SP: Chemical Oxygen Demand	----	10	mg/L	<10	50 mg/L	100	86	112
EP030: Biochemical Oxygen Demand (BOD) (QCLot: 2555995)								
EP030: Biochemical Oxygen Demand	----	2	mg/L	<2	198 mg/L	80.4	77	115
EP080/071: Total Petroleum Hydrocarbons (QCLot: 2560151)								
EP080: C6 - C9 Fraction	----	20	µg/L	<20	160 µg/L	116	67	122
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 2560151)								
EP080: C6 - C10 Fraction	C6_C10	20	µg/L	<20	185 µg/L	123	65	123
EP080: C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	----	----	----	----
EP080: BTEXN (QCLot: 2560151)								



Sub-Matrix: **WATER**

Sub-Matrix: WATER				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) LowHigh	
Method: Compound	CAS Number	LOR	Unit	Result				
EP080: BTEXN (QCLot: 2560151) - continued								
EP080: Benzene	71-43-2	1	µg/L	<1	10 µg/L	102	80	115
EP080: Toluene	108-88-3	2	µg/L	<2	10 µg/L	95.5	79	116
EP080: Ethylbenzene	100-41-4	2	µg/L	<2	10 µg/L	101	77	115
EP080: meta- & para-Xylene	108-38-3	2	µg/L	<2	20 µg/L	101	76	120
	106-42-3							
EP080: ortho-Xylene	95-47-6	2	µg/L	<2	10 µg/L	105	81	115
EP080: Total Xylenes	----	2	µg/L	<2	----	----	----	----
EP080: Sum of BTEX	----	1	µg/L	<1	----	----	----	----
EP080: Naphthalene	91-20-3	5	µg/L	<5	10 µg/L	106	78	116

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

Sub-Matrix: WATER				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EK055G: Ammonia as N by Discrete Analyser (QCLot: 2562369)							
EB1922738-002	WQ-02	EK055G: Ammonia as N	7664-41-7	0.4 mg/L	108	70	130
EK057G: Nitrite as N by Discrete Analyser (QCLot: 2556206)							
EB1922686-003	Anonymous	EK057G: Nitrite as N	14797-65-0	0.4 mg/L	100	70	130
EK057G: Nitrite as N by Discrete Analyser (QCLot: 2556210)							
EB1922738-014	WQ-25	EK057G: Nitrite as N	14797-65-0	0.4 mg/L	98.8	70	130
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2562370)							
EB1922738-002	WQ-02	EK059G: Nitrite + Nitrate as N	----	0.4 mg/L	82.6	70	130
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2554900)							
EB1922688-001	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	5 mg/L	86.6	70	130
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2554901)							
EB1922688-001	Anonymous	EK067G: Total Phosphorus as P	----	1 mg/L	98.4	70	130
EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 2556208)							
EB1922738-014	WQ-25	EK071G: Reactive Phosphorus as P	14265-44-2	0.4 mg/L	98.3	70	130
EK085M: Sulfide as S2- (QCLot: 2554877)							
EB1922738-001	WQ-01	EK085: Sulfide as S2-	18496-25-8	0.9913 mg/L	78.0	70	130
EP026SP: Chemical Oxygen Demand (Spectrophotometric) (QCLot: 2562689)							
EB1922738-013	WQ-24	EP026SP: Chemical Oxyaen Demand	----	50 mg/L	102	70	130



Sub-Matrix: WATER

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EP080/071: Total Petroleum Hydrocarbons (QCLot: 2560151)							
EB1922604-022	Anonymous	EP080: C6 - C9 Fraction	----	40 µg/L	91.1	70	130
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 2560151)							
EB1922604-022	Anonymous	EP080: C6 - C10 Fraction	C6_C10	40 µg/L	98.5	70	130
EP080: BTEXN (QCLot: 2560151)							
EB1922604-022	Anonymous	EP080: Benzene	71-43-2	10 µg/L	94.9	70	130
		EP080: Toluene	108-88-3	10 µg/L	88.5	70	130

QUALITY CONTROL REPORT

Work Order	: EB1922738	Page	: 1 of 6
Amendment	: 1		
Client	: COFFEY ENVIRONMENTS PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: ERICA COLLEY	Contact	: Andrew Epps
Address	: Level 5 12 Creek St Brisbane QLD, AUSTRALIA 4000	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: 64277004057	Telephone	: +61 7 3552 8639
Project	: JDD PROJECT	Date Samples Received	: 29-Aug-2019
Order number	:	Date Analysis Commenced	: 30-Aug-2019
C-O-C number	: ----	Issue Date	: 11-Sep-2019
Sampler	: ERICA COLLEY		
Site	:		
Quote number	: EN/222		
No. of samples received	: 14		
No. of samples analysed	: 14		



Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Sarah Ashworth	Laboratory Manager - Brisbane	Brisbane Organics, Stafford, QLD

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
= Indicates failed QC

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: WATER				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EA025: Total Suspended Solids dried at 104 ± 2°C (QC Lot: 2556235)									
EB1922738-001	WQ-01	EA025H: Suspended Solids (SS)	----	5	mg/L	<5	<5	0.00	No Limit
EB1922751-003	Anonymous	EA025H: Suspended Solids (SS)	----	5	mg/L	6310	6330	0.253	0% - 20%
EK055G: Ammonia as N by Discrete Analyser (QC Lot: 2562369)									
EB1922738-001	WQ-01	EK055G: Ammonia as N	7664-41-7	0.01	mg/L	0.01	0.01	0.00	No Limit
EB1922738-013	WQ-24	EK055G: Ammonia as N	7664-41-7	0.01	mg/L	<0.01	0.02	0.00	No Limit
EK057G: Nitrite as N by Discrete Analyser (QC Lot: 2556206)									
EB1922738-001	WQ-01	EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	0.00	No Limit
EB1922686-003	Anonymous	EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	0.00	No Limit
EK057G: Nitrite as N by Discrete Analyser (QC Lot: 2556210)									
EB1922738-013	WQ-24	EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	0.00	No Limit
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 2562370)									
EB1922738-001	WQ-01	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	<0.01	0.00	No Limit
EB1922738-013	WQ-24	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	<0.01	0.00	No Limit
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QC Lot: 2554900)									
EB1922523-001	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	20.2	20.0	0.825	0% - 20%
EB1922738-008	WQ-11	EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	<1.0	<1.0	0.00	No Limit
EK067G: Total Phosphorus as P by Discrete Analyser (QC Lot: 2554901)									
EB1922523-001	Anonymous	EK067G: Total Phosphorus as P	----	0.01	mg/L	0.01	0.01	0.00	No Limit
EB1922738-008	WQ-11	EK067G: Total Phosphorus as P	----	0.01	mg/L	<0.10	<0.10	0.00	No Limit
EK071G: Reactive Phosphorus as P by discrete analyser (QC Lot: 2556208)									
EB1922589-001	Anonymous	EK071G: Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
EB1922738-013	WQ-24	EK071G: Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
EK085M: Sulfide as S2- (QC Lot: 2554877)									

Page : 3 of 6
 Work Order : EB1922738 Amendment 1
 Client : COFFEY ENVIRONMENTS PTY LTD
 Project : JDD PROJECT



Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EK085M: Sulfide as S2- (QC Lot: 2554877) - continued									
EB1922738-002	WQ-02	EK085: Sulfide as S2-	18496-25-8	0.1	mg/L	<0.1	<0.1	0.00	No Limit
EP026SP: Chemical Oxygen Demand (Spectrophotometric) (QC Lot: 2562689)									
EB1922738-003	WQ-03	EP026SP: Chemical Oxygen Demand	----	10	mg/L	430	460	6.74	No Limit
EB1922751-016	Anonymous	EP026SP: Chemical Oxygen Demand	----	10	mg/L	12	14	13.9	No Limit
EP030: Biochemical Oxygen Demand (BOD) (QC Lot: 2555995)									
EB1922540-002	Anonymous	EP030: Biochemical Oxygen Demand	----	2	mg/L	<2	<2	0.00	No Limit
EB1922547-001	Anonymous	EP030: Biochemical Oxygen Demand	----	2	mg/L	385	443	14.0	0% - 20%
EP080/071: Total Petroleum Hydrocarbons (QC Lot: 2560151)									
EB1922604-021	Anonymous	EP080: C6 - C9 Fraction	----	20	µg/L	<20	<20	0.00	No Limit
EB1922738-014	WQ-25	EP080: C6 - C9 Fraction	----	20	µg/L	<20	<20	0.00	No Limit
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QC Lot: 2560151)									
EB1922604-021	Anonymous	EP080: C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	0.00	No Limit
EB1922738-014	WQ-25	EP080: C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	0.00	No Limit
EP080: BTEXN (QC Lot: 2560151)									
EB1922604-021	Anonymous	EP080: Benzene	71-43-2	1	µg/L	<1	<1	0.00	No Limit
		EP080: Toluene	108-88-3	2	µg/L	<2	<2	0.00	No Limit
		EP080: Ethylbenzene	100-41-4	2	µg/L	<2	<2	0.00	No Limit
		EP080: meta- & para-Xylene	108-38-3	2	µg/L	<2	<2	0.00	No Limit
			106-42-3						
		EP080: ortho-Xylene	95-47-6	2	µg/L	<2	<2	0.00	No Limit
EB1922738-014	WQ-25	EP080: Naphthalene	91-20-3	5	µg/L	<5	<5	0.00	No Limit
		EP080: Benzene	71-43-2	1	µg/L	<1	<1	0.00	No Limit
		EP080: Toluene	108-88-3	2	µg/L	<2	<2	0.00	No Limit
		EP080: Ethylbenzene	100-41-4	2	µg/L	<2	<2	0.00	No Limit
		EP080: meta- & para-Xylene	108-38-3	2	µg/L	<2	<2	0.00	No Limit
			106-42-3						
		EP080: ortho-Xylene	95-47-6	2	µg/L	<2	<2	0.00	No Limit
		EP080: Naphthalene	91-20-3	5	µg/L	<5	<5	0.00	No Limit

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: WATER				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low High	
Method: Compound	CAS Number	LOR	Unit	Result				
EA025: Total Suspended Solids dried at 104 ± 2°C (QCLot: 2556235)								
EA025H: Suspended Solids (SS)	----	5	mg/L	<5	150 mg/L	103	88	112
				<5	1000 mg/L	103	88	112
				<5	951 mg/L	106	88	116
EK055G: Ammonia as N by Discrete Analyser (QCLot: 2562369)								
EK055G: Ammonia as N	7664-41-7	0.01	mg/L	<0.01	0.5 mg/L	90.1	84	114
EK057G: Nitrite as N by Discrete Analyser (QCLot: 2556206)								
EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	0.5 mg/L	103	90	110
EK057G: Nitrite as N by Discrete Analyser (QCLot: 2556210)								
EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	0.5 mg/L	103	90	110
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2562370)								
EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	0.5 mg/L	92.1	86	111
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2554900)								
EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	<0.1	10 mg/L	86.9	70	108
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2554901)								
EK067G: Total Phosphorus as P	----	0.01	mg/L	<0.01	4.42 mg/L	94.3	79	105
EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 2556208)								
EK071G: Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	0.5 mg/L	101	82	117
EK085M: Sulfide as S2- (QCLot: 2554877)								
EK085: Sulfide as S2-	18496-25-8	0.1	mg/L	<0.1	0.5 mg/L	115	80	123
EP020: Oil and Grease (O&G) (QCLot: 2559054)								
EP020: Oil & Grease	----	5	mg/L	<5	5000 mg/L	101	88	112
EP026SP: Chemical Oxygen Demand (Spectrophotometric) (QCLot: 2562689)								
EP026SP: Chemical Oxygen Demand	----	10	mg/L	<10	50 mg/L	100	86	112
EP030: Biochemical Oxygen Demand (BOD) (QCLot: 2555995)								
EP030: Biochemical Oxygen Demand	----	2	mg/L	<2	198 mg/L	80.4	77	115
EP080/071: Total Petroleum Hydrocarbons (QCLot: 2560151)								
EP080: C6 - C9 Fraction	----	20	µg/L	<20	160 µg/L	116	67	122
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 2560151)								
EP080: C6 - C10 Fraction	C6_C10	20	µg/L	<20	185 µg/L	123	65	123
EP080: C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	----	----	----	----
EP080: BTEXN (QCLot: 2560151)								



Sub-Matrix: **WATER**

Sub-Matrix: WATER				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) LowHigh	
Method: Compound	CAS Number	LOR	Unit	Result				
EP080: BTEXN (QCLot: 2560151) - continued								
EP080: Benzene	71-43-2	1	µg/L	<1	10 µg/L	102	80	115
EP080: Toluene	108-88-3	2	µg/L	<2	10 µg/L	95.5	79	116
EP080: Ethylbenzene	100-41-4	2	µg/L	<2	10 µg/L	101	77	115
EP080: meta- & para-Xylene	108-38-3	2	µg/L	<2	20 µg/L	101	76	120
	106-42-3							
EP080: ortho-Xylene	95-47-6	2	µg/L	<2	10 µg/L	105	81	115
EP080: Total Xylenes	----	2	µg/L	<2	----	----	----	----
EP080: Sum of BTEX	----	1	µg/L	<1	----	----	----	----
EP080: Naphthalene	91-20-3	5	µg/L	<5	10 µg/L	106	78	116

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

Sub-Matrix: WATER				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EK055G: Ammonia as N by Discrete Analyser (QCLot: 2562369)							
EB1922738-002	WQ-02	EK055G: Ammonia as N	7664-41-7	0.4 mg/L	108	70	130
EK057G: Nitrite as N by Discrete Analyser (QCLot: 2556206)							
EB1922686-003	Anonymous	EK057G: Nitrite as N	14797-65-0	0.4 mg/L	100	70	130
EK057G: Nitrite as N by Discrete Analyser (QCLot: 2556210)							
EB1922738-014	WQ-25	EK057G: Nitrite as N	14797-65-0	0.4 mg/L	98.8	70	130
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2562370)							
EB1922738-002	WQ-02	EK059G: Nitrite + Nitrate as N	----	0.4 mg/L	82.6	70	130
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2554900)							
EB1922688-001	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	5 mg/L	86.6	70	130
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2554901)							
EB1922688-001	Anonymous	EK067G: Total Phosphorus as P	----	1 mg/L	98.4	70	130
EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 2556208)							
EB1922738-014	WQ-25	EK071G: Reactive Phosphorus as P	14265-44-2	0.4 mg/L	98.3	70	130
EK085M: Sulfide as S2- (QCLot: 2554877)							
EB1922738-001	WQ-01	EK085: Sulfide as S2-	18496-25-8	0.9913 mg/L	78.0	70	130
EP026SP: Chemical Oxygen Demand (Spectrophotometric) (QCLot: 2562689)							
EB1922738-013	WQ-24	EP026SP: Chemical Oxygen Demand	----	50 mg/L	102	70	130



Sub-Matrix: WATER

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EP080/071: Total Petroleum Hydrocarbons (QCLot: 2560151)							
EB1922604-022	Anonymous	EP080: C6 - C9 Fraction	----	40 µg/L	91.1	70	130
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 2560151)							
EB1922604-022	Anonymous	EP080: C6 - C10 Fraction	C6_C10	40 µg/L	98.5	70	130
EP080: BTEXN (QCLot: 2560151)							
EB1922604-022	Anonymous	EP080: Benzene	71-43-2	10 µg/L	94.9	70	130
		EP080: Toluene	108-88-3	10 µg/L	88.5	70	130

QUALITY CONTROL REPORT

Work Order	: EB1922795	Page	: 1 of 5
Client	: COFFEY ENVIRONMENTS PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MS ERICA COLLEY	Contact	: Andrew Epps
Address	: Level 5 12 Creek St Brisbane QLD, AUSTRALIA 4000	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3608 2500	Telephone	: +61 7 3552 8639
Project	: 754-MCLCN221697/JDD PROJECT	Date Samples Received	: 29-Aug-2019
Order number	:	Date Analysis Commenced	: 30-Aug-2019
C-O-C number	: ----	Issue Date	: 13-Sep-2019
Sampler	: ----		
Site	:		
Quote number	: EN/222		
No. of samples received	: 8		
No. of samples analysed	: 8		



This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Franco Lentini	LCMS Coordinator	Sydney Organics, Smithfield, NSW
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
= Indicates failed QC

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: WATER				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EA025: Total Suspended Solids dried at 104 ± 2°C (QC Lot: 2564357)									
EB1921893-003	Anonymous	EA025H: Suspended Solids (SS)	----	5	mg/L	<5	<5	0.00	No Limit
EB1922780-001	Anonymous	EA025H: Suspended Solids (SS)	----	5	mg/L	<5	<5	0.00	No Limit
ED093F: Dissolved Major Cations (QC Lot: 2578521)									
EB1922795-001	WQ-06	ED093F: Potassium	7440-09-7	1	mg/L	395	397	0.608	0% - 20%
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 2561432)									
EB1922983-003	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	<0.01	0.00	No Limit
EB1922983-001	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	0.02	0.00	No Limit
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QC Lot: 2557953)									
EB1922564-001	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	<1.0	<1.0	0.00	No Limit
EB1922795-002	WQ-07	EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	<1.0	<1.0	0.00	No Limit
EK067G: Total Phosphorus as P by Discrete Analyser (QC Lot: 2557952)									
EB1922564-001	Anonymous	EK067G: Total Phosphorus as P	----	0.01	mg/L	<0.10	0.12	15.7	No Limit
EB1922795-002	WQ-07	EK067G: Total Phosphorus as P	----	0.01	mg/L	<0.10	<0.10	0.00	No Limit
EK085M: Sulfide as S2- (QC Lot: 2557738)									
EB1922754-001	Anonymous	EK085: Sulfide as S2-	18496-25-8	0.1	mg/L	<0.1	<0.1	0.00	No Limit
ET1902651-008	Anonymous	EK085: Sulfide as S2-	18496-25-8	0.1	mg/L	<0.1	<0.1	0.00	No Limit
EP026SP: Chemical Oxygen Demand (Spectrophotometric) (QC Lot: 2562689)									
EB1922738-003	Anonymous	EP026SP: Chemical Oxygen Demand	----	10	mg/L	430	460	6.74	No Limit
EB1922751-016	Anonymous	EP026SP: Chemical Oxygen Demand	----	10	mg/L	12	14	13.9	No Limit
EP030: Biochemical Oxygen Demand (BOD) (QC Lot: 2556768)									
EB1922776-002	Anonymous	EP030: Biochemical Oxygen Demand	----	2	mg/L	<2	<2	0.00	No Limit
EB1922776-001	Anonymous	EP030: Biochemical Oxygen Demand	----	2	mg/L	4	6	27.1	No Limit
EP030: Biochemical Oxygen Demand (BOD) (QC Lot: 2556769)									

Page : 3 of 5
 Work Order : EB1922795
 Client : COFFEY ENVIRONMENTS PTY LTD
 Project : 754-MCLCN221697/JDD PROJECT



Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EP030: Biochemical Oxygen Demand (BOD) (QC Lot: 2556769) - continued									
EB1922795-008	WQ-05	EP030: Biochemical Oxygen Demand	----	2	mg/L	<2	<2	0.00	No Limit
EP262: Ethanolamines (QC Lot: 2566357)									
EB1922850-002	Anonymous	EP262: Ethanolamine	141-43-5	1	µg/L	<1	<1	0.00	No Limit
		EP262: Diethanolamine	111-42-2	1	µg/L	<1	<1	0.00	No Limit
		EP262: Methyl diethanolamine (MDEA)	105-59-9	1	µg/L	<1	<1	0.00	No Limit
EB1922850-003	Anonymous	EP262: Ethanolamine	141-43-5	1	µg/L	<1	<1	0.00	No Limit
		EP262: Diethanolamine	111-42-2	1	µg/L	<1	<1	0.00	No Limit
		EP262: Methyl diethanolamine (MDEA)	105-59-9	1	µg/L	<1	<1	0.00	No Limit



Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

Sub-Matrix: WATER				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low High	
Method: Compound	CAS Number	LOR	Unit	Result				
EA025: Total Suspended Solids dried at 104 ± 2°C (QCLot: 2564357)								
EA025H: Suspended Solids (SS)	----	5	mg/L	<5	150 mg/L	97.6	88	112
				<5	1000 mg/L	98.8	88	112
				<5	951 mg/L	106	88	116
ED093F: Dissolved Major Cations (QCLot: 2578521)								
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	101	70	130
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2561432)								
EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	0.5 mg/L	92.3	86	111
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2557953)								
EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	<0.1	10 mg/L	86.2	70	108
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2557952)								
EK067G: Total Phosphorus as P	----	0.01	mg/L	<0.01	4.42 mg/L	91.7	79	105
EK085M: Sulfide as S2- (QCLot: 2557738)								
EK085: Sulfide as S2-	18496-25-8	0.1	mg/L	<0.1	0.5 mg/L	115	80	123
EP020: Oil and Grease (O&G) (QCLot: 2562615)								
EP020: Oil & Grease	----	5	mg/L	<5	5000 mg/L	108	88	112
EP026SP: Chemical Oxygen Demand (Spectrophotometric) (QCLot: 2562689)								
EP026SP: Chemical Oxygen Demand	----	10	mg/L	<10	50 mg/L	100	86	112
EP030: Biochemical Oxygen Demand (BOD) (QCLot: 2556768)								
EP030: Biochemical Oxygen Demand	----	2	mg/L	<2	198 mg/L	80.4	77	115
EP030: Biochemical Oxygen Demand (BOD) (QCLot: 2556769)								
EP030: Biochemical Oxygen Demand	----	2	mg/L	<2	198 mg/L	80.4	77	115
EP262: Ethanolamines (QCLot: 2566357)								
EP262: Ethanolamine	141-43-5	1	µg/L	<1	10 µg/L	120	50	130
EP262: Diethanolamine	111-42-2	1	µg/L	<1	10 µg/L	118	50	130
EP262: Methyl diethanolamine (MDEA)	105-59-9	1	µg/L	<1	10 µg/L	113	50	130

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike Concentration	Spike Recovery (%) MS	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number			Low	High

Page : 5 of 5
 Work Order : EB1922795
 Client : COFFEY ENVIRONMENTS PTY LTD
 Project : 754-MCLCN221697/JDD PROJECT



Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2561432)							
EB1922983-002	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.4 mg/L	91.6	70	130
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2557953)							
EB1922564-002	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	5 mg/L	88.5	70	130
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2557952)							
EB1922564-002	Anonymous	EK067G: Total Phosphorus as P	----	1 mg/L	97.4	70	130
EK085M: Sulfide as S2- (QCLot: 2557738)							
EB1922795-001	WQ-06	EK085: Sulfide as S2-	18496-25-8	0.9913 mg/L	84.2	70	130
EP026SP: Chemical Oxygen Demand (Spectrophotometric) (QCLot: 2562689)							
EB1922738-013	Anonymous	EP026SP: Chemical Oxygen Demand	----	50 mg/L	102	70	130
EP262: Ethanolamines (QCLot: 2566357)							
EB1922850-002	Anonymous	EP262: Ethanolamine	141-43-5	10 µg/L	# 0.590	50	130
		EP262: Diethanolamine	111-42-2	10 µg/L	# 1.04	50	130
		EP262: Methyl diethanolamine (MDEA)	105-59-9	10 µg/L	# 0.740	50	130

QUALITY CONTROL REPORT

Work Order	: EB1923115	Page	: 1 of 8
Client	: COFFEY ENVIRONMENTS PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MS ERICA COLLEY	Contact	: Andrew Epps
Address	: Level 5 12 Creek St Brisbane QLD, AUSTRALIA 4000	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3608 2500	Telephone	: +61 7 3552 8639
Project	: JDD PROJECT	Date Samples Received	: 03-Sep-2019
Order number	:	Date Analysis Commenced	: 04-Sep-2019
C-O-C number	: ----	Issue Date	: 01-Oct-2019
Sampler	: ERICA COLLEY		
Site	:		
Quote number	: EN/222		
No. of samples received	: 31		
No. of samples analysed	: 30		



Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane External Subcontracting, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Minh Wills	2IC Organic Chemist	Brisbane Organics, Stafford, QLD

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
= Indicates failed QC

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EG005(ED093)T: Total Metals by ICP-AES (QC Lot: 2563922)									
EB1923115-002	SED16	EG005T: Barium	7440-39-3	10	mg/kg	<50	<40	0.00	No Limit
		EG005T: Cobalt	7440-48-4	2	mg/kg	<5	<4	0.00	No Limit
		EG005T: Silver	7440-22-4	2	mg/kg	<5	<4	0.00	No Limit
		EG005T: Manganese	7439-96-5	5	mg/kg	223	226	1.50	0% - 20%
		EG005T: Selenium	7782-49-2	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Tin	7440-31-5	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Vanadium	7440-62-2	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Boron	7440-42-8	50	mg/kg	<50	<50	0.00	No Limit
		EG005T: Iron	7439-89-6	50	mg/kg	5160	4680	9.62	0% - 20%
EG005(ED093)T: Total Metals by ICP-AES (QC Lot: 2600396)									
EB1923115-026	SED16 <2000µm Fraction	EG005T: Barium	7440-39-3	10	mg/kg	<20	<20	0.00	No Limit
		EG005T: Cobalt	7440-48-4	2	mg/kg	<2	<2	0.00	No Limit
		EG005T: Silver	7440-22-4	2	mg/kg	<2	<2	0.00	No Limit
		EG005T: Manganese	7439-96-5	5	mg/kg	154	156	1.50	0% - 20%
		EG005T: Selenium	7782-49-2	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Tin	7440-31-5	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Vanadium	7440-62-2	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Boron	7440-42-8	50	mg/kg	<50	<50	0.00	No Limit
		EG005T: Iron	7439-89-6	50	mg/kg	5130	4870	5.21	0% - 20%
EA055: Moisture Content (Dried @ 105-110°C) (QC Lot: 2563926)									
EB1923115-001	SED3	EA055: Moisture Content	----	0.1	%	39.3	39.5	0.521	0% - 20%
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 2563925)									
EB1923115-002	SED16	EK059G: Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	1.5	1.6	7.07	0% - 50%
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QC Lot: 2563923)									



Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QC Lot: 2563923) - continued									
EB1923115-002	SED16	EK061G: Total Kjeldahl Nitrogen as N	----	20	mg/kg	400	350	13.6	0% - 20%
EK067G: Total Phosphorus as P by Discrete Analyser (QC Lot: 2563924)									
EB1923115-002	SED16	EK067G: Total Phosphorus as P	----	2	mg/kg	333	295	12.1	0% - 20%
EP003: Total Organic Carbon (TOC) in Soil (QC Lot: 2604638)									
EB1923115-002	SED16	EP003: Total Organic Carbon	----	0.02	%	0.18	0.22	20.8	0% - 50%
EP003TC: Total Carbon (TC) in Soil (QC Lot: 2604639)									
EB1923115-002	SED16	EP003TC: Total Carbon	TC	0.02	%	10.2	10.4	1.77	0% - 20%
EP066: Polychlorinated Biphenyls (PCB) (QC Lot: 2563917)									
EB1923115-001	SED3	EP066: Total Polychlorinated biphenyls	----	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
EP068A: Organochlorine Pesticides (OC) (QC Lot: 2563916)									
EB1923115-001	SED3	EP068: alpha-BHC	319-84-6	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: Hexachlorobenzene (HCB)	118-74-1	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: beta-BHC	319-85-7	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: gamma-BHC	58-89-9	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: delta-BHC	319-86-8	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: Heptachlor	76-44-8	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: Aldrin	309-00-2	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: Heptachlor epoxide	1024-57-3	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: Total Chlordane (sum)	----	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: trans-Chlordane	5103-74-2	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: alpha-Endosulfan	959-98-8	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: cis-Chlordane	5103-71-9	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: Dieldrin	60-57-1	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: 4,4`-DDE	72-55-9	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: Endrin	72-20-8	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: beta-Endosulfan	33213-65-9	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: Endosulfan (sum)	115-29-7	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: 4,4`-DDD	72-54-8	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: Endrin aldehyde	7421-93-4	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: Endosulfan sulfate	1031-07-8	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: Endrin ketone	53494-70-5	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: Sum of DDD + DDE + DDT	72-54-8/72-55-9/50-2	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: Sum of Aldrin + Dieldrin	309-00-2/60-57-1	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: 4,4`-DDT	50-29-3	0.2	mg/kg	<0.2	<0.2	0.00	No Limit
		EP068: Methoxychlor	72-43-5	0.2	mg/kg	<0.2	<0.2	0.00	No Limit
EP080/071: Total Petroleum Hydrocarbons (QC Lot: 2563918)									
EB1923115-001	SED3	EP071: C15 - C28 Fraction	----	100	mg/kg	<100	<100	0.00	No Limit



Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EP080/071: Total Petroleum Hydrocarbons (QC Lot: 2563918) - continued									
EB1923115-001	SED3	EP071: C29 - C36 Fraction	----	100	mg/kg	<100	<100	0.00	No Limit
		EP071: C10 - C14 Fraction	----	50	mg/kg	<50	<50	0.00	No Limit
EP080/071: Total Petroleum Hydrocarbons (QC Lot: 2563920)									
EB1923115-001	SED3	EP080: C6 - C9 Fraction	----	10	mg/kg	<10	<10	0.00	No Limit
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QC Lot: 2563918)									
EB1923115-001	SED3	EP071: >C16 - C34 Fraction	----	100	mg/kg	<100	<100	0.00	No Limit
		EP071: >C34 - C40 Fraction	----	100	mg/kg	<100	<100	0.00	No Limit
		EP071: >C10 - C16 Fraction	----	50	mg/kg	<50	<50	0.00	No Limit
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QC Lot: 2563920)									
EB1923115-001	SED3	EP080: C6 - C10 Fraction	C6_C10	10	mg/kg	<10	<10	0.00	No Limit
EP080: BTEXN (QC Lot: 2563920)									
EB1923115-001	SED3	EP080: Benzene	71-43-2	0.2	mg/kg	<0.2	<0.2	0.00	No Limit
		EP080: Toluene	108-88-3	0.5	mg/kg	<0.5	<0.5	0.00	No Limit
		EP080: Ethylbenzene	100-41-4	0.5	mg/kg	<0.5	<0.5	0.00	No Limit
		EP080: meta- & para-Xylene	108-38-3	0.5	mg/kg	<0.5	<0.5	0.00	No Limit
			106-42-3						
		EP080: ortho-Xylene	95-47-6	0.5	mg/kg	<0.5	<0.5	0.00	No Limit
	EP080: Naphthalene	91-20-3	1	mg/kg	<1	<1	0.00	No Limit	
EP090: Organotin Compounds (QC Lot: 2563921)									
EB1923115-001	SED3	EP090: Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	0.00	No Limit
Sub-Matrix: WATER				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EA025: Total Suspended Solids dried at 104 ± 2°C (QC Lot: 2563754)									
EB1921022-001	Anonymous	EA025H: Suspended Solids (SS)	----	5	mg/L	3330	3440	3.23	0% - 20%
EB1921022-014	Anonymous	EA025H: Suspended Solids (SS)	----	5	mg/L	4670	4640	0.730	0% - 20%
EA025: Total Suspended Solids dried at 104 ± 2°C (QC Lot: 2563755)									
EB1923115-013	TSS 05	EA025H: Suspended Solids (SS)	----	5	mg/L	<5	<5	0.00	No Limit
EB1923115-023	TSS 09	EA025H: Suspended Solids (SS)	----	5	mg/L	<5	<5	0.00	No Limit



Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

Sub-Matrix: SOIL				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low High	
Method: Compound	CAS Number	LOR	Unit	Result				
EG005(ED093)T: Total Metals by ICP-AES (QCLot: 2563922)								
EG005T: Barium	7440-39-3	10	mg/kg	<10	79.4 mg/kg	96.1	89	129
EG005T: Boron	7440-42-8	50	mg/kg	<50	----	----	----	----
EG005T: Cobalt	7440-48-4	2	mg/kg	<2	9.8 mg/kg	84.9	82	118
EG005T: Iron	7439-89-6	50	mg/kg	<50	27922 mg/kg	102	70	120
EG005T: Manganese	7439-96-5	5	mg/kg	<5	482 mg/kg	90.8	84	113
EG005T: Selenium	7782-49-2	5	mg/kg	<5	----	----	----	----
EG005T: Silver	7440-22-4	2	mg/kg	<2	2.4 mg/kg	97.8	70	130
EG005T: Tin	7440-31-5	5	mg/kg	<5	----	----	----	----
EG005T: Vanadium	7440-62-2	5	mg/kg	<5	42 mg/kg	100	82	118
EG005(ED093)T: Total Metals by ICP-AES (QCLot: 2600396)								
EG005T: Barium	7440-39-3	10	mg/kg	<10	79.4 mg/kg	97.8	89.0	129
EG005T: Boron	7440-42-8	50	mg/kg	<50	----	----	----	----
EG005T: Cobalt	7440-48-4	2	mg/kg	<2	9.8 mg/kg	89.3	82.0	118
EG005T: Iron	7439-89-6	50	mg/kg	<50	27922 mg/kg	104	70.0	120
EG005T: Manganese	7439-96-5	5	mg/kg	<5	482 mg/kg	97.1	84.0	113
EG005T: Selenium	7782-49-2	5	mg/kg	<5	----	----	----	----
EG005T: Silver	7440-22-4	2	mg/kg	<2	2.4 mg/kg	94.3	70.0	130
EG005T: Tin	7440-31-5	5	mg/kg	<5	----	----	----	----
EG005T: Vanadium	7440-62-2	5	mg/kg	<5	42 mg/kg	101	82.0	118
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2563925)								
EK059G: Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	<0.1	2.5 mg/kg	95.6	83	111
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2563923)								
EK061G: Total Kjeldahl Nitrogen as N	----	20	mg/kg	<20	848 mg/kg	107	73	121
				<20	3644 mg/kg	90.2	73	121
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2563924)								
EK067G: Total Phosphorus as P	----	2	mg/kg	<2	939 mg/kg	97.0	80	115
				<2	1200 mg/kg	93.0	80	115
EP003: Total Organic Carbon (TOC) in Soil (QCLot: 2604638)								
EP003: Total Organic Carbon	----	0.02	%	<0.02	0.48 %	102	70.0	130
				<0.02	0.44 %	96.6	70.0	130
EP003TC: Total Carbon (TC) in Soil (QCLot: 2604639)								
EP003TC: Total Carbon	TC	0.02	%	<0.02	8.3 %	104	70.0	130
EP066: Polychlorinated Biphenyls (PCB) (QCLot: 2563917)								
EP066: Total Polychlorinated biphenyls	----	0.1	mg/kg	<0.1	1 mg/kg	103	72	155

Sub-Matrix: SOIL				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low High	
Method: Compound	CAS Number	LOR	Unit	Result				
EP068A: Organochlorine Pesticides (OC) (QCLot: 2563916)								
EP068: alpha-BHC	319-84-6	0.05	mg/kg	<0.05	0.5 mg/kg	108	54	121
EP068: Hexachlorobenzene (HCB)	118-74-1	0.05	mg/kg	<0.05	0.5 mg/kg	116	80	134
EP068: beta-BHC	319-85-7	0.05	mg/kg	<0.05	0.5 mg/kg	106	49	121
EP068: gamma-BHC	58-89-9	0.05	mg/kg	<0.05	0.5 mg/kg	112	76	136
EP068: delta-BHC	319-86-8	0.05	mg/kg	<0.05	0.5 mg/kg	102	61	122
EP068: Heptachlor	76-44-8	0.05	mg/kg	<0.05	0.5 mg/kg	124	65	130
EP068: Aldrin	309-00-2	0.05	mg/kg	<0.05	0.5 mg/kg	116	70	130
EP068: Heptachlor epoxide	1024-57-3	0.05	mg/kg	<0.05	0.5 mg/kg	108	58	118
EP068: Total Chlordane (sum)	----	0.05	mg/kg	<0.05	----	----	----	----
EP068: trans-Chlordane	5103-74-2	0.05	mg/kg	<0.05	0.5 mg/kg	107	56	119
EP068: alpha-Endosulfan	959-98-8	0.05	mg/kg	<0.05	0.5 mg/kg	109	51	125
EP068: cis-Chlordane	5103-71-9	0.05	mg/kg	<0.05	0.5 mg/kg	108	57	118
EP068: Dieldrin	60-57-1	0.05	mg/kg	<0.05	0.5 mg/kg	109	67	129
EP068: 4,4'-DDE	72-55-9	0.05	mg/kg	<0.05	0.5 mg/kg	110	62	121
EP068: Endrin	72-20-8	0.05	mg/kg	<0.05	0.5 mg/kg	110	60	137
EP068: beta-Endosulfan	33213-65-9	0.05	mg/kg	<0.05	0.5 mg/kg	104	61	122
EP068: Endosulfan (sum)	115-29-7	0.05	mg/kg	<0.05	----	----	----	----
EP068: 4,4'-DDD	72-54-8	0.05	mg/kg	<0.05	0.5 mg/kg	119	60	123
EP068: Endrin aldehyde	7421-93-4	0.05	mg/kg	<0.05	0.5 mg/kg	122	52	125
EP068: Endosulfan sulfate	1031-07-8	0.05	mg/kg	<0.05	0.5 mg/kg	94.8	55	125
EP068: 4,4'-DDT	50-29-3	0.2	mg/kg	<0.2	0.5 mg/kg	96.2	80	142
EP068: Endrin ketone	53494-70-5	0.05	mg/kg	<0.05	0.5 mg/kg	97.6	55	129
EP068: Methoxychlor	72-43-5	0.2	mg/kg	<0.2	0.5 mg/kg	96.0	53	136
EP068: Sum of DDD + DDE + DDT	72-54-8/72-5 5-9/50-2	0.05	mg/kg	<0.05	----	----	----	----
EP068: Sum of Aldrin + Dieldrin	309-00-2/60- 57-1	0.05	mg/kg	<0.05	----	----	----	----
EP080/071: Total Petroleum Hydrocarbons (QCLot: 2563918)								
EP071: C10 - C14 Fraction	----	50	mg/kg	<50	310 mg/kg	90.4	79	123
EP071: C15 - C28 Fraction	----	100	mg/kg	<100	490 mg/kg	97.8	77	123
EP071: C29 - C36 Fraction	----	100	mg/kg	<100	----	----	----	----
EP080/071: Total Petroleum Hydrocarbons (QCLot: 2563920)								
EP080: C6 - C9 Fraction	----	10	mg/kg	<10	18 mg/kg	101	60	125
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 2563918)								
EP071: >C10 - C16 Fraction	----	50	mg/kg	<50	450 mg/kg	90.4	81	122
EP071: >C16 - C34 Fraction	----	100	mg/kg	<100	320 mg/kg	98.3	74	122
EP071: >C34 - C40 Fraction	----	100	mg/kg	<100	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 2563920)								



Sub-Matrix: SOIL				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low High	
Method: Compound	CAS Number	LOR	Unit	Result				
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 2563920) - continued								
EP080: C6 - C10 Fraction	C6_C10	10	mg/kg	<10	22.5 mg/kg	104	58	124
EP080: BTEXN (QCLot: 2563920)								
EP080: Benzene	71-43-2	0.2	mg/kg	<0.2	1 mg/kg	112	67	115
EP080: Toluene	108-88-3	0.5	mg/kg	<0.5	1 mg/kg	102	69	116
EP080: Ethylbenzene	100-41-4	0.5	mg/kg	<0.5	1 mg/kg	108	69	116
EP080: meta- & para-Xylene	108-38-3	0.5	mg/kg	<0.5	2 mg/kg	111	70	118
	106-42-3							
EP080: ortho-Xylene	95-47-6	0.5	mg/kg	<0.5	1 mg/kg	108	72	116
EP080: Naphthalene	91-20-3	1	mg/kg	<1	1 mg/kg	103	73	116
EP090: Organotin Compounds (QCLot: 2563921)								
EP090: Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	1.25 µgSn/kg	98.4	52	139

Sub-Matrix: WATER				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low High	
Method: Compound	CAS Number	LOR	Unit	Result				
EA025: Total Suspended Solids dried at 104 ± 2°C (QCLot: 2563754)								
EA025H: Suspended Solids (SS)	----	5	mg/L	<5	150 mg/L	106	88	112
				<5	1000 mg/L	101	88	112
				<5	951 mg/L	103	88	116
EA025: Total Suspended Solids dried at 104 ± 2°C (QCLot: 2563755)								
EA025H: Suspended Solids (SS)	----	5	mg/L	<5	150 mg/L	96.3	88	112
				<5	1000 mg/L	97.2	88	112
				<5	951 mg/L	98.8	88	116

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: SOIL				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EG005(ED093)T: Total Metals by ICP-AES (QCLot: 2563922)							
EB1923115-004	SED19	EG005T: Barium	7440-39-3	50 mg/kg	92.2	70	130
		EG005T: Cobalt	7440-48-4	50 mg/kg	96.4	70	130
		EG005T: Manganese	7439-96-5	50 mg/kg	89.3	70	130
		EG005T: Vanadium	7440-62-2	50 mg/kg	97.9	70	130
EG005(ED093)T: Total Metals by ICP-AES (QCLot: 2600396)							
EB1923115-027	SED19 <2000µm Fraction	EG005T: Barium	7440-39-3	100 mg/kg	90.3	70.0	130
		EG005T: Cobalt	7440-48-4	100 mg/kg	87.0	70.0	130



Sub-Matrix: **SOIL**

Sub-Matrix: SOIL				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EG005(ED093)T: Total Metals by ICP-AES (QCLot: 2600396) - continued							
EB1923115-027	SED19 <2000µm Fraction	EG005T: Manganese	7439-96-5	100 mg/kg	84.0	70.0	130
		EG005T: Vanadium	7440-62-2	100 mg/kg	90.5	70.0	130
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2563925)							
EB1923115-004	SED19	EK059G: Nitrite + Nitrate as N (Sol.)	----	2 mg/kg	97.6	70	130
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2563923)							
EB1923115-004	SED19	EK061G: Total Kjeldahl Nitrogen as N	----	500 mg/kg	115	70	130
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2563924)							
EB1923115-004	SED19	EK067G: Total Phosphorus as P	----	100 mg/kg	86.4	70	130
EP066: Polychlorinated Biphenyls (PCB) (QCLot: 2563917)							
EB1923115-002	SED16	EP066: Total Polychlorinated biphenyls	----	1 mg/kg	107	70	130
EP068A: Organochlorine Pesticides (OC) (QCLot: 2563916)							
EB1923115-002	SED16	EP068: gamma-BHC	58-89-9	0.5 mg/kg	114	76	136
		EP068: Heptachlor	76-44-8	0.5 mg/kg	125	65	130
		EP068: Aldrin	309-00-2	0.5 mg/kg	116	70	130
		EP068: Dieldrin	60-57-1	0.5 mg/kg	113	67	129
		EP068: Endrin	72-20-8	0.5 mg/kg	113	60	137
		EP068: 4,4`-DDT	50-29-3	0.5 mg/kg	93.2	80	142
EP080/071: Total Petroleum Hydrocarbons (QCLot: 2563918)							
EB1923115-002	SED16	EP071: C10 - C14 Fraction	----	310 mg/kg	91.3	70	130
		EP071: C15 - C28 Fraction	----	490 mg/kg	98.5	70	130
EP080/071: Total Petroleum Hydrocarbons (QCLot: 2563920)							
EB1923115-002	SED16	EP080: C6 - C9 Fraction	----	8 mg/kg	86.7	70	130
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 2563918)							
EB1923115-002	SED16	EP071: >C10 - C16 Fraction	----	450 mg/kg	92.2	70	130
		EP071: >C16 - C34 Fraction	----	320 mg/kg	99.0	70	130
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 2563920)							
EB1923115-002	SED16	EP080: C6 - C10 Fraction	C6_C10	8 mg/kg	84.3	70	130
EP080: BTEXN (QCLot: 2563920)							
EB1923115-002	SED16	EP080: Benzene	71-43-2	2 mg/kg	78.9	70	130
		EP080: Toluene	108-88-3	2 mg/kg	77.5	70	130
EP090: Organotin Compounds (QCLot: 2563921)							
EB1923115-003	SED18	EP090: Tributyltin	56573-85-4	1.25 µgSn/kg	73.8	20	130

QUALITY CONTROL REPORT

Work Order : **EB1923115**

Page : 1 of 10

Amendment : **1**

Client : **COFFEY ENVIRONMENTS PTY LTD**

Contact : **MS ERICA COLLEY**

Address : Level 5 12 Creek St
Brisbane QLD, AUSTRALIA 4000

Telephone : +61 07 3608 2500

Project : **JDD PROJECT**

Order number :

C-O-C number : ----

Sampler : **ERICA COLLEY**

Site :

Quote number : **EN/222**

No. of samples received : **31**

No. of samples analysed : **30**

Laboratory : Environmental Division Brisbane

Contact : Andrew Epps

Address : 2 Byth Street Stafford QLD Australia 4053

Telephone : +61 7 3552 8639

Date Samples Received : 03-Sep-2019

Date Analysis Commenced : 04-Sep-2019

Issue Date : 13-Mar-2020



Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane External Subcontracting, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Minh Wills	2IC Organic Chemist	Brisbane Organics, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high

Key :
 Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
 CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
 LOR = Limit of reporting
 RPD = Relative Percentage Difference
 # = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **SOIL**

Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EG005(ED093)T: Total Metals by ICP-AES (QC Lot: 2563922)									
EB1923115-002	SED16	EG005T: Beryllium	7440-41-7	1	mg/kg	<1	<1	0.00	No Limit
		EG005T: Cadmium	7440-43-9	1	mg/kg	<1	<1	0.00	No Limit
		EG005T: Barium	7440-39-3	10	mg/kg	<50	<40	0.00	No Limit
		EG005T: Chromium	7440-47-3	2	mg/kg	4	4	0.00	No Limit
		EG005T: Cobalt	7440-48-4	2	mg/kg	<5	<4	0.00	No Limit
		EG005T: Nickel	7440-02-0	2	mg/kg	2	2	0.00	No Limit
		EG005T: Silver	7440-22-4	2	mg/kg	<5	<4	0.00	No Limit
		EG005T: Arsenic	7440-38-2	5	mg/kg	8	7	14.5	No Limit
		EG005T: Copper	7440-50-8	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Lead	7439-92-1	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Manganese	7439-96-5	5	mg/kg	223	226	1.50	0% - 20%
		EG005T: Selenium	7782-49-2	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Tin	7440-31-5	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Vanadium	7440-62-2	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Zinc	7440-66-6	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Boron	7440-42-8	50	mg/kg	<50	<50	0.00	No Limit
		EG005T: Iron	7439-89-6	50	mg/kg	5160	4680	9.62	0% - 20%
EG005(ED093)T: Total Metals by ICP-AES (QC Lot: 2600396)									
EB1923115-026	SED16 <2000µm Fraction	EG005T: Beryllium	7440-41-7	1	mg/kg	<1	<1	0.00	No Limit
		EG005T: Cadmium	7440-43-9	1	mg/kg	<1	<1	0.00	No Limit
		EG005T: Barium	7440-39-3	10	mg/kg	<20	<20	0.00	No Limit
		EG005T: Chromium	7440-47-3	2	mg/kg	4	4	0.00	No Limit
		EG005T: Cobalt	7440-48-4	2	mg/kg	<2	<2	0.00	No Limit
		EG005T: Nickel	7440-02-0	2	mg/kg	<2	<2	0.00	No Limit
		EG005T: Silver	7440-22-4	2	mg/kg	<2	<2	0.00	No Limit



Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EG005(ED093)T: Total Metals by ICP-AES (QC Lot: 2600396) - continued									
EB1923115-026	SED16 <2000µm Fraction	EG005T: Arsenic	7440-38-2	5	mg/kg	7	<5	35.5	No Limit
		EG005T: Copper	7440-50-8	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Lead	7439-92-1	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Manganese	7439-96-5	5	mg/kg	154	156	1.50	0% - 20%
		EG005T: Selenium	7782-49-2	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Tin	7440-31-5	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Vanadium	7440-62-2	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Zinc	7440-66-6	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Boron	7440-42-8	50	mg/kg	<50	<50	0.00	No Limit
EG005T: Iron	7439-89-6	50	mg/kg	5130	4870	5.21	0% - 20%		
EA055: Moisture Content (Dried @ 105-110°C) (QC Lot: 2563926)									
EB1923115-001	SED3	EA055: Moisture Content	----	0.1	%	39.3	39.5	0.521	0% - 20%
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 2563925)									
EB1923115-002	SED16	EK059G: Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	1.5	1.6	7.07	0% - 50%
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QC Lot: 2563923)									
EB1923115-002	SED16	EK061G: Total Kjeldahl Nitrogen as N	----	20	mg/kg	400	350	13.6	0% - 20%
EK067G: Total Phosphorus as P by Discrete Analyser (QC Lot: 2563924)									
EB1923115-002	SED16	EK067G: Total Phosphorus as P	----	2	mg/kg	333	295	12.1	0% - 20%
EP003: Total Organic Carbon (TOC) in Soil (QC Lot: 2604638)									
EB1923115-002	SED16	EP003: Total Organic Carbon	----	0.02	%	0.18	0.22	20.8	0% - 50%
EP003TC: Total Carbon (TC) in Soil (QC Lot: 2604639)									
EB1923115-002	SED16	EP003TC: Total Carbon	TC	0.02	%	10.2	10.4	1.77	0% - 20%
EP066: Polychlorinated Biphenyls (PCB) (QC Lot: 2563917)									
EB1923115-001	SED3	EP066: Total Polychlorinated biphenyls	----	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
EP068A: Organochlorine Pesticides (OC) (QC Lot: 2563916)									
EB1923115-001	SED3	EP068: alpha-BHC	319-84-6	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: Hexachlorobenzene (HCB)	118-74-1	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: beta-BHC	319-85-7	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: gamma-BHC	58-89-9	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: delta-BHC	319-86-8	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: Heptachlor	76-44-8	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: Aldrin	309-00-2	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: Heptachlor epoxide	1024-57-3	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: Total Chlordane (sum)	----	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: trans-Chlordane	5103-74-2	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: alpha-Endosulfan	959-98-8	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: cis-Chlordane	5103-71-9	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: Dieldrin	60-57-1	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: 4,4`-DDE	72-55-9	0.05	mg/kg	<0.05	<0.05	0.00	No Limit



Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EP068A: Organochlorine Pesticides (OC) (QC Lot: 2563916) - continued									
EB1923115-001	SED3	EP068: Endrin	72-20-8	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: beta-Endosulfan	33213-65-9	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: Endosulfan (sum)	115-29-7	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: 4,4'-DDD	72-54-8	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: Endrin aldehyde	7421-93-4	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: Endosulfan sulfate	1031-07-8	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: Endrin ketone	53494-70-5	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: Sum of DDD + DDE + DDT	72-54-8/72-55-9/50-2	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: Sum of Aldrin + Dieldrin	309-00-2/60-57-1	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
		EP068: 4,4'-DDT	50-29-3	0.2	mg/kg	<0.2	<0.2	0.00	No Limit
EP068: Methoxychlor	72-43-5	0.2	mg/kg	<0.2	<0.2	0.00	No Limit		
EP080/071: Total Petroleum Hydrocarbons (QC Lot: 2563918)									
EB1923115-001	SED3	EP071: C15 - C28 Fraction	----	100	mg/kg	<100	<100	0.00	No Limit
		EP071: C29 - C36 Fraction	----	100	mg/kg	<100	<100	0.00	No Limit
		EP071: C10 - C14 Fraction	----	50	mg/kg	<50	<50	0.00	No Limit
EP080/071: Total Petroleum Hydrocarbons (QC Lot: 2563920)									
EB1923115-001	SED3	EP080: C6 - C9 Fraction	----	10	mg/kg	<10	<10	0.00	No Limit
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QC Lot: 2563918)									
EB1923115-001	SED3	EP071: >C16 - C34 Fraction	----	100	mg/kg	<100	<100	0.00	No Limit
		EP071: >C34 - C40 Fraction	----	100	mg/kg	<100	<100	0.00	No Limit
		EP071: >C10 - C16 Fraction	----	50	mg/kg	<50	<50	0.00	No Limit
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QC Lot: 2563920)									
EB1923115-001	SED3	EP080: C6 - C10 Fraction	C6_C10	10	mg/kg	<10	<10	0.00	No Limit
EP080: BTEXN (QC Lot: 2563920)									
EB1923115-001	SED3	EP080: Benzene	71-43-2	0.2	mg/kg	<0.2	<0.2	0.00	No Limit
		EP080: Toluene	108-88-3	0.5	mg/kg	<0.5	<0.5	0.00	No Limit
		EP080: Ethylbenzene	100-41-4	0.5	mg/kg	<0.5	<0.5	0.00	No Limit
		EP080: meta- & para-Xylene	108-38-3	0.5	mg/kg	<0.5	<0.5	0.00	No Limit
			106-42-3						
		EP080: ortho-Xylene	95-47-6	0.5	mg/kg	<0.5	<0.5	0.00	No Limit
EP080: Naphthalene	91-20-3	1	mg/kg	<1	<1	0.00	No Limit		
EP090: Organotin Compounds (QC Lot: 2563921)									
EB1923115-001	SED3	EP090: Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	0.00	No Limit
Sub-Matrix: WATER				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EA025: Total Suspended Solids dried at 104 ± 2°C (QC Lot: 2563754)									
EB1921022-001	Anonymous	EA025H: Suspended Solids (SS)	----	5	mg/L	3330	3440	3.23	0% - 20%



Sub-Matrix: WATER				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EA025: Total Suspended Solids dried at 104 ± 2°C (QC Lot: 2563754) - continued									
EB1921022-014	Anonymous	EA025H: Suspended Solids (SS)	----	5	mg/L	4670	4640	0.730	0% - 20%
EA025: Total Suspended Solids dried at 104 ± 2°C (QC Lot: 2563755)									
EB1923115-013	TSS 05	EA025H: Suspended Solids (SS)	----	5	mg/L	<5	<5	0.00	No Limit
EB1923115-023	TSS 09	EA025H: Suspended Solids (SS)	----	5	mg/L	<5	<5	0.00	No Limit



Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

Sub-Matrix: SOIL				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low High	
Method: Compound	CAS Number	LOR	Unit	Result				
EG005(ED093)T: Total Metals by ICP-AES (QCLot: 2563922)								
EG005T: Arsenic	7440-38-2	5	mg/kg	<5	98 mg/kg	90.2	84	123
EG005T: Barium	7440-39-3	10	mg/kg	<10	79.4 mg/kg	96.1	89	129
EG005T: Beryllium	7440-41-7	1	mg/kg	<1	----	----	----	----
EG005T: Boron	7440-42-8	50	mg/kg	<50	----	----	----	----
EG005T: Cadmium	7440-43-9	1	mg/kg	<1	----	----	----	----
EG005T: Chromium	7440-47-3	2	mg/kg	<2	15.4 mg/kg	101	83	125
EG005T: Cobalt	7440-48-4	2	mg/kg	<2	9.8 mg/kg	84.9	82	118
EG005T: Copper	7440-50-8	5	mg/kg	<5	48 mg/kg	94.2	86	122
EG005T: Iron	7439-89-6	50	mg/kg	<50	27922 mg/kg	102	70	120
EG005T: Lead	7439-92-1	5	mg/kg	<5	50 mg/kg	93.4	84	119
EG005T: Manganese	7439-96-5	5	mg/kg	<5	482 mg/kg	90.8	84	113
EG005T: Nickel	7440-02-0	2	mg/kg	<2	12.4 mg/kg	95.1	82	119
EG005T: Selenium	7782-49-2	5	mg/kg	<5	----	----	----	----
EG005T: Silver	7440-22-4	2	mg/kg	<2	2.4 mg/kg	97.8	70	130
EG005T: Tin	7440-31-5	5	mg/kg	<5	----	----	----	----
EG005T: Vanadium	7440-62-2	5	mg/kg	<5	42 mg/kg	100	82	118
EG005T: Zinc	7440-66-6	5	mg/kg	<5	115 mg/kg	86.7	80	120
EG005(ED093)T: Total Metals by ICP-AES (QCLot: 2600396)								
EG005T: Arsenic	7440-38-2	5	mg/kg	<5	98 mg/kg	96.2	84.0	123
EG005T: Barium	7440-39-3	10	mg/kg	<10	79.4 mg/kg	97.8	89.0	129
EG005T: Beryllium	7440-41-7	1	mg/kg	<1	----	----	----	----
EG005T: Boron	7440-42-8	50	mg/kg	<50	----	----	----	----
EG005T: Cadmium	7440-43-9	1	mg/kg	<1	----	----	----	----
EG005T: Chromium	7440-47-3	2	mg/kg	<2	15.4 mg/kg	107	83.0	125
EG005T: Cobalt	7440-48-4	2	mg/kg	<2	9.8 mg/kg	89.3	82.0	118
EG005T: Copper	7440-50-8	5	mg/kg	<5	48 mg/kg	98.0	86.0	122
EG005T: Iron	7439-89-6	50	mg/kg	<50	27922 mg/kg	104	70.0	120
EG005T: Lead	7439-92-1	5	mg/kg	<5	50 mg/kg	101	84.0	119
EG005T: Manganese	7439-96-5	5	mg/kg	<5	482 mg/kg	97.1	84.0	113
EG005T: Nickel	7440-02-0	2	mg/kg	<2	12.4 mg/kg	104	81.5	118
EG005T: Selenium	7782-49-2	5	mg/kg	<5	----	----	----	----
EG005T: Silver	7440-22-4	2	mg/kg	<2	2.4 mg/kg	94.3	70.0	130
EG005T: Tin	7440-31-5	5	mg/kg	<5	----	----	----	----
EG005T: Vanadium	7440-62-2	5	mg/kg	<5	42 mg/kg	101	82.0	118



Sub-Matrix: SOIL				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low High	
Method: Compound	CAS Number	LOR	Unit	Result				
EG005(ED093)T: Total Metals by ICP-AES (QCLot: 2600396) - continued								
EG005T: Zinc	7440-66-6	5	mg/kg	<5	115 mg/kg	92.9	80.0	120
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2563925)								
EK059G: Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	<0.1	2.5 mg/kg	95.6	83	111
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2563923)								
EK061G: Total Kjeldahl Nitrogen as N	----	20	mg/kg	<20	848 mg/kg	107	73	121
				<20	3644 mg/kg	90.2	73	121
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2563924)								
EK067G: Total Phosphorus as P	----	2	mg/kg	<2	939 mg/kg	97.0	80	115
				<2	1200 mg/kg	93.0	80	115
EP003: Total Organic Carbon (TOC) in Soil (QCLot: 2604638)								
EP003: Total Organic Carbon	----	0.02	%	<0.02	0.48 %	102	70.0	130
				<0.02	0.44 %	96.6	70.0	130
EP003TC: Total Carbon (TC) in Soil (QCLot: 2604639)								
EP003TC: Total Carbon	TC	0.02	%	<0.02	8.3 %	104	70.0	130
EP066: Polychlorinated Biphenyls (PCB) (QCLot: 2563917)								
EP066: Total Polychlorinated biphenyls	----	0.1	mg/kg	<0.1	1 mg/kg	103	72	155
EP068A: Organochlorine Pesticides (OC) (QCLot: 2563916)								
EP068: alpha-BHC	319-84-6	0.05	mg/kg	<0.05	0.5 mg/kg	108	54	121
EP068: Hexachlorobenzene (HCB)	118-74-1	0.05	mg/kg	<0.05	0.5 mg/kg	116	80	134
EP068: beta-BHC	319-85-7	0.05	mg/kg	<0.05	0.5 mg/kg	106	49	121
EP068: gamma-BHC	58-89-9	0.05	mg/kg	<0.05	0.5 mg/kg	112	76	136
EP068: delta-BHC	319-86-8	0.05	mg/kg	<0.05	0.5 mg/kg	102	61	122
EP068: Heptachlor	76-44-8	0.05	mg/kg	<0.05	0.5 mg/kg	124	65	130
EP068: Aldrin	309-00-2	0.05	mg/kg	<0.05	0.5 mg/kg	116	70	130
EP068: Heptachlor epoxide	1024-57-3	0.05	mg/kg	<0.05	0.5 mg/kg	108	58	118
EP068: Total Chlordane (sum)	----	0.05	mg/kg	<0.05	----	----	----	----
EP068: trans-Chlordane	5103-74-2	0.05	mg/kg	<0.05	0.5 mg/kg	107	56	119
EP068: alpha-Endosulfan	959-98-8	0.05	mg/kg	<0.05	0.5 mg/kg	109	51	125
EP068: cis-Chlordane	5103-71-9	0.05	mg/kg	<0.05	0.5 mg/kg	108	57	118
EP068: Dieldrin	60-57-1	0.05	mg/kg	<0.05	0.5 mg/kg	109	67	129
EP068: 4,4`-DDE	72-55-9	0.05	mg/kg	<0.05	0.5 mg/kg	110	62	121
EP068: Endrin	72-20-8	0.05	mg/kg	<0.05	0.5 mg/kg	110	60	137
EP068: beta-Endosulfan	33213-65-9	0.05	mg/kg	<0.05	0.5 mg/kg	104	61	122
EP068: Endosulfan (sum)	115-29-7	0.05	mg/kg	<0.05	----	----	----	----
EP068: 4,4`-DDD	72-54-8	0.05	mg/kg	<0.05	0.5 mg/kg	119	60	123
EP068: Endrin aldehyde	7421-93-4	0.05	mg/kg	<0.05	0.5 mg/kg	122	52	125
EP068: Endosulfan sulfate	1031-07-8	0.05	mg/kg	<0.05	0.5 mg/kg	94.8	55	125
EP068: 4,4`-DDT	50-29-3	0.2	mg/kg	<0.2	0.5 mg/kg	96.2	80	142

Sub-Matrix: **WATER**



Sub-Matrix: **WATER**

Sub-Matrix: WATER				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report				
					Spike Concentration	Spike Recovery (%)	Recovery Limits (%)		
				Method: Compound		CAS Number	LOR	Unit	Result
EA025: Total Suspended Solids dried at 104 ± 2°C (QCLot: 2563755) - continued									
EA025H: Suspended Solids (SS)	----	5	mg/L	<5	150 mg/L	96.3	88	112	
				<5	1000 mg/L	97.2	88	112	
				<5	951 mg/L	98.8	88	116	

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **SOIL**

Sub-Matrix: SOIL				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EG005(ED093)T: Total Metals by ICP-AES (QCLot: 2563922)							
EB1923115-004	SED19	EG005T: Arsenic	7440-38-2	50 mg/kg	95.1	70	130
		EG005T: Barium	7440-39-3	50 mg/kg	92.2	70	130
		EG005T: Beryllium	7440-41-7	5 mg/kg	86.7	70	130
		EG005T: Cadmium	7440-43-9	25 mg/kg	77.8	70	130
		EG005T: Chromium	7440-47-3	50 mg/kg	83.8	70	130
		EG005T: Cobalt	7440-48-4	50 mg/kg	96.4	70	130
		EG005T: Copper	7440-50-8	50 mg/kg	103	70	130
		EG005T: Lead	7439-92-1	50 mg/kg	82.2	70	130
		EG005T: Manganese	7439-96-5	50 mg/kg	89.3	70	130
		EG005T: Nickel	7440-02-0	50 mg/kg	78.6	70	130
		EG005T: Vanadium	7440-62-2	50 mg/kg	97.9	70	130
		EG005T: Zinc	7440-66-6	50 mg/kg	75.0	70	130
EG005(ED093)T: Total Metals by ICP-AES (QCLot: 2600396)							
EB1923115-027	SED19 <2000µm Fraction	EG005T: Arsenic	7440-38-2	100 mg/kg	87.4	70.0	130
		EG005T: Barium	7440-39-3	100 mg/kg	90.3	70.0	130
		EG005T: Beryllium	7440-41-7	100 mg/kg	88.8	70.0	130
		EG005T: Cadmium	7440-43-9	25 mg/kg	88.4	70.0	130
		EG005T: Chromium	7440-47-3	100 mg/kg	87.8	70.0	130
		EG005T: Cobalt	7440-48-4	100 mg/kg	87.0	70.0	130
		EG005T: Copper	7440-50-8	100 mg/kg	91.6	70.0	130
		EG005T: Lead	7439-92-1	100 mg/kg	88.7	70.0	130
		EG005T: Manganese	7439-96-5	100 mg/kg	84.0	70.0	130
		EG005T: Nickel	7440-02-0	100 mg/kg	85.4	70.0	130
		EG005T: Vanadium	7440-62-2	100 mg/kg	90.5	70.0	130
		EG005T: Zinc	7440-66-6	100 mg/kg	84.6	70.0	130
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2563925)							
EB1923115-004	SED19						



Sub-Matrix: SOIL				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2563925) - continued							
EB1923115-004	SED19	EK059G: Nitrite + Nitrate as N (Sol.)	----	2 mg/kg	97.6	70	130
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2563923)							
EB1923115-004	SED19	EK061G: Total Kjeldahl Nitrogen as N	----	500 mg/kg	115	70	130
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2563924)							
EB1923115-004	SED19	EK067G: Total Phosphorus as P	----	100 mg/kg	86.4	70	130
EP066: Polychlorinated Biphenyls (PCB) (QCLot: 2563917)							
EB1923115-002	SED16	EP066: Total Polychlorinated biphenyls	----	1 mg/kg	107	70	130
EP068A: Organochlorine Pesticides (OC) (QCLot: 2563916)							
EB1923115-002	SED16	EP068: gamma-BHC	58-89-9	0.5 mg/kg	114	76	136
		EP068: Heptachlor	76-44-8	0.5 mg/kg	125	65	130
		EP068: Aldrin	309-00-2	0.5 mg/kg	116	70	130
		EP068: Dieldrin	60-57-1	0.5 mg/kg	113	67	129
		EP068: Endrin	72-20-8	0.5 mg/kg	113	60	137
		EP068: 4,4'-DDT	50-29-3	0.5 mg/kg	93.2	80	142
EP080/071: Total Petroleum Hydrocarbons (QCLot: 2563918)							
EB1923115-002	SED16	EP071: C10 - C14 Fraction	----	310 mg/kg	91.3	70	130
		EP071: C15 - C28 Fraction	----	490 mg/kg	98.5	70	130
EP080/071: Total Petroleum Hydrocarbons (QCLot: 2563920)							
EB1923115-002	SED16	EP080: C6 - C9 Fraction	----	8 mg/kg	86.7	70	130
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 2563918)							
EB1923115-002	SED16	EP071: >C10 - C16 Fraction	----	450 mg/kg	92.2	70	130
		EP071: >C16 - C34 Fraction	----	320 mg/kg	99.0	70	130
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 2563920)							
EB1923115-002	SED16	EP080: C6 - C10 Fraction	C6_C10	8 mg/kg	84.3	70	130
EP080: BTEXN (QCLot: 2563920)							
EB1923115-002	SED16	EP080: Benzene	71-43-2	2 mg/kg	78.9	70	130
		EP080: Toluene	108-88-3	2 mg/kg	77.5	70	130
EP090: Organotin Compounds (QCLot: 2563921)							
EB1923115-003	SED18	EP090: Tributyltin	56573-85-4	1.25 µgSn/kg	73.8	20	130

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: EB1923115	Page	: 1 of 9
Amendment	: 1		
Client	: COFFEY ENVIRONMENTS PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MS ERICA COLLEY	Telephone	: +61 7 3552 8639
Project	: JDD PROJECT	Date Samples Received	: 03-Sep-2019
Site	:	Issue Date	: 13-Mar-2020
Sampler	: ERICA COLLEY	No. of samples received	: 31
Order number	:	No. of samples analysed	: 30

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO** Method Blank value outliers occur.
- **NO** Duplicate outliers occur.
- **NO** Laboratory Control outliers occur.
- **NO** Matrix Spike outliers occur.
- For all regular sample matrices, **NO** surrogate recovery outliers occur.

Outliers : Analysis Holding Time Compliance

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- **NO** Quality Control Sample Frequency Outliers exist.



Outliers : Analysis Holding Time Compliance

Matrix: **SOIL**

Method		Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EP003: Total Organic Carbon (TOC) in Soil							
Snap Lock Bag							
SED16,	SED19,	25-Sep-2019	22-Sep-2019	3	25-Sep-2019	22-Sep-2019	3
SED27,	SED28						
Soil Glass Jar - Unpreserved							
SED29		25-Sep-2019	22-Sep-2019	3	25-Sep-2019	22-Sep-2019	3
EP003TC: Total Carbon (TC) in Soil							
Snap Lock Bag							
SED16,	SED19,	25-Sep-2019	22-Sep-2019	3	25-Sep-2019	22-Sep-2019	3
SED27,	SED28						
Soil Glass Jar - Unpreserved							
SED29		25-Sep-2019	22-Sep-2019	3	25-Sep-2019	22-Sep-2019	3

Matrix: **WATER**

Method		Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EA025: Total Suspended Solids dried at 104 ± 2°C							
Clear Plastic Bottle - Natural							
TSS 28,	TSS 08,	----	----	----	04-Sep-2019	02-Sep-2019	2
TSS 08 DEEP,	TSS 05,						
TSS 05 DEEP,	TSS 02 DEEP,						
TSS 43 DEEP,	TSS 43,						
TSS 09 DEEP,	TSS 46,						
TSS 44,	TSS 44 DEEP,						
TSS 47,	TSS 09,						
TSS 45,	TSS 18						

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for VOC in soils vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **SOIL**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation



Matrix: **SOIL**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA055: Moisture Content (Dried @ 105-110°C)								
Soil Glass Jar - Unpreserved (EA055)		25-Aug-2019	----	----	----	04-Sep-2019	08-Sep-2019	✓
SED3,	SED16,							
SED18,	SED19,							
SED21,	SED22,							
SED27,	SED28,							
SED29								
EA150: Particle Sizing								
Snap Lock Bag (EA150H)		25-Aug-2019	----	----	----	19-Sep-2019	21-Feb-2020	✓
SED16,	SED19,							
SED27,	SED28							
EA150: Soil Classification based on Particle Size								
Snap Lock Bag (EA150H)		25-Aug-2019	----	----	----	19-Sep-2019	21-Feb-2020	✓
SED16,	SED19,							
SED27,	SED28							
EA152: Soil Particle Density								
Snap Lock Bag (EA152)		25-Aug-2019	----	----	----	19-Sep-2019	21-Feb-2020	✓
SED16,	SED19,							
SED27,	SED28							
EG005(ED093)T: Total Metals by ICP-AES								
Pulp Bag (-2000µm) (EG005T)		17-Sep-2019	26-Sep-2019	15-Mar-2020	✓	26-Sep-2019	15-Mar-2020	✓
SED16 - <2000µm Fraction,	SED19 - <2000µm Fraction,							
SED27 - <2000µm Fraction,	SED28 - <2000µm Fraction,							
SED29 - <2000µm Fraction								
Soil Glass Jar - Unpreserved (EG005T)		25-Aug-2019	05-Sep-2019	21-Feb-2020	✓	05-Sep-2019	21-Feb-2020	✓
SED16,	SED19,							
SED27,	SED28,							
SED29								
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Soil Glass Jar - Unpreserved (EK059G)		25-Aug-2019	05-Sep-2019	21-Feb-2020	✓	06-Sep-2019	21-Feb-2020	✓
SED16,	SED19,							
SED27,	SED28,							
SED29								
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Soil Glass Jar - Unpreserved (EK061G)		25-Aug-2019	05-Sep-2019	21-Feb-2020	✓	09-Sep-2019	21-Feb-2020	✓
SED16,	SED19,							
SED27,	SED28,							
SED29								



Matrix: **SOIL**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EK067G: Total Phosphorus as P by Discrete Analyser								
Soil Glass Jar - Unpreserved (EK067G)		25-Aug-2019	05-Sep-2019	21-Feb-2020	✓	09-Sep-2019	21-Feb-2020	✓
SED16,	SED19,							
SED27,	SED28,							
SED29								
EP003: Total Organic Carbon (TOC) in Soil								
Snap Lock Bag (EP003)		25-Aug-2019	25-Sep-2019	22-Sep-2019	✗	25-Sep-2019	22-Sep-2019	✗
SED16,	SED19,							
SED27,	SED28							
Soil Glass Jar - Unpreserved (EP003)		25-Aug-2019	25-Sep-2019	22-Sep-2019	✗	25-Sep-2019	22-Sep-2019	✗
SED29								
EP003TC: Total Carbon (TC) in Soil								
Snap Lock Bag (EP003TC)		25-Aug-2019	25-Sep-2019	22-Sep-2019	✗	25-Sep-2019	22-Sep-2019	✗
SED16,	SED19,							
SED27,	SED28							
Soil Glass Jar - Unpreserved (EP003TC)		25-Aug-2019	25-Sep-2019	22-Sep-2019	✗	25-Sep-2019	22-Sep-2019	✗
SED29								
EP066: Polychlorinated Biphenyls (PCB)								
Soil Glass Jar - Unpreserved (EP066)		25-Aug-2019	05-Sep-2019	08-Sep-2019	✓	06-Sep-2019	15-Oct-2019	✓
SED3,	SED16,							
SED18,	SED19,							
SED21,	SED22,							
SED27,	SED28,							
SED29								
EP068A: Organochlorine Pesticides (OC)								
Soil Glass Jar - Unpreserved (EP068)		25-Aug-2019	05-Sep-2019	08-Sep-2019	✓	06-Sep-2019	15-Oct-2019	✓
SED3,	SED16,							
SED18,	SED19,							
SED21,	SED22,							
SED27,	SED28,							
SED29								
EP080/071: Total Petroleum Hydrocarbons								
Soil Glass Jar - Unpreserved (EP080)		25-Aug-2019	05-Sep-2019	08-Sep-2019	✓	06-Sep-2019	08-Sep-2019	✓
SED3,	SED16,							
SED18,	SED19,							
SED21,	SED22,							
SED27,	SED28,							
SED29								

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA025: Total Suspended Solids dried at 104 ± 2°C							
Clear Plastic Bottle - Natural (EA025H)							
TSS 28,	TSS 08,	26-Aug-2019	----	----	----	04-Sep-2019	02-Sep-2019
TSS 08 DEEP,	TSS 05,						
TSS 05 DEEP,	TSS 02 DEEP,						
TSS 43 DEEP,	TSS 43,						
TSS 09 DEEP,	TSS 46,						
TSS 44,	TSS 44 DEEP,						
TSS 47,	TSS 09,						
TSS 45,	TSS 18						



Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)		Quality Control Specification	
Analytical Methods	Method	QC	Regular	Actual	Expected		Evaluation
Laboratory Duplicates (DUP)							
Moisture Content	EA055	1	9	11.11	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	1	5	20.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Organotin Analysis	EP090	1	7	14.29	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Pesticides by GCMS	EP068	1	9	11.11	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Polychlorinated Biphenyls (PCB)	EP066	1	9	11.11	10.00	✓	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	1	5	20.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Carbon	EP003TC	1	5	20.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-AES	EG005T	2	10	20.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP003	1	5	20.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus By Discrete Analyser	EK067G	1	5	20.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	1	9	11.11	10.00	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	1	9	11.11	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	1	5	20.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Organotin Analysis	EP090	1	7	14.29	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Pesticides by GCMS	EP068	1	9	11.11	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Polychlorinated Biphenyls (PCB)	EP066	1	9	11.11	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	2	5	40.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Carbon	EP003TC	1	5	20.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-AES	EG005T	2	10	20.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP003	2	5	40.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus By Discrete Analyser	EK067G	2	5	40.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	1	9	11.11	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	1	9	11.11	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	1	5	20.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Organotin Analysis	EP090	1	7	14.29	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Pesticides by GCMS	EP068	1	9	11.11	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Polychlorinated Biphenyls (PCB)	EP066	1	9	11.11	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	1	5	20.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Carbon	EP003TC	1	5	20.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-AES	EG005T	2	10	20.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP003	1	5	20.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard



Matrix: **SOIL** Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	
Method Blanks (MB) - Continued							
Total Phosphorus By Discrete Analyser	EK067G	1	5	20.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	1	9	11.11	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	1	9	11.11	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	1	5	20.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Organotin Analysis	EP090	1	7	14.29	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Pesticides by GCMS	EP068	1	9	11.11	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Polychlorinated Biphenyls (PCB)	EP066	1	9	11.11	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	1	5	20.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-AES	EG005T	2	10	20.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus By Discrete Analyser	EK067G	1	5	20.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	1	9	11.11	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	1	9	11.11	5.00	✓	NEPM 2013 B3 & ALS QC Standard

Matrix: **WATER** Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	
Laboratory Duplicates (DUP)							
Suspended Solids (High Level)	EA025H	4	33	12.12	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Suspended Solids (High Level)	EA025H	6	33	18.18	15.00	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Suspended Solids (High Level)	EA025H	2	33	6.06	5.00	✓	NEPM 2013 B3 & ALS QC Standard



Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Moisture Content	EA055	SOIL	In house: A gravimetric procedure based on weight loss over a 12 hour drying period at 105-110 degrees C. This method is compliant with NEPM (2013) Schedule B(3) Section 6.1 and Table 1 (14 day holding time).
Particle Size Analysis by Hydrometer	EA150H	SOIL	Particle Size Analysis by Hydrometer according to AS1289.3.6.3 - 2003
Soil Particle Density	EA152	SOIL	Soil Particle Density by AS 1289.3.5.1-2006 : Methods of testing soils for engineering purposes - Soil classification tests - Determination of the soil particle density of a soil - Standard method
Gross Alpha and Beta activity in solids	EA250	SOIL	In house: Referenced to ISO 9697 / CSN 757611. Determination of Gross Alpha and Beta activity in soil and sediment by Thick Source method. An appropriate mass of sample is dried and pulverised prior to direct activity counting. (If required, Potassium may be determined separately and results corrected accordingly for 40K.) Analysis is performed by ALS (Czech Republic) who hold technical accreditation #1163 for Gross alpha and beta activity under CAI. CAI are a European accreditation body, equivalent to NATA in Australia and recognised internationally by NATA under ILAC.
Total Metals by ICP-AES	EG005T	SOIL	In house: Referenced to APHA 3120; USEPA SW 846 - 6010. Metals are determined following an appropriate acid digestion of the soil. The ICPAES technique ionises samples in a plasma, emitting a characteristic spectrum based on metals present. Intensities at selected wavelengths are compared against those of matrix matched standards. This method is compliant with NEPM (2013) Schedule B(3)
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	SOIL	In house: Thermo Scientific Method D08727 and NEMI (National Environmental Method Index) Method ID: 9171. This method covers the determination of total oxidised nitrogen (NOx-N) and nitrate (NO3-N) by calculation, Combined oxidised Nitrogen (NO2+NO3) in a water extract is determined by direct colourimetry by Discrete Analyser.
TKN as N By Discrete Analyser	EK061G	SOIL	In house: Referenced to APHA 4500-Norg-D Soil samples are digested using Kjeldahl digestion followed by determination by Discrete Analyser.
Total Nitrogen as N (TKN + NOx) By Discrete Analyser	EK062G	SOIL	In house: Referenced to APHA 4500 Norg/NO3- Total Nitrogen is determined as the sum of TKN and Oxidised Nitrogen, each determined separately as N.
Total Phosphorus By Discrete Analyser	EK067G	SOIL	In house: Referenced to APHA 4500 P-B&F This procedure involves sulfuric acid digestion and quantification using Discrete Analyser.
Total Organic Carbon	EP003	SOIL	In house C-IR17. Dried and pulverised sample is reacted with acid to remove inorganic Carbonates, then combusted in a furnace in the presence of strong oxidants / catalysts. The evolved (Organic) Carbon (as CO2) is automatically measured by infra-red detector.
Total Carbon	EP003TC	SOIL	In house C-IR07. Dried and pulverised sample is combusted in a LECO furnace in the presence of strong oxidants / catalysts. The evolved Carbon (as CO2) is measured by infra-red detector
Total Inorganic Carbon	EP003TIC	SOIL	In house C-CAL15. Determined as the difference between Total Carbon and Organic Carbon.
Polychlorinated Biphenyls (PCB)	EP066	SOIL	In house: Referenced to USEPA SW 846 - 8270D Extracts are analysed by Capillary GC/MS and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (2013) Schedule B(3) (Method 504)
Pesticides by GCMS	EP068	SOIL	In house: Referenced to USEPA SW 846 - 8270D Extracts are analysed by Capillary GC/MS and quantification is by comparison against an established 5 point calibration curve. This technique is compliant with NEPM (2013) Schedule B(3) (Method 504,505)



Analytical Methods	Method	Matrix	Method Descriptions
TRH - Semivolatile Fraction	EP071	SOIL	In house: Referenced to USEPA SW 846 - 8015A Sample extracts are analysed by Capillary GC/FID and quantified against alkane standards over the range C10 - C40. Compliant with NEPM amended 2013.
TRH Volatiles/BTEX	EP080	SOIL	In house: Referenced to USEPA SW 846 - 8260B. Extracts are analysed by Purge and Trap, Capillary GC/MS. Quantification is by comparison against an established 5 point calibration curve. Compliant with NEPM amended 2013.
Organotin Analysis	EP090	SOIL	In house: Referenced to USEPA SW 846 - 8270D Prepared sample extracts are analysed by GC/MS coupled with high volume injection, and quantified against an established calibration curve.
Suspended Solids (High Level)	EA025H	WATER	In house: Referenced to APHA 2540D. A gravimetric procedure employed to determine the amount of 'non-filterable' residue in a aqueous sample. The prescribed GFC (1.2um) filter is rinsed with deionised water, oven dried and weighed prior to analysis. A well-mixed sample is filtered through a glass fibre filter (1.2um). The residue on the filter paper is dried at 104+/-2C . This method is compliant with NEPM (2013) Schedule B(3)
Preparation Methods	Method	Matrix	Method Descriptions
TKN/TP Digestion	EK061/EK067	SOIL	In house: Referenced to APHA 4500 Norg- D; APHA 4500 P - H. Macro Kjeldahl digestion.
1:5 solid / water leach for soluble analytes	EN34	SOIL	10 g of soil is mixed with 50 mL of reagent grade water and tumbled end over end for 1 hour. Water soluble salts are leached from the soil by the continuous suspension. Samples are settled and the water filtered off for analysis.
Hot Block Digest for metals in soils sediments and sludges	EN69	SOIL	In house: Referenced to USEPA 200.2. Hot Block Acid Digestion 1.0g of sample is heated with Nitric and Hydrochloric acids, then cooled. Peroxide is added and samples heated and cooled again before being filtered and bulked to volume for analysis. Digest is appropriate for determination of selected metals in sludge, sediments, and soils. This method is compliant with NEPM (2013) Schedule B(3) (Method 202)
Sieving (fine to -2mm)	GEO26	SOIL	In house: The dried sample is sieved to 2mm and the fines are then analysed per the client's request.
Dry and Pulverise (up to 100g)	GEO30	SOIL	#
Methanolic Extraction of Soils for Purge and Trap	ORG16	SOIL	In house: Referenced to USEPA SW 846 - 5030A. 5g of solid is shaken with surrogate and 10mL methanol prior to analysis by Purge and Trap - GC/MS.
Tumbler Extraction of Solids	ORG17	SOIL	In house: Mechanical agitation (tumbler). 10g of sample, Na2SO4 and surrogate are extracted with 30mL 1:1 DCM/Acetone by end over end tumble. The solvent is decanted, dehydrated and concentrated (by KD) to the desired volume for analysis.
Organotin Sample Preparation	ORG35	SOIL	In house: 20g sample is spiked with surrogate and leached in a methanol:acetic acid:UHP water mix and vacuum filtered. Reagents and solvents are added to the sample and the mixture tumbled. The butyltin compounds are simultaneously derivatised and extracted. The extract is further extracted with petroleum ether. The resultant extracts are combined and concentrated for analysis.