

TNG LIMITED

DRAFT ENVIRONMENTAL IMPACT STATEMENT DARWIN PROCESSING FACILITY

MIDDLE ARM, DARWIN, NORTHERN
TERRITORY

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TNG LIMITED

DRAFT ENVIRONMENTAL IMPACT
STATEMENT

DARWIN PROCESSING FACILITY

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GLOSSARY 1 – PROJECT TERMINOLOGY

Term	Meaning
The Project, Darwin Processing Facility, Processing Facility	The proposed construction and operation of the Darwin TIVAN® Processing Facility.
The Project area, can also be referred to as the Site	Lot 1817, Hundred of Ayers, Middle Arm Industrial Precinct, Wickham, NT. The Project area is approximately 507 hectares (ha) of which 40 ha is mangrove forest and intertidal zone, and 467 ha is terrestrial land.
Concentrate	Magnetite concentrate from the Mount Peake mine site.
Development Envelope	That part of the Project area that will be impacted by any development activities. The envelope, in hectares, includes the proposed buildings, infrastructure, associated access roads and services. The Development Envelope is approximately 264 ha.
Direct Environmental Impact	Impact caused by direct interaction of the Project with the Environment, at the same time and in the same place as construction and/ or operation activities are occurring.
Environmental Aspect	Element of an organisation's activities, products or services that can interact with the environment.
Indirect Environmental Impact	Impact which is not a direct result of construction and/or operation activities. Generally occurs outside of the Development Envelope and may be realised through relatively complex pathways. Sometimes referred to as second or third level impacts, or secondary impacts.
Proponent	TNG Limited.
Northern peninsula	Northern part of Lot 1817, location of support infrastructure for the Processing Facility.
Southern peninsula	Southern part of Lot 1817, location of the major parts of the Processing Facility, along with some support infrastructure.

GLOSSARY 2 – ACRONYMS, ABBREVIATIONS AND DEFINITIONS

Abbreviation	Meaning
AAPA	Aboriginal Areas Protection Authority
AASS	Actual Acid Sulfate Soils
ABS	Australian Bureau of Statistics
AHD	Australian Height Datum
ANZG	Australian and New Zealand Guideline
ASS	Acid Sulfate Soils
BCF	Burrell Creek Formation
BHC	Benthic Habitat and Communities
BMP	Biodiversity Management Plan
BoM	Bureau of Meteorology
BU	Beneficial Use
CBD	Central Business District
CH ₄	Methane
Cl ₂	Chlorine gas
CO	Carbon monoxide
CO ₂	Carbon dioxide

Abbreviation	Meaning
CO ₂ eq	Carbon dioxide equivalent
CoPC	Contaminant of Particular Concern
CR	Critically Endangered
CSM	Conceptual Site Model
DD	Data Deficient
DENR	Department the Environment and Natural Resources
DLRM	Department of Land Resource Management
DO	Dissolved Oxygen
DoEE	Department of the Environment and Energy
DPIR	Department of Primary Industry and Resources
DVG	Default Value Guideline
EA Act	Environmental Assessment Act 1982
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement, comprises: • Draft EIS (subject to public exhibition), • Supplement (addressing written comments of the Draft EIS) • Further info requested by NT EPA
EMP	Environment Management Plan
EN	Endangered
Environmental Factors	Aspects of the environment as defined by the NT EPA
EP Act	Environment Protection Act 2019
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
EPBC Regulations	Environment Protection and Biodiversity Conservation Regulations 2000
EQC	Environmental Quality Criteria
EQG	Environmental Quality Guideline
EQI	Environmental Quality Indicators
EQO	Environmental Quality Objectives
EQS	Environmental Quality Standard
ESCP	Erosion and Sediment Control Plan
ESD	Ecologically sustainable development as defined in Australia's National Strategy for ESD (1992)
Fe	Iron
Fe ₂ O ₃	Iron (III) oxide / Ferric oxide
FMP	Fire Management Plan
GHG	Greenhouse gas
GSD	Gross Domestic Product
GSP	Gross State Product
HAT	Highest Astronomical Tide
HCl	Hydrochloric acid
HD	Highly Disturbed
HEV	High Ecological Value

Abbreviation	Meaning
IBC	Intermediate Bulk Container
IBRA	Interim Biogeographic Regionalisation for Australia
LAT	Lowest Astronomical Tide
LEP	Level of Ecological Protection
LGA	Local Government Area
LNG	Liquid Natural Gas
Ma	Marine
MAH	Monocyclic Aromatic Hydrocarbons
Mi	Migratory
MNES	Matters of National Environmental Significance, as listed under the EPBC Act
MSDS	Material Safety Data Sheet
NAG	Net Acid Generation
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NES	(matters of) National Environmental Significance,
NHMRC	National Health and Medical Research Council
NO ₂	Nitrogen dioxide
NOI	Notice of Intent
NPUG	Non-potable Groundwater Use Guidelines
NRETAS	NT Department of Natural Resources, Environment, The Arts and Sport
NT	Northern Territory
NT EPA	Northern Territory Environmental Protection Authority
NTG	Northern Territory Government
NTU	Nephelometric Turbidity Unit
NWQMS	National Water Quality Monitoring Strategy
N ₂ O	Nitrous oxide
MEQMMP	Marine Environmental Quality Monitoring and Management Plan
O ₃	Ozone
O2M	O2 Marine Consultants
PAH	Polynuclear Aromatic Hydrocarbons
PASS	Potential Acid Sulfate Soils
POL	Petrol, oil and lubricants
PV	Photovoltaic
ROV	Remotely operated vehicle
SEIA	Socio-Economic Impact Assessment
ESIMP	Economic and Social Impact Management Plan
SMD	Slightly to Moderately Disturbed
SO ₂	Sulfur dioxide
SO ₃	Sulfur trioxide
SoCS	Sites of Conservation Significance
TDS	Total Dissolved Solids

Abbreviation	Meaning
TiO ₂	Titanium dioxide
TOR	Terms of Reference; as prepared by the NT EPA for the proposed Project identifying the matters to be addressed in the EIS
TDS	Total dissolved solids
TIVAN®	TIVAN® leach circuit – TNG’s proprietary TIVAN® Process is a hydro-extraction process designed to produce very high-purity vanadium pentoxide, titanium dioxide and iron oxide
TNG	TNG Limited
TPH	Total Petroleum Hydrocarbons
TPWC Act	Territory Parks and Wildlife Conservation Act 2000 (NT)
TRH	Total Recoverable Hydrocarbons
TSF	Tailings Storage Facility
UTM	Universal Transverse Mercator
VA	Vegetation Association
V ₂ O ₅	Vanadium pentoxide
VU	Vulnerable
WQO	Water Quality Objective
WQPP	Darwin Harbour Water Quality Protection Plan

GLOSSARY 3 – LIST OF UNITS

Unit	Meaning
%	Percentage
‰	Per-mille
°	Degree
GL	Gigalitre
GL/yr	Gigalitres per year
ha	Hectare
kL/h	Kilolitre per hour
km	Kilometre
kPa	Kilopascals
kW	Kilowatt
L/s	Litres per second
m	Metre
mbgl	Metres below ground level
mg/L	Milligram per litre
mm	Millimetre
ML	Megalitre – million litres
m/d	Metre per day
m/m	Metre per metre
Mt	Million tonnes

Unit	Meaning
MWh	Megawatt hour
mv	millivolts
m/y	Metre per year
m ³ /hr	Metres cubed per hour
PJ/y	Petajoules per year
µg/L	Micrograms per litre
µS/cm	Microseconds per centimetre
t	Tonne (1 t = 1000kg)
tpa	Tonnes per annum
tpd	Tonnes per day
tph	Tonnes per hour
vpd	Vehicles per day

TNG LIMITED

DRAFT ENVIRONMENTAL IMPACT
STATEMENT

DARWIN PROCESSING FACILITY

INTRODUCTION AND GENERAL INFORMATION

1. INTRODUCTION AND GENERAL INFORMATION

This chapter introduces the proposed development: the Darwin TIVAN® Processing Facility, herein referred to as the **Project**.

The Draft Environmental Impact Statement (**EIS**) has been developed for the Project as a result of the Northern Territory Environmental Protection Authority (**NT EPA**) review of the Notice of Intent (**NOI**) submitted in 2015. The Terms of Reference (**TOR**) to assist the proponent to develop the EIS were issued on 20 May 2016.

The Project requires assessment under the *Northern Territory Environmental Assessment Act 1982 (EA Act)* and is a controlled action under the *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)* (Commonwealth). The Project is being assessed at the level of an EIS under the bilateral agreement between the Northern Territory and Australian Governments.

1.1 PROJECT OVERVIEW

The Proponent proposes to construct and operate the Darwin Processing Facility at Lot 1817, Hundred of Ayers, Middle Arm Industrial Precinct, (658 Channel Island Road) Wickham. The Project is approximately 16 kilometres (**km**) south east of Darwin, Northern Territory (**NT**). The purpose of the Project is processing magnetite concentrate (**concentrate**) to produce higher value products for export from East Arm Wharf to international customers. The scope of the Project, and therefore this Draft EIS, is limited to activities within the Processing Facility allotment, encompassing construction, operation, decommissioning and closure of the Processing Facility.

The Project will comprise:

- Clearing of a partially vegetated allotment formerly utilised for extractive industries;
- Construction and operation of a magnetite concentrate Processing Facility;
- Development of support infrastructure, including workshops and stores, office/administration buildings, laydown areas, water storage and treatment facilities, car parking, electrical sub-station and utilities infrastructure, access roads and outfall pipeline;
- Construction and operation of a rail siding, unloading and loadout facilities on the Adelaide-Darwin railway; and
- Loading of trains at the rail siding, with products to be railed to East Arm Wharf.

The Project, with associated access roads, supporting infrastructure and services comprises a Development Envelope of approximately 264 hectares (**ha**), of which 180 ha has been previously disturbed. The Project requires access to the following existing services:

- Road access from the existing Channel Island Road;
- Natural gas supplied from the Amadeus gas pipeline;
- Power to be supplied by natural gas fired power plant, to be built, owned and operated by a third party;
- Communications;
- Water from the Palmerston zone pipeline; and
- Access to the Adelaide-Darwin railway.

New infrastructure requirements on Lot 1817 Middle Arm include:

- Rail siding – 3.8 km long, adjoining the Adelaide-Darwin railway;
- Processing Facility;
- Concentrate and coke stockpiles and conveyor tunnels;
- Process water, raw water, cooling water and waste water ponds;
- Filter cake stockpile area / hardstand;
- Workshop and stores;
- Offices, administration area, including kitchen / mess-hall, emergency services;
- Electricity sub-station;
- Potable water, raw water and fire water tanks;
- Gatehouse;
- Oxygen plant;
- Acid regeneration plant;
- Tank farm and reagent storage;
- Laydown areas; and
- Car parking.

Third parties will provide services external to the Processing Facility's allotment boundary including:

- Concentrate transport by rail to the Processing Facility;
- Transport of consumables by rail to the Processing Facility;
- Transport of consumables by road to the Processing Facility;
- Transport of products by rail from the Processing Facility to East Arm Wharf;
- Port activities including the unloading, storage, handling and export of products; and
- Port importing activities for consumables such as coke.

Third party services will assume responsibility for environmental management measures associated with these activities.

Construction is scheduled to commence in late 2020 with first production in late 2022, subject to statutory approvals, finance and TNG Board Financial Investment Decision approval of the Mount Peake Project. The construction period is anticipated to be 24 months continuing over both wet and dry seasons.

The design life of the Processing Facility is 40 years. Processing of concentrate would occur at a rate of 700,000 tonnes per annum (**tpa**). The life of the Processing Facility mirrors the production of concentrate from the Mount Peake mine site, the primary source of concentrate for the Project. Additional concentrate may in future be sourced from the Mount Peake area (subject to the results of further exploration drilling and economic evaluation) or from third parties.

Ultimate decommissioning of the site would be evaluated throughout the operation of the Processing Facility and discussed with regulators as part of ongoing licence requirements.

The location of the Project in the national context appears as Figure 1-1. The Project location in relation to Darwin appears as Figure 1-2.

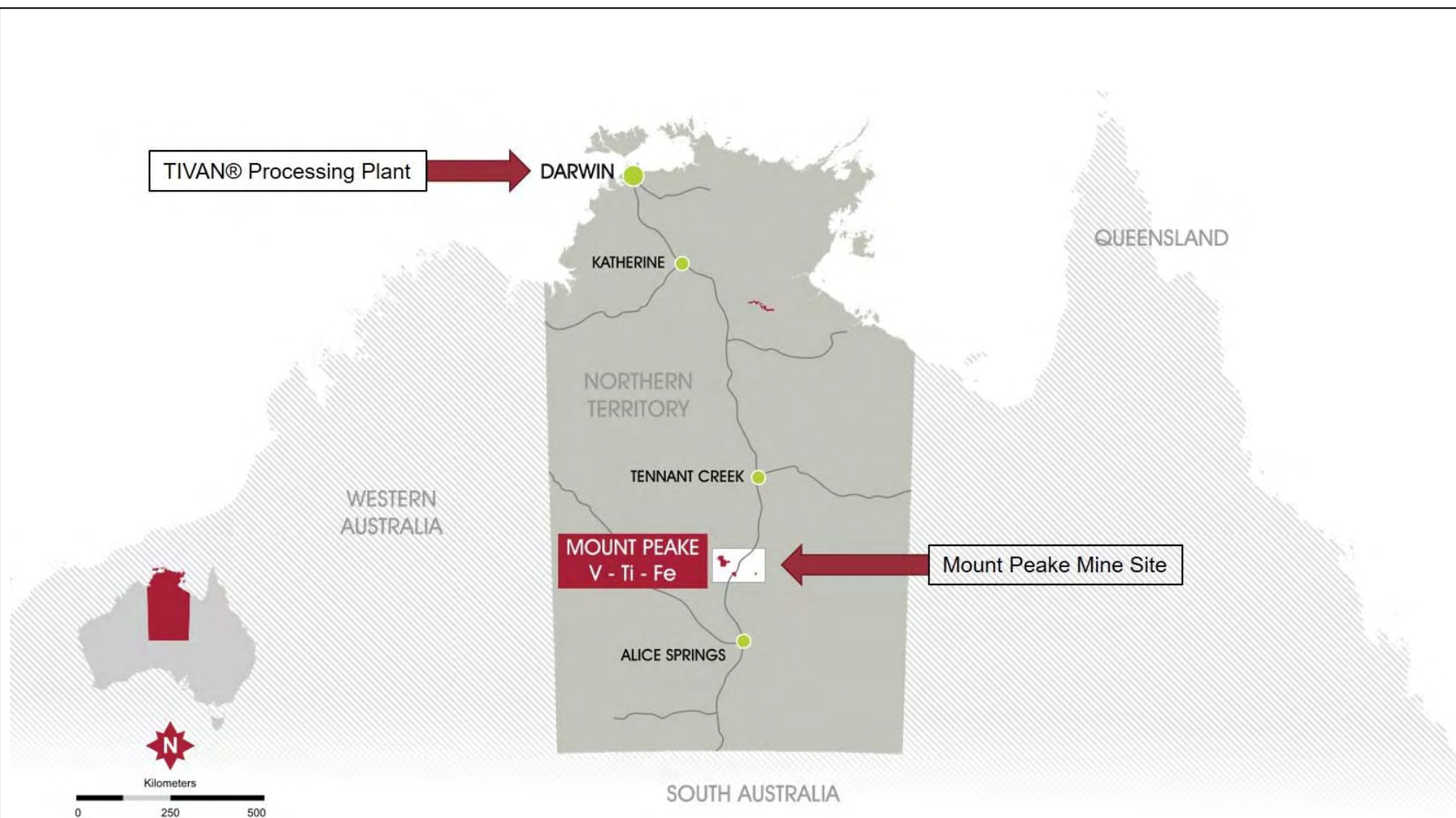


Figure 1-1: Location of the Darwin Processing Facility – National Context

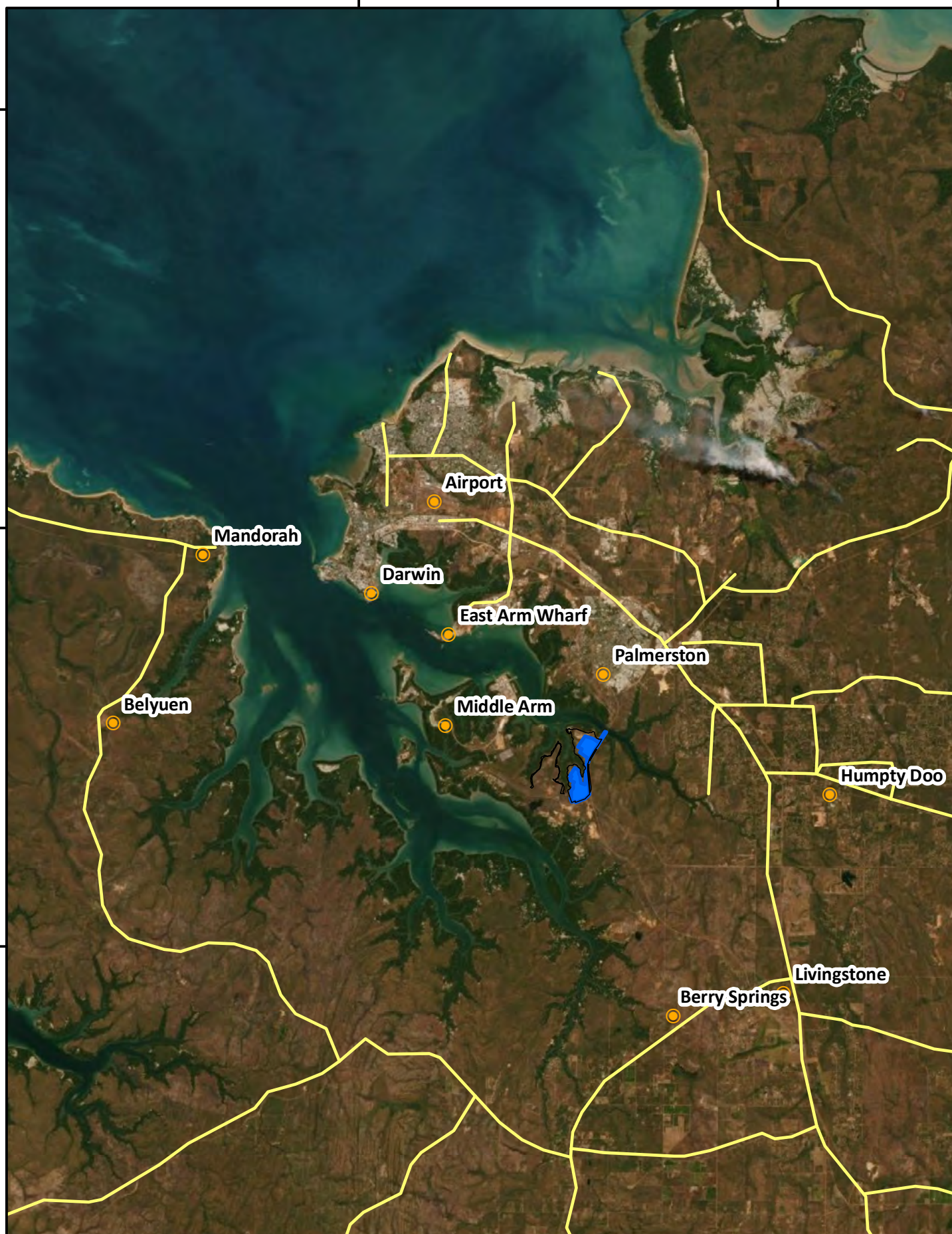


Figure 1-2: Location of Darwin Processing Facility - NT context

Legend

- Darwin locations
- Lot 1817, Hundred of Ayers
- Darwin Processing Facility Envelope



1:300,000 GDA 94 MGA Zone 52
Date: 22/11/2019

1.2 DRAFT EIS STRUCTURE

The Draft EIS has been developed with regard to the NT EPA *General Guidance for Proponents Preparing An Environmental Impact Statement* (NT EPA, 2019). This document provides general guidance on an appropriate structure and information requirements that should appear within the document.

The TOR also provides specific information required for inclusion in the Draft EIS; this appears as

Appendix A. The TOR has been annotated with a brief summary of the work completed is cross referenced to the chapter of the Draft EIS or relevant appendix where information is contained. Specialist studies to satisfy the TOR have been completed by qualified, experienced practitioners and all contributors to the preparation of the Draft EIS appear within Appendix B.

The Draft EIS is separated into chapters as per the *Guidance* as follows:

1. Introduction
2. The Proponent
3. Regional setting
4. Proposal description
5. Approvals and regulatory framework
6. Stakeholder engagement and consultation
7. Key Environmental Factors
8. Environmental offsets
9. Ecologically sustainable development
10. Concluding Statement
11. References
12. Appendices

This document has been prepared to provide decision makers, stakeholders and the public with information about the Project in support of key environmental approvals under the EA Act and the EPBC Act by:

- Describing the objectives of and justification for the Project;
- Discussing alternatives to the Project;
- Addressing environmental risks identified by the NT EPA and DoEE;
- Outlining legislation, standards and other regulations applicable to the Project;
- Addressing issues raised by community stakeholders;
- Identifying and assessing potential impacts to environmental factors associated with the Project; and
- Committing to environmental management, monitoring, performance criteria and reporting measures to mitigate potential adverse impacts of the Project.

To assess the environmental risks and potential environmental impacts of the Project identified by the NT EPA and DoEE, the Proponent initiated technical studies including; hydrology, hydrogeology, hydrodynamic modelling, air, noise, traffic, marine, flora, fauna, social and climate change. These studies have been completed by qualified specialists to provide an understanding of the Project's surrounding physical, biological, chemical and social landscape.

TNG LIMITED

DRAFT ENVIRONMENTAL IMPACT
STATEMENT

DARWIN PROCESSING FACILITY

THE PROPONENT

2. THE PROPONENT

2.1 GENERAL INFORMATION

TNG Limited (**TNG**) is referred to herein as the Proponent. Contact details for the Proponent and EIS consultant are as follows:

Key Contact: Paul Burton (Managing Director and Chief Executive Officer)

Address: PO Box 1126
Subiaco WA 6904

Phone: 08 9327 0900

Email: corporate@tngltd.com.au

Web: www.tngltd.com.au

ABN: 12 000 817 023

ACN: 000 817 023

Key EIS Contact: Sharon Arena (Principal Environmental Consultant – Animal Plant Mineral)

Phone: 0419 934 461

Email: sharon@animalplantmineral.com.au

2.2 COMPANY STRUCTURE

TNG's corporate structure appears as Figure 2-1 and the organisation chart appears as Figure 2-2.



Note: TNG owns all Mining, Exploration and ancillary licences 100%. TNG owns TIVAN® Process and Patents 100%

Figure 2-1: Corporate structure of TNG Limited

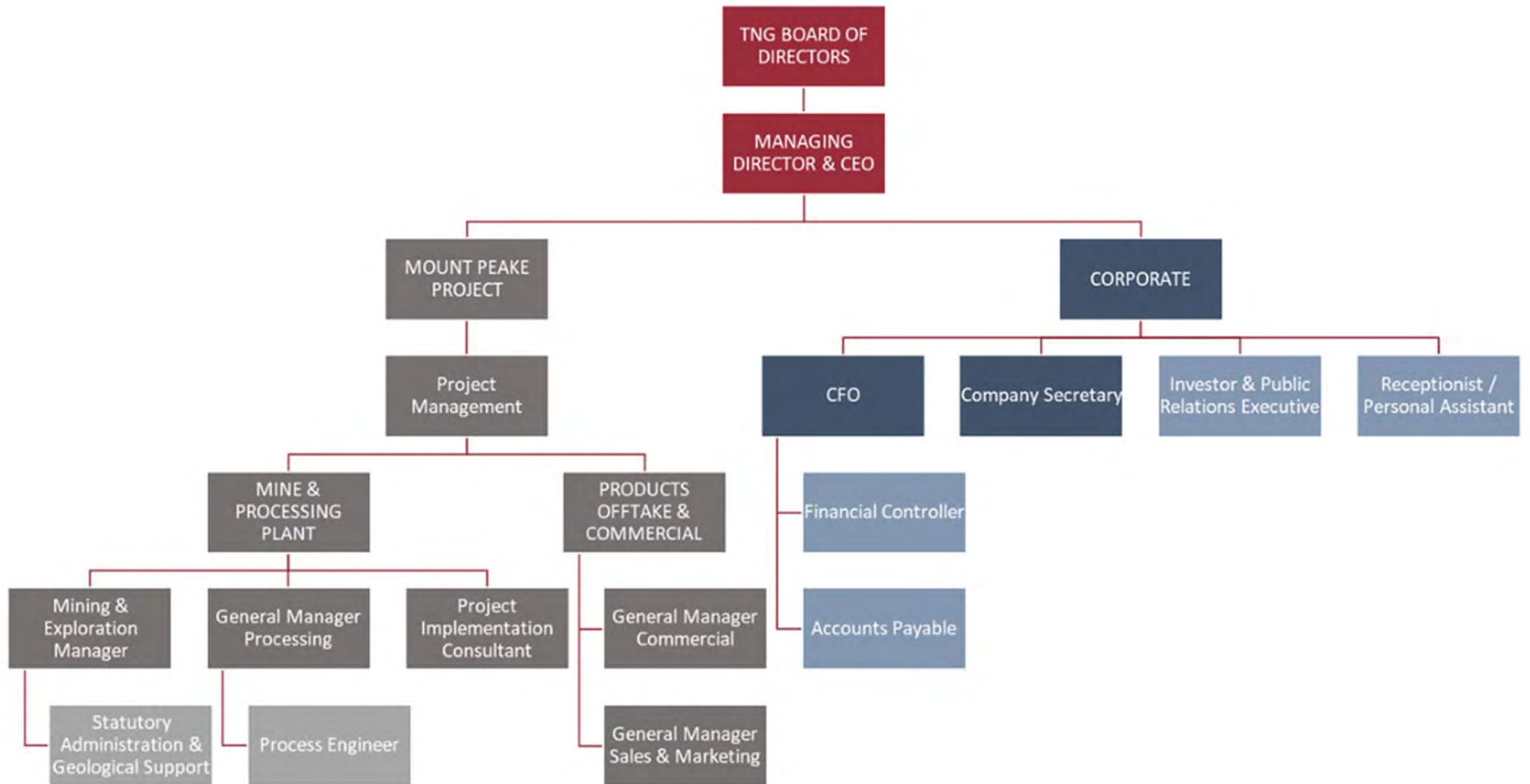


Figure 2-2: Organisation structure of TNG Limited

2.3 TNG'S ENVIRONMENTAL HISTORY AND PERFORMANCE

TNG is an Australian resources company founded in 1971. It engages in the exploration, evaluation, and development of mineral properties in the Northern Territory and Western Australia.

2.3.1 Other TNG Proposals Undergoing Environmental Assessment

TNG has focused on the evaluation and development of its 100%-owned Mount Peake Titanium-Vanadium-Iron deposit, located in the Arunta Geological Province approximately 235 km north-west of Alice Springs in the Northern Territory. Discovered by TNG in early 2008, the Mount Peake deposit comprises a current Joint Ore Reserves Committee (*Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves*) Indicated Resource of 160 million tonnes (**Mt**) grading 5.3% Titanium dioxide (**TiO₂**), 0.28% Vanadium pentoxide (**V₂O₅**) and 23% Iron (**Fe**), making it one of the largest of the known vanadium projects in Australia.

The Mount Peake mine site received Federal environmental approval on 11 May 2018 under the EPBC Act, which followed the NT EPA's assessment report in January 2018. A Mining Management Plan was submitted to the NT Department of Primary Industry and Resources (**DPIR**) for assessment in September 2019. The proposed Darwin TIVAN® Processing Facility, will take suitable ore directly from Mount Peake for processing.

2.3.2 Corporate Governance

TNG's Board of Directors and management team have extensive experience in the mining and exploration industries; both in Australia and internationally.

TNG's Corporate Governance Statement (26 September 2019) includes the following:

- The full Board is responsible for the oversight of the Company's risk management and control framework. Responsibility for control and risk management is delegated to the appropriate level of management within the Company, with the Managing Director & Chief Executive Officer having ultimate responsibility to the Board for the implementation of the risk management and control framework.
- The operations and proposed activities of the Company are subject to State and Federal laws and regulations concerning the environment. As with most resource projects, the Company's activities are expected to have an impact on the environment. It is the Company's intention to conduct its activities to the highest standard of environmental obligation, including compliance with all applicable environmental laws.
- The Company's social sustainability risk relates primarily to the communities in which it operates and the part it plays in corporate social responsibility, including the employment and welfare of local communities. Heritage matters and consultation with stakeholders will be given high priority to ensure that all aspects relating to its operations are adequately addressed.

The company has established a Code of Conduct that sets out standards which the Board, management and employees of the company are to comply with when dealing with each other, shareholders, customers and the broader community.

2.3.3 Environmental Policy

TNG is committed to ensuring that environmental responsibility is incorporated as part of their normal business practice and have developed their Environmental Policy on this basis.

In summary, the key tenet of TNG's Environmental policy is as follows:

'The Company (TNG) is committed to minimising the impact of all aspects of its operations on the environment to a statutory and socially acceptable level through the pro-active implementation, maintenance, monitoring and continuous improvement of our Environmental Management Systems'.

TNG's Environmental Policy in full is attached as Appendix C.

2.3.4 Environmental Management System

TNG is not certified by any international or national accreditations at this stage, but have the following documents as part of their (environmental) management system:

- Environmental Policy;
- Environmental Management Guidelines, Plans and Procedures – these documents provide TNG employees with a resource to proficiently manage environmental issues related to their business activities; and
- Accident/incident report form – this is designed to enable reporting on environmental accidents/incidents. External incident reports are to be directed to NT EPA or NT Worksafe.

TNG have no current or past proceedings under Commonwealth, State or Territory law for the protection of the environment or the conservation and sustainable use of natural resources.

All environmental commitments arising from the Draft EIS appear attached as Appendix E.

TNG LIMITED

DRAFT ENVIRONMENTAL IMPACT
STATEMENT

DARWIN PROCESSING FACILITY

**REGIONAL
SETTING**

3. REGIONAL SETTING

3.1 PROJECT SITE

The Project is located on Darwin Harbour, adjacent to the Elizabeth River. Contained within the Middle Arm Industrial Precinct, Lot 1817 has an area of approximately 507 ha, of which 40 ha is mangrove forest and intertidal zone, and 467 ha is terrestrial land. It is accessed from Channel Island Road, south of Elizabeth River Bridge.

Darwin Harbour is a major waterway and an important recreational fishery. Significant subtidal and intertidal habitats within Darwin Harbour include estuaries, mangroves, scleractinian (stony or hard corals) reefs, sponge and soft coral beds, macroalgae-dominated communities, rocky outcrops, and bare sandy/ silty substrates. There are no significant groundwater or surface water resources associated with the Project area.

Middle Arm Industrial Precinct also includes the Darwin Liquid Natural Gas (**LNG**) Plant and the INPEX Ichthys Onshore LNG Processing Facility. Existing residential areas nearest to the Project are the suburbs of Bellamack, approximately 2.7 km north-northeast, and Virginia, approximately 4.8 km east. The potential future suburban development of Weddell is proposed approximately 2.4 km to the southwest of the Project.

Locations of sacred, cultural, historical, recreational or social interest within the local vicinity of the Project are summarised in Table 3-1. A depiction of the locations of interest appears as Figure 3-1.

Table 3-1: Proximity of the Project to locations of interest

Location of Interest	Direction from the Project	Distance from the Project (km)	Aspect/s of Interest
Palmerston/ Elizabeth River boat ramp	Northeast	0.9	Boat access to Elizabeth River and Darwin Harbour at all tides Fishing jetty
Charles Darwin National Park	Northwest	10.5	National Reserve System
Elizabeth River – unidentified wreck (Identification no. 3435)	Northwest	0.2	Ship wreck
Royal Australian Air Force Catalina A24-1	Northwest	3.8	Wrecked aircraft (1945)
Darwin Harbour Wetlands	N/A	Adjacent	Register of the National Estate
Channel Island Leprosarium and Reefs/ Channel Island Conservation Reserve	West	9.3	NT Heritage Register National Reserve System
Middle Arm Petroglyphs	West-Southwest	3	Locally and regionally significant Aboriginal art
Yirra (Catalina Island)	Northwest	7.5	Registered Sacred Site (5073-0066)

The Aboriginal Areas Protection Authority (**AAPA**) Authority Certificate (No 201900386; covering letter 31 July 2019) obtained for the Project indicates there are no Registered or Recorded Sacred Sites within the site.

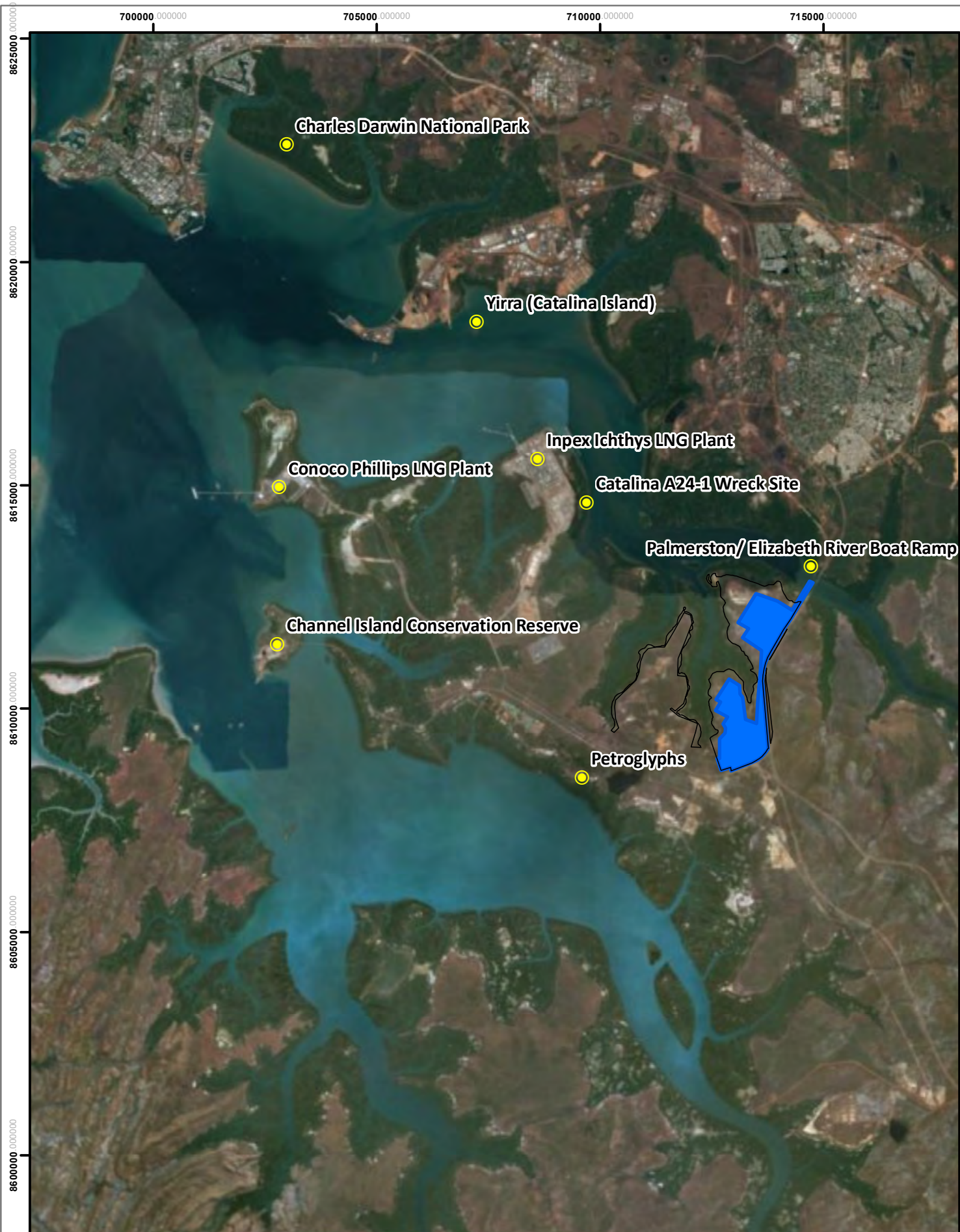
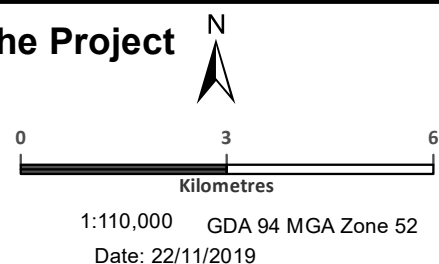


Figure 3-1: Locations of interest in the vicinity of the Project

Legend

-  *Areas of Interest*
-  *Lot 1817, Hundred of Ayers*
-  *Darwin Processing Facility Envelope*



3.2 PROJECT AREA TENURE AND ZONING

The Project site is vacant Crown Land situated within the Darwin Building Control Area. The Register of Native Title Claims, Register of Indigenous Land Use Agreements, Native Title Register and unregistered applications indicate that the site was assessed under Native Title application DC96/4 Darwin Larrakia and a determination made that 'Native Title does not exist'.

Lot 1817 is separated into two main areas, a northern peninsula and a southern peninsula. Most of the Lot is land based, adjacent and to the west of Channel Island Road. A smaller area to the west follows the coastal perimeter of Lot 1902. A utilities easement bisects the Project site at a north east orientation.

According to the Northern Territory Planning Scheme (Department of Infrastructure, Planning and Logistics 2018), four town planning zones apply to the Project:

- Future Development: most of the Project site;
- Conservation: mangrove forest and intertidal areas;
- Utilities: utilities easement; and
- Main Road: the eastern segment between the Lot 1817 railway corridor and the Channel Island Road Main Road corridor.

Lot 1817 and the planning scheme layers associated with the Project site appear on Figure 3-2.

3.2.1 Land uses

Land uses in the vicinity of the Project include quarrying for gravels, electricity substations and transmission, estuary and coastal waters, gas treatment, storage and transmission, railways, roads and residual native cover. The land use at Lot 1817 and the surrounding area is depicted on Figure 3-3. The quarrying activity has been extensive over the proposed Project Site, and existing disturbance at the Site is shown in more detail on Figure 3-4.

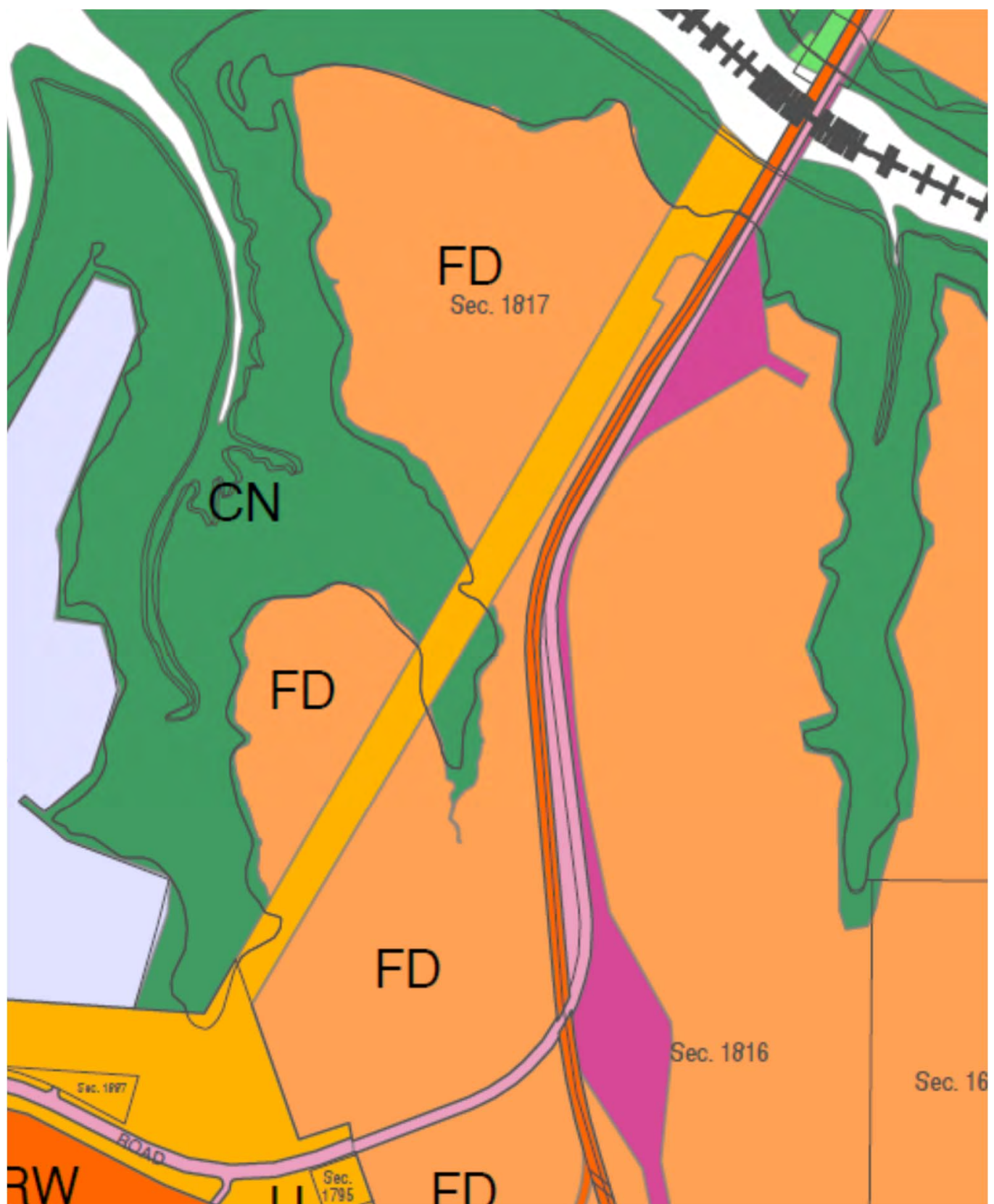


Figure 3-2: Lot 1817 and Northern Territory Planning Scheme Layers



TNG LIMITED

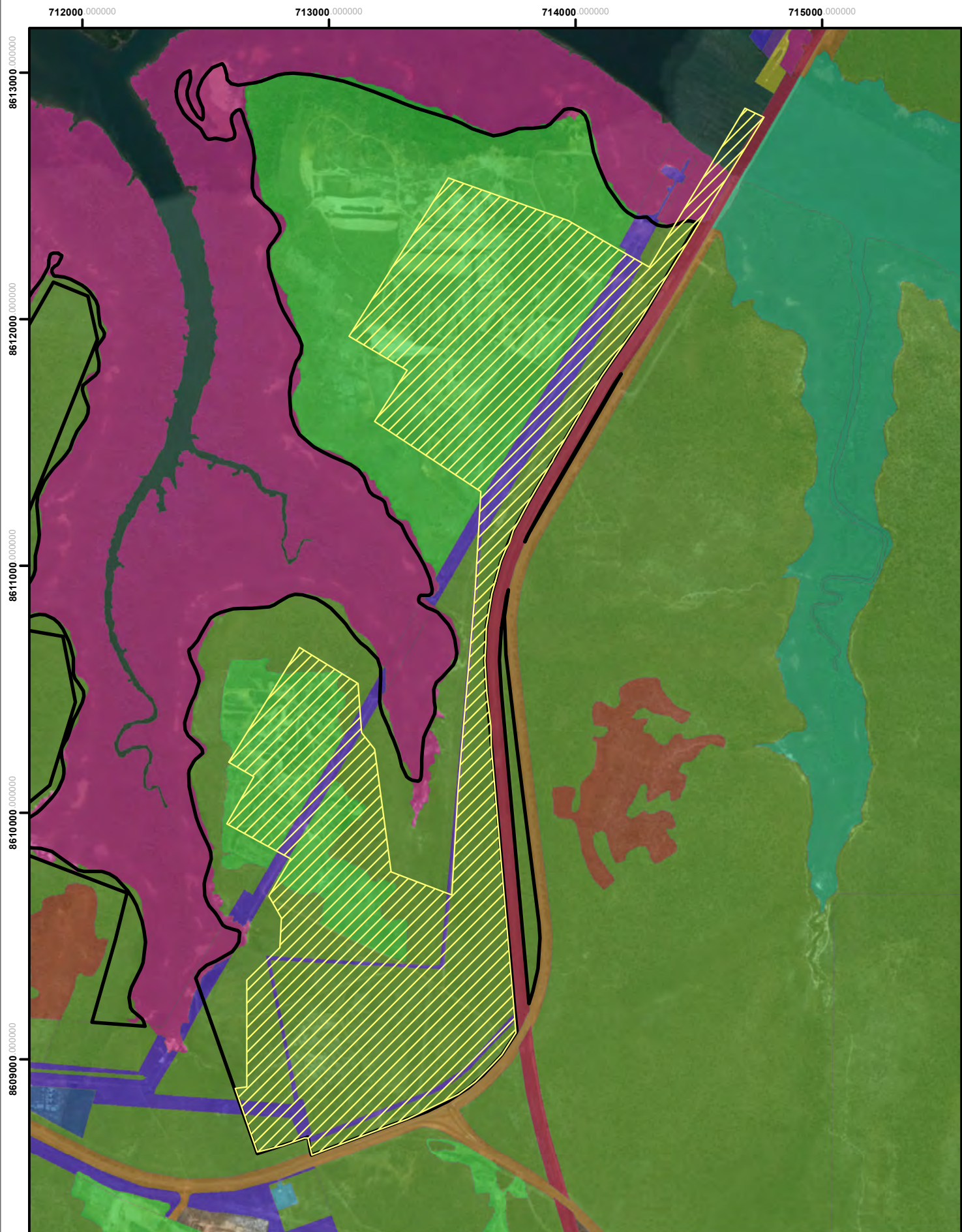


Figure 3-3: Lot 1817 and land use in the vicinity of the Project

Legend

Darwin Processing Facility Envelope

Lot 1817, Hundred of Ayers

Land Use Description

Electricity substations and transmission

Estuary/coastal waters

Estuary/coastal waters - conservation

Extractive Industry not in use

Fuel powered electricity generation

Gas treatment, storage and transmission

Marsh/wetland - conservation

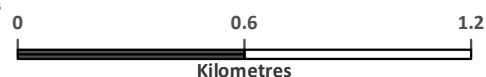
Public services

Quarries

Railways

Residual native cover

Roads



1:20,000

GDA 94 MGA Zone 52

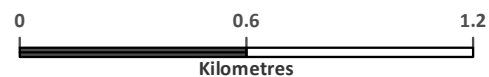
Date: 22/11/2019



Figure 3-4: Previously disturbed vegetation of the Project area

Legend

- Previously disturbed/cleared areas
- Darwin Processing Facility Envelope
- Lot 1817, Hundred of Ayers



1:20,000 GDA 94 MGA Zone 52
Date: 22/11/2019

3.3 REASONABLY FORESEEABLE FUTURE ACTIVITIES

The *Darwin Regional Land Use Plan 2015* (Department of Lands, Planning and the Environment, 2015) identifies land on Middle Arm as an area with potential for strategic industrial development, including additional deep water port development.

The Middle Arm Industrial Precinct is designed to accommodate large strategic industrial lots for downstream gas processing and gas related industry; with access to an extensive corridor network to carry utilities, gas, feedstock and products. Future developments (by others) within the Precinct, including the NT Land Development Corporation (LDC) Kittyhawk Estate, are expected to incorporate commercial and support industry zones.

Coogee Chemicals Pty Ltd are proposing to develop a methanol plant in the Middle Arm Industrial Precinct. While little information is publicly available, Coogee are examining the feasibility of a 350,000 tpa methanol plant. A final investment decision is expected in early 2021 with potential for start-up in 2024. The approval, construction and operation of the methanol plant will create a draw on potential workforce personnel, water and gas resources. Traffic movements are likely to significantly increase during construction and operations of the methanol plant should it proceed.

3.4 BIOPHYSICAL SETTING

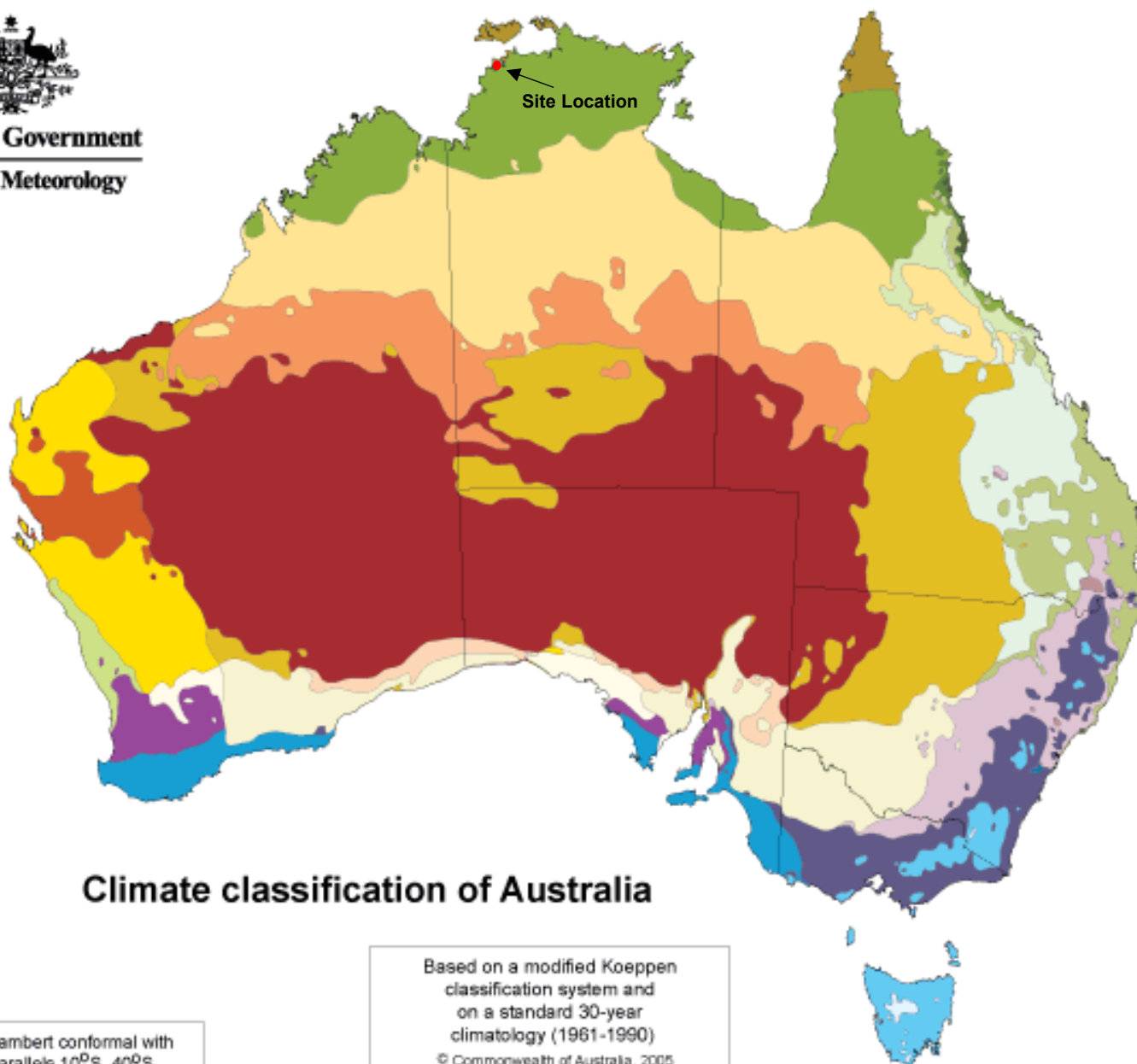
3.4.1 Climate

The climate for the site is described by the Köppen classification system as Tropical Savanna (Figure 3-5). This is typified by monthly mean temperatures above 18 degrees Celsius for every month of the year and the driest month having less than 60 mm of rain.

Of the four types of tropical savanna climates, the site is typified by a pronounced wet and dry season of relatively equal duration, with summer dominant rainfall.



Australian Government
Bureau of Meteorology



Climate classes

Equatorial

- rainforest (monsoonal)
- savanna

Tropical

- rainforest (persistently wet)
- rainforest (monsoonal)
- savanna

Subtropical

- no dry season
- distinctly dry summer
- distinctly dry winter
- moderately dry winter

Desert

- hot (persistently dry)
- hot (summer drought)
- hot (winter drought)
- warm (persistently dry)

Grassland

- hot (persistently dry)
- hot (summer drought)
- hot (winter drought)
- warm (persistently dry)
- warm (summer drought)

Temperate

- no dry season (hot summer)
- moderately dry winter (hot summer)
- distinctly dry (and hot) summer
- no dry season (warm summer)
- moderately dry winter (warm summer)
- distinctly dry (and warm) summer
- no dry season (mild summer)
- distinctly dry (and mild) summer
- no dry season (cool summer)



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Figure 3-5: Köppen Climate Classification (Source: Bureau of Meteorology)

3.4.1.1 Temperature

Darwin Airport (Site No. 014015) has a recorded mean maximum temperature of 32.1 degrees Celsius and a mean minimum temperature of 23.2 degrees Celsius. Mean monthly maximum temperatures only vary by approximately three degrees Celsius between the summer and winter extremes, however mean monthly minimum temperature extremes vary by up to six degrees Celsius. Figure 3-6 presents the monthly maximum and minimum mean temperatures.

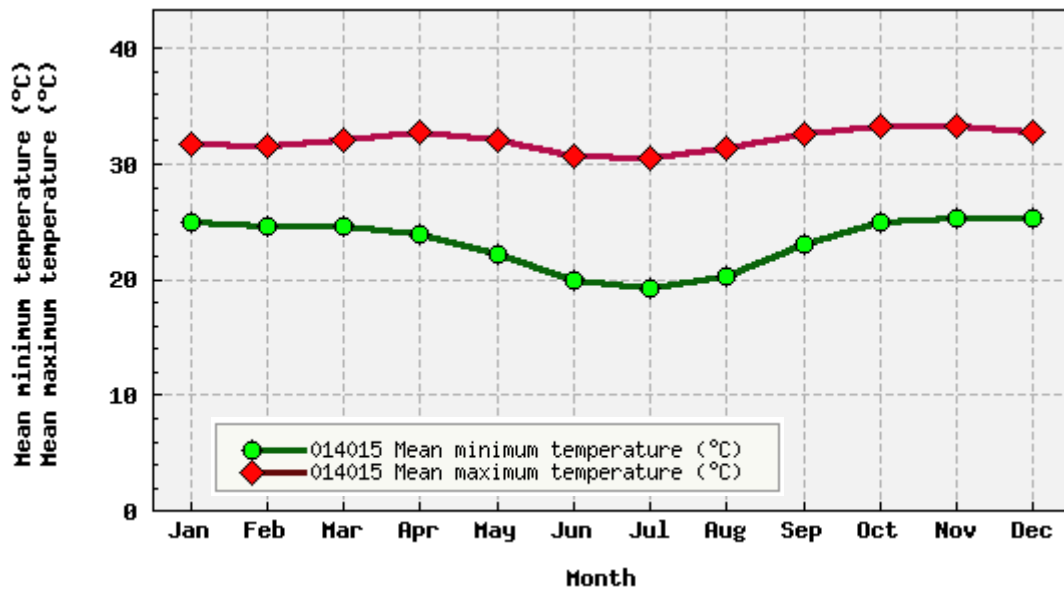


Figure 3-6: Mean monthly maximum and minimum temperatures – Darwin airport (Source: BoM)

3.4.1.2 Rainfall

Darwin Airport (Site No. 014015) has a recorded mean annual rainfall of 1725 mm. Approximately 93% of this annual total falls in the months between November and April. The distinct wet and dry seasons are typically of equal duration (6 months each).

Mean monthly rainfall and 30 year mean rainfall statistics for the period between 1981 – 2010 are presented in Figure 3-7.

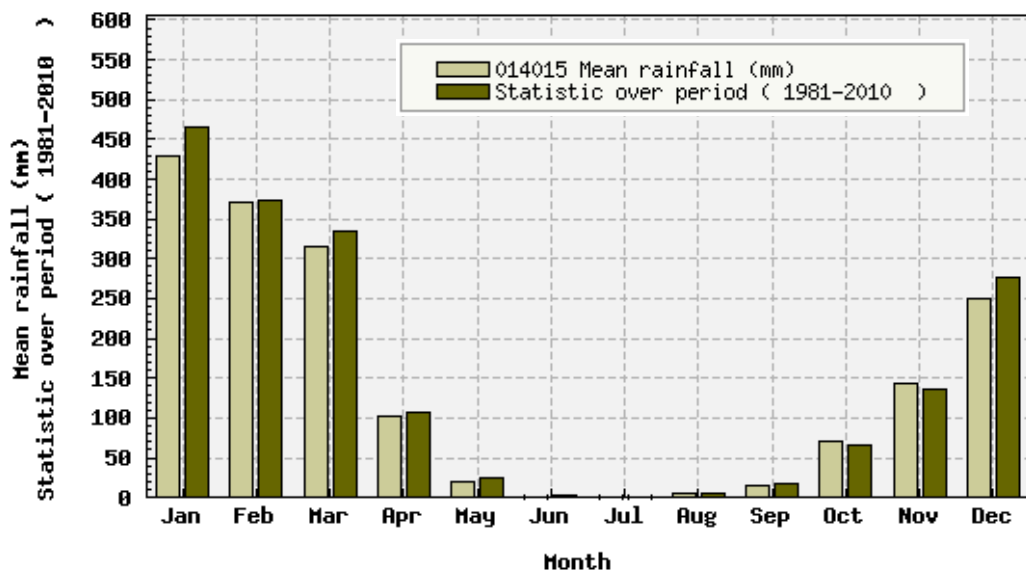


Figure 3-7: Mean monthly rainfall and 30 year mean (1981-2010) – Darwin airport (Source: BoM)

3.4.1.3 Humidity

Darwin Airport (Site No. 014015) has a recorded mean 9 am relative humidity of 71% and a mean 3 pm relative humidity of 54%. During the wet season months of January to March, the humidity levels are higher with a mean 9 am and 3 pm relative humidity of approximately 82% and 70% respectively. The mean 9 am and 3 pm relative humidity monthly statistics are presented in Figure 3-8.

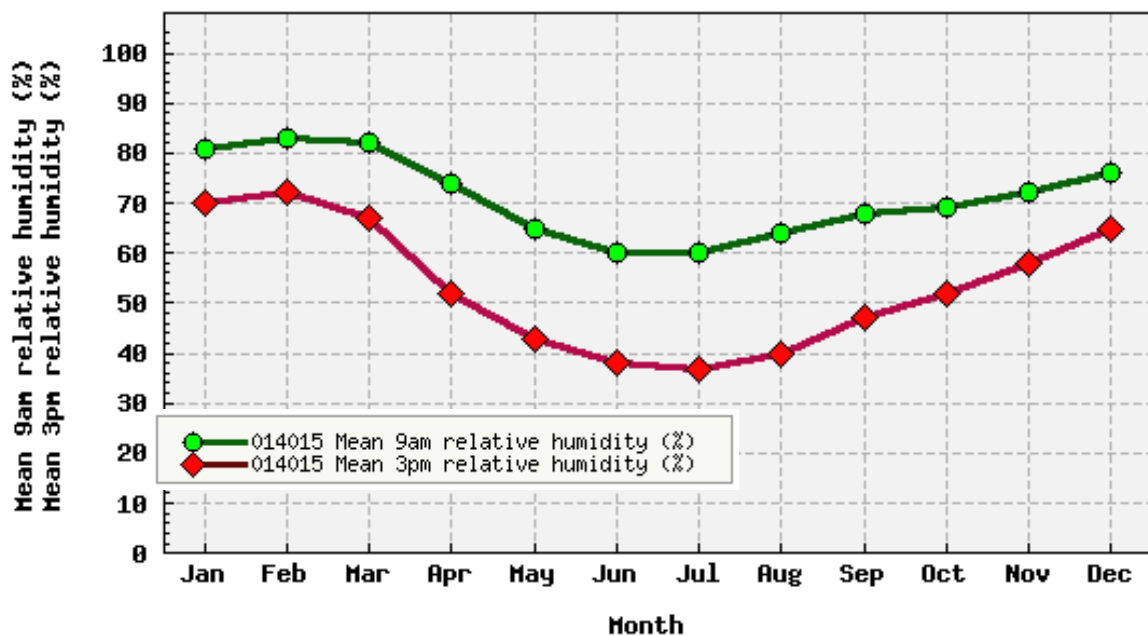


Figure 3-8: Mean monthly 9am and 3pm relative humidity (%) – Darwin airport (Source: BoM)

3.4.1.4 Evaporation

The BoM gridded mean annual pan evaporation dataset indicates the mean annual pan evaporation for the site is 2345 mm. Mean daily evaporation rates are presented in Figure 3-9.

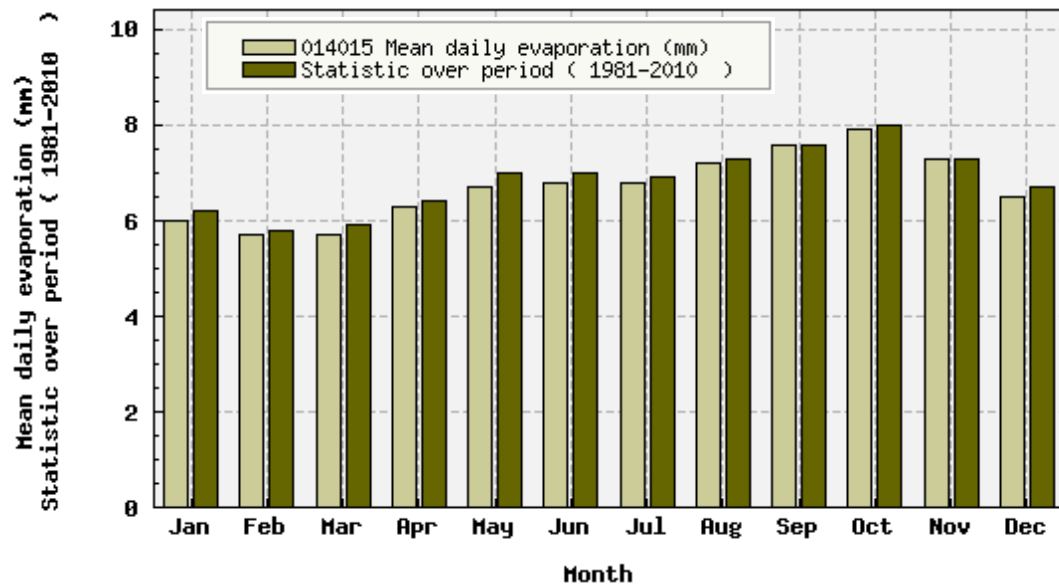


Figure 3-9: Mean daily evaporation and 30 year mean (1981-2010) – Darwin airport (Source: BoM)

3.4.1.5 Wind

Wind roses derived from three-dimensional meteorological modelling for the site indicates that the dominant wind direction is from northwest – westerly during the summer months, whilst in autumn and winter the winds are primarily from a southeast direction.

Wind roses are presented in

Figure 3-10 below.

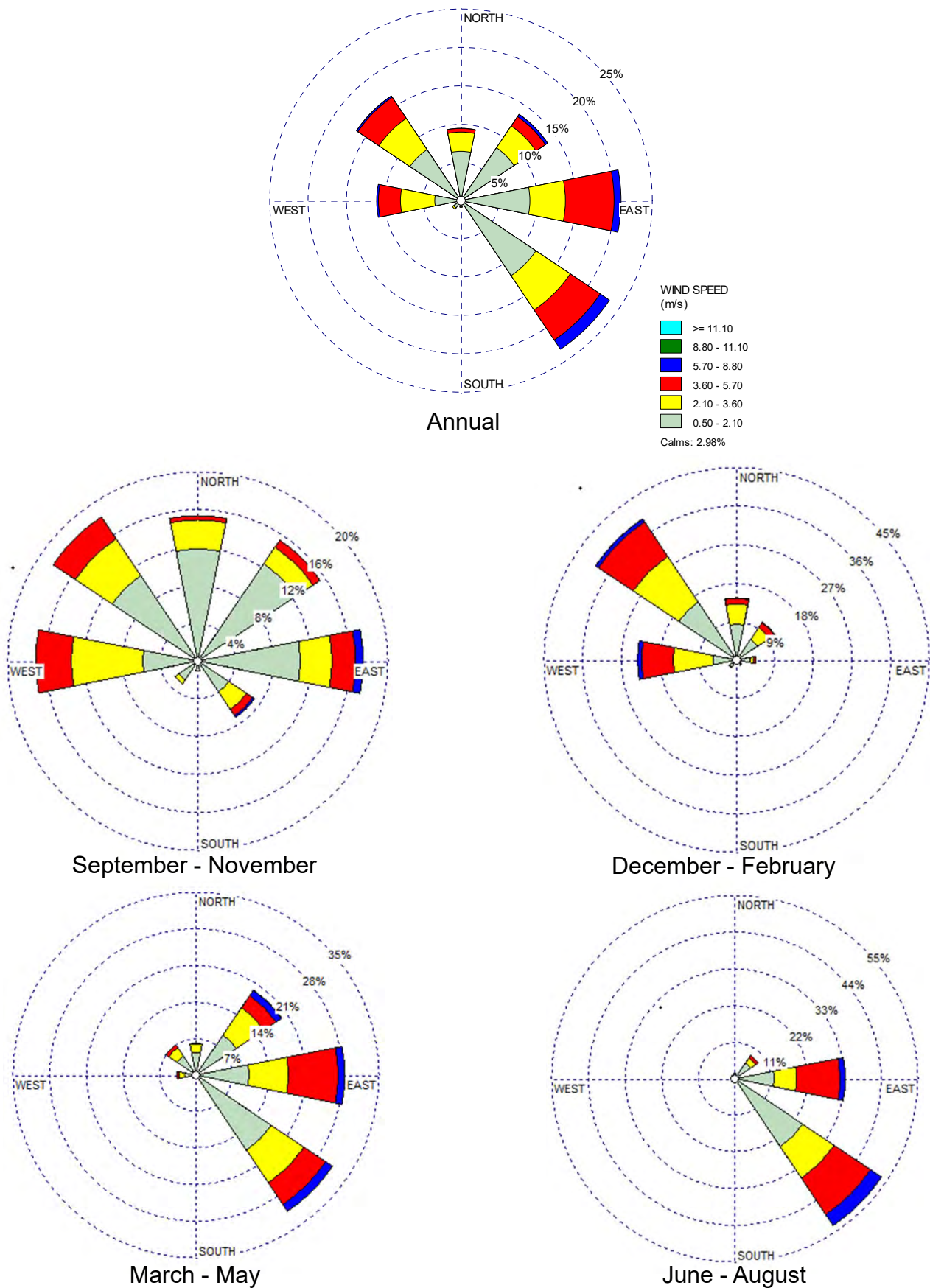


Figure 3-10: Wind Roses for the Project Area Based on TAPM-CALMET Modelling for the Year 2017

3.4.1.6 Tropical Cyclones

The tropical cyclone season for the northern region is defined as being from November to April, with cyclones forming from lows within the monsoon trough.

The BoM indicates that there are on average 7.7 days per season when a cyclone exists in the Northern Region. Typically, the Arafura and Timor Seas average one cyclone per year.

3.4.2 Bioregion

The Project site is within the Darwin Coastal Bioregion, as classified by the Interim Biogeographic Regionalisation for Australia (**IBRA**) Version 7 (Thackway & Creswell 1995 – updated by DoEE).

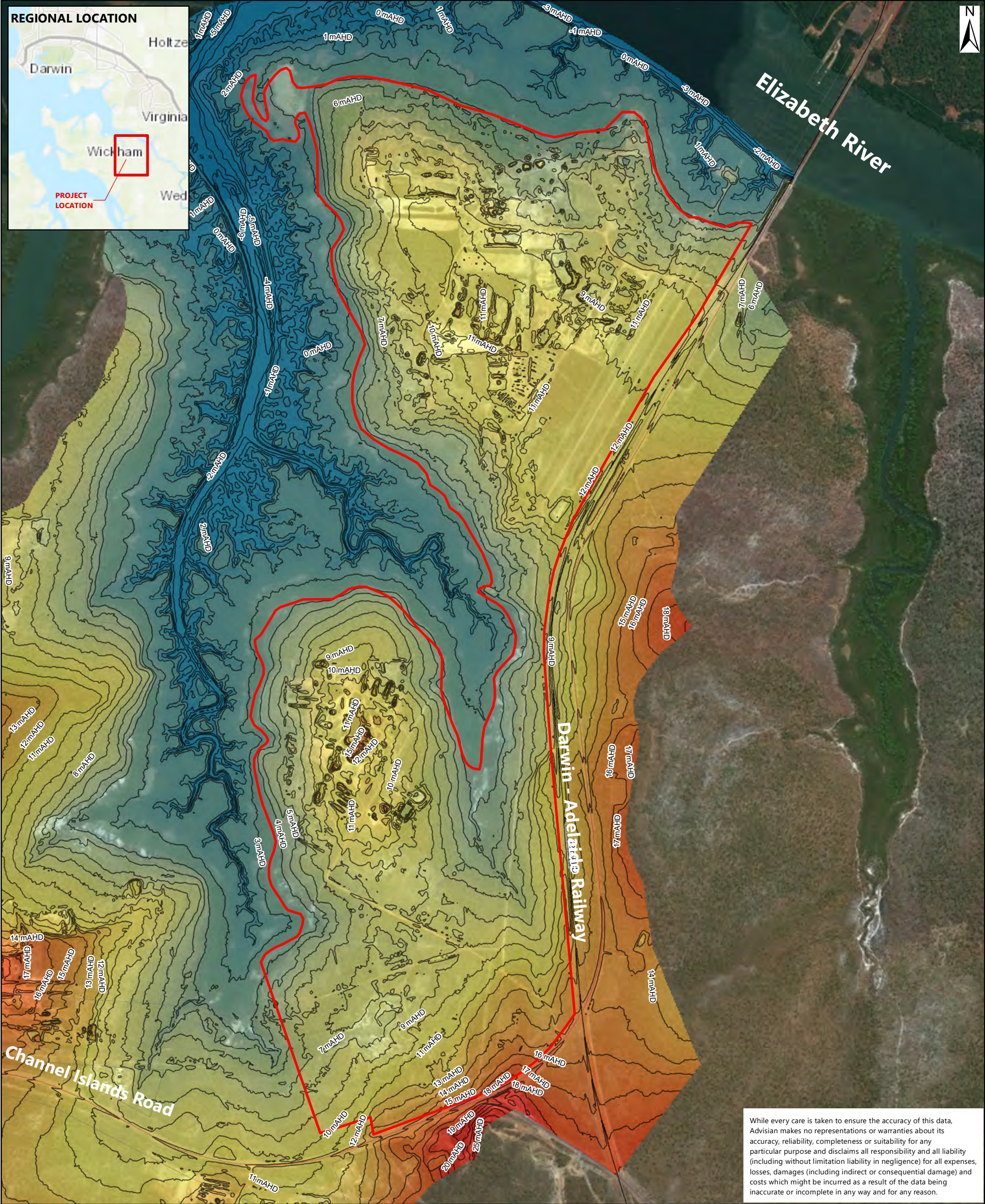
Land within the Darwin Coastal Bioregion is predominantly flat with minimal elevation above sea level. It is intersected by several major rivers. Vegetation is comprised of eucalypt forest and woodlands with tussock and hummock grass understorey.

Land use is mixed within the bioregion, with urban development concentrated around Darwin; Aboriginal land, pastoral leases and conservation reserves occupy other areas of the bioregion. The major population centres are Palmerston and Darwin (Department of the Environment 2008).

3.4.3 Topography

The site is comprised of two raised peninsulas, with the western and northern cadastral boundaries of the site located at an elevation of approximately 3 to 4 m Australian Height Datum (**mAHD**). The southern and eastern boundaries (parallel to Channel Island Road) represent the higher regions of the site and elevations along this perimeter vary from approximately 6 mAHD (western perimeter between peninsulas) to 18 mAHD (southern perimeter).

The proposed main project hub, within the southern peninsula, has an average elevation of approximately 8 mAHD. The site topography is presented in Figure 3-11.



TNG Darwin Processing Facility

Figure 3-11: Site Topography

3.4.4 Land Units

The *Land Systems of the Darwin Region* report (Wood et al. 1985) is a broadscale land resource inventory of the Darwin Region, and an evaluation of the capability of the land to support a number of land uses. It serves as a basis for regional planning decisions and aims to promote sustainable land use. Wood et al. (1985) classified the survey area into Land Systems, defined as areas of land which have distinctive and recurring pattern of landforms, soils and vegetation. A Land System is comprised of a sequence of Land Units, the latter being relatively homogeneous. Two Land Systems occur at the Site:

- **Keefers Hut:** Lateritic plains and rises associated with deeply weathered profiles (laterite), including sand sheets and other depositional products, sandy and earth soils. The dominant landform is dissected, gently undulating to undulating rises on deeply weathered rocks. Soils are generally described as Orthic and Leptic Tenosols and Leptic Rudosols, which appear as shallow, gravelly yellow earths. Acid Sulfate Soils (**ASS**) do not generally occur. A broad description of vegetation is mid-high open woodland of *Eucalyptus tetradonta*, *E. miniata*, *Corymbia foelscheana*, *E. tectifica*, and *C. ferruginea* over *Heteropogon* spp, *Chrysopogon fallax* and *Sehima nervosum*.
- **Littoral 1:** tidal mudflats and coastal floodplains with channels and estuaries. Poorly drained clays and muds are subject to tidal inundation. The dominant landforms are level tidal flats with channels and estuaries, and minor dunes. Soils are comprised of supratidal and intertidal Hydrosols (saline muds and grey cracking clays). ASS commonly occur on tidal flats, coastal floodplains and some coastal sandplains. Vegetation generally consists of samphire, sedgeland, or mangrove low closed forest.

Land Systems are divided into Land Units (Department of Environment and Natural Resources 2000). The Land Units present at the Site (pre-disturbance) are listed in Table 3-2 and appear as Figure 3-12.

Table 3-2: Land units of the site (Department of Environment and Natural Resources, 2000)

Unit	Landform	Soils	Vegetation
1c	Rises and short steep slopes	Leptic Rudosols	Woodland of <i>Eucalyptus miniata</i> and <i>Corymbia bleeseri</i> over <i>Sorghum</i> spp.
2a1	Rises	Leptic Rudosols	Open Woodland of <i>E. miniata</i> , <i>E. tetradonta</i> , or <i>C. foelscheana</i> , <i>C. confertifolia</i> and <i>E. tectifica</i> over mixed grasses
2b2	Sideslopes	Brown Kandosols	Low Open to Open Woodland of mixed species over sparse grasses
4d	Plains	Leptic Rudosols	Grassland of mixed species with emergent trees and shrubs
9b	Marine	Intertidal Hydrosols	Low Closed Forest of Mangrove spp.; intertidal inundation
9a	Marine	Supratidal Hydrosols	-

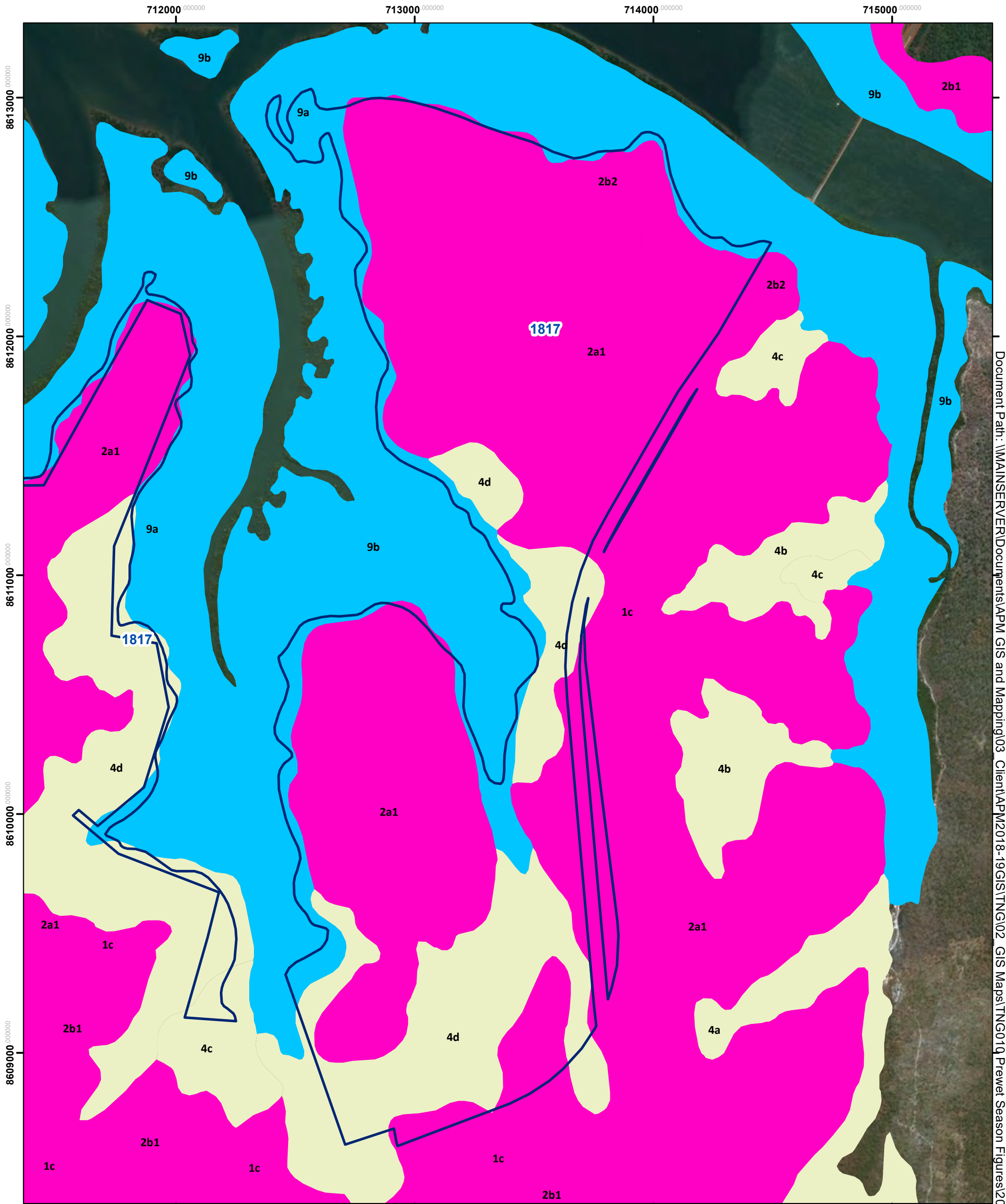


Figure 3-12: Land Units of the Study Area

Legend

Land Units of the Greater Darwin Area

- Drainage Systems
- Marine

- Plains
- Rises

Lot 1817 Hundred of Ayres



0 0.2 0.4 0.8
km

1 centimeter = 150 meters

Date: 11/10/2019

Coordinate System: GDA 1994 MGA Zone 52

Author: ems@animalplantmineral.com.au

3.4.5 Sensitive environments

3.4.5.1 Sites of Conservation Significance

Sites of Conservation Significance (**SoCS**) are identified as important sites for biodiversity that need protecting. In the NT there have been 67 sites identified as SoCS. The Darwin Harbour is a SoCS and as such the entire Project falls within the Darwin Harbour SoCS.

3.4.5.2 Nationally Important Wetlands

The Port of Darwin is a Nationally Important Wetland and is listed on the Directory of Important Wetlands in Australia. The fringing mangroves and waterways adjacent to Lot 1817 Hundred of Ayres are within the boundaries of the Port of Darwin Nationally Important Wetland (Figure 3-13).

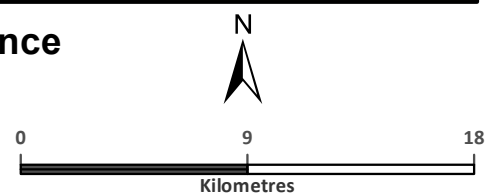
Further detail on environmental values of the Project area are incorporated into Chapter 7 – Environmental Factors.



Figure 3-13: Sites of Conservation Significance surrounding the Project area

Legend

-  Site of Conservation Significance
-  Lot 1817, Hundred of Ayers
-  Darwin Processing Facility Envelope



1:300,000 GDA 94 MGA Zone 52
Date: 22/11/2019

TNG LIMITED

DRAFT ENVIRONMENTAL IMPACT
STATEMENT

DARWIN PROCESSING FACILITY

**PROPOSAL
DESCRIPTION**

4. PROPOSAL DESCRIPTION

4.1 PROPOSAL HISTORY

The Darwin Processing Facility is intended to process concentrate produced at the Mount Peake mine site, a mine approximately 1,400 km south of Darwin and 235 km north-west of Alice Springs in the NT.

The mine site, also 100% owned by the Proponent, received EIS approval in 2018. To obtain Mining Authority, a Mining Management Plan, incorporating recommendations by the NT EPA, as outlined in their assessment report, was submitted in September 2019.

Once the Mount Peake mine site is operational, the Proponent proposes to rail concentrate to the Darwin Processing Facility via the Adelaide-Darwin railway. Refinement of the concentrate will produce TiO_2 , V_2O_5 and ferric oxide (Fe_2O_3) for export through the Port of Darwin's East Arm Wharf to international customers.

An NOI providing formal notification of the Project was submitted to the NT EPA on 27 October 2015 for consideration under the EA Act. The NT EPA recommended that assessment of the Project under the EA Act be set at the level of an EIS.

The Project was also referred by the Proponent on 11 November 2015 to the Australian Department of the Environment and Energy (DoEE) for consideration under the EPBC Act. On 4 January 2016 a delegate of the Commonwealth Minister for the Environment determined that the proposed Project was a *controlled action* and, as such, required assessment and an approval decision under the EPBC Act.

The Project is being assessed under the bilateral agreement between the Australian and NT Governments. Further detail on approval requirements is provided in Chapter 5.

4.2 CONTEXT

The objective of the Project is to construct and operate a facility to process magnetite concentrate railed from TNG's Mount Peake mine site to produce the following products:

- Titanium dioxide pigment;
- Vanadium pentoxide; and
- Ferric oxide.

4.2.1 Products

4.2.1.1 Titanium dioxide pigment

Titanium is a lustrous transition metal with a silver colour, low density, and high strength. Titanium dioxide (TiO_2), a white pigment, is the naturally occurring oxide of titanium, generally sourced from ilmenite, rutile and anatase. It is mostly used in the production of paints, varnishes, paper and plastics. Other common applications include printing inks, fibres, rubber, cosmetic products and food colourings. Global TiO_2 pigment production capacity for 2018 was estimated at 7.66 Mt (United States Geological Survey 2019a). The Project represents a significant contribution to global TiO_2 production, with a design output of 100,000 tpa of pigment grade product.

4.2.1.2 Vanadium pentoxide

Vanadium is a metal used as an alloying agent, catalyst and ingredient in battery manufacture. Total vanadium production in 2018 was 73,000 t (United States Geological Survey 2019b). Demand is predicted to continue increasing due to the implementation of higher steel making standards in China and manufacture of vanadium redox batteries (The Economist 2018). The Project, with a design production output of 6,700 tpa of V_2O_5 flake, will provide a significant proportion of global output of this important commodity.

4.2.1.3 Iron Oxide

Ferric oxide (also known as hematite) is one of the three main oxides of iron and is the main source of iron for the steel making industry. Given the level of global hematite production, the Project's contribution of 550,000 tpa will be minor relative to that for V_2O_5 and TiO_2 . However, Fe_2O_3 remains a valuable commodity and the production output will increase the efficiency and value of the Project.

4.2.2 Project Benefits

The Project will provide significant local, regional and national benefits, such as:

- Employment – up to 1,311 full time equivalent jobs including:
 - Short to medium term employment opportunities during the construction phase.
 - Long term (40 years) employment opportunities during the operational phase.
- Indirect employment and income (e.g. workforce consumption of goods and services, workforce accommodation expenditure):
 - Boost to direct and indirect local employment;
 - Provision of skills training, apprenticeships and scholarships to local people, especially Aboriginal and Torres Strait Islander people;
 - Local business benefit from project-related contracts;
 - Boost to local housing market; and
 - Increased population.
- Tax revenue for NT and Australian governments:
 - The Project will generate State and Federal tax income (e.g. corporate tax, income tax, Goods and Services Tax);
 - \$0.03 in corporate tax on every \$1 generated in income for construction and \$0.02 in corporate tax on every \$1 generated in income for manufacturing (primary metal and metal product manufacturing);
 - Construction phase payroll tax obligation estimate of approximately \$3,361,372 per annum based on multiple project parameters; and
 - Operational phase payroll tax obligation estimate of approximately \$1,911,516 per annum based on multiple project parameters.

- Development of the Middle Arm Industrial Precinct in accordance with Northern Territory Government (NTG) policy for strategic development:
 - Middle Arm has been identified by the NTG as a site to accommodate large strategic industry, including industrial (oil, gas and chemical) facilities such as the Darwin Processing Facility (Land Development Corporation 2016).
- Site rehabilitation and development:
 - The Site is currently in poor condition, having been exploited historically by extractive industry activities. Development of the Project will result in more versatile, productive land use options for the duration of the Project and future use.

In summary, the Project is justified by the demand for, and importance of, the products being produced, both domestically and globally.

4.2.3 Future proposals/activities

No future expansion of the Project beyond the scale and scope described within this EIS is currently planned. Future activities associated with the Project potentially include supplementing the electricity supply (from the transmission network) with a cogeneration facility and/ or a solar photovoltaic electricity supply facility (chapter 4.3.5).

4.2.4 Consequences of Not Proceeding with the Project

In summary, the consequences of the Project not proceeding include:

- Loss of short to medium term employment opportunities during the construction phase (approx. 24 months);
- Loss of long term (~ 40 years) employment opportunities during the operational phase;
- Loss of indirect employment and income (e.g. income for businesses offering support products or services;
- Loss of export income;
- Loss of royalties for the NTG;
- Loss of tax revenue for NT and Australian governments; and
- Delay in developing Middle Arm Industrial Precinct in alignment with NTG strategic policy (Land Development Corporation, 2016).

4.3 ALTERNATIVES

4.3.1 Alternative Locations for the Project Components

Alternative locations considered for the Project include:

- The Mount Peake mine site;
- A location within South Australia;
- An offshore location; and
- Other vacant land located within the Darwin region.

4.3.1.1 Mount Peake alternative location

Advantages of constructing a Processing Facility at the Mount Peake site include isolation from residential and other sensitive receptors, and the availability of large areas of undeveloped land within which to operate. Acquisition of land at the Mount Peake mine site is also relatively affordable. Access to the large-scale utilities required for operation of the Processing Facility (gas, electricity and water) is restricted, however. In addition, the work force would likely be largely employed on a fly-in fly-out basis, significantly reducing the economic and social benefits of the Project.

Whilst potential impacts on Darwin Harbour, Elizabeth River, and residential receptors would be eliminated by undertaking the Project at Mount Peake, satisfactory mitigation of these impacts is possible by way of implementing appropriate measures (see mitigation and management measures for each environmental factor in chapter 7). Construction and operation at Mount Peake would require far greater energy and other resource inputs over the life of the project (e.g. transport of materials and personnel, and construction of infrastructure), with a likely higher carbon footprint and greenhouse gas emissions.

4.3.1.2 South Australia alternative location

A site within South Australia was investigated as an alternative location to Darwin. The site would have utilised existing rail facilities and been adjacent to Port facilities, however the access to utilities to operate the facility, particularly water, were again restricted. It is likely Port facilities would have to be upgraded and securing an appropriate sized land parcel was problematic.

4.3.1.3 Offshore alternative location

A prefeasibility study identified potentially lower construction and operating costs for an offshore location compared to a site in Australia. The economic and social benefits to Australia of constructing and operating the Processing Facility at an offshore location, however, would be limited to indirect impacts associated with the expenditure on, and taxation of, railing the concentrate to port and exporting it. For the purpose of environmental impact assessment (EIA), an offshore Processing Facility is equivalent to the alternative of taking no action.

4.3.1.4 Darwin alternative locations

Further cost optimisation, the inclusion of additional high value product streams, and discussions with the NTG resulted in undertaking the Project within the Darwin region becoming potentially viable. Three options for siting the Processing Facility were proposed by the NTG: Lot 11482, Lot 1820 and Lot 1817 (Figure 4-1).

Of the three allotments considered, Lots 11482 and 1820 were not suitable, as their dimensions prohibited accommodation of a rail bottom concentrate discharge assembly and the associated rail siding. The proximity of Lot 11482 to residential areas was also considered potentially problematic. Lot 1817 was therefore considered to be best suited for the Processing Facility, as:

- The dimensions are sufficient to accommodate the rail siding, which is paramount for the unloading of concentrate from Mount Peake and for railing of finished product to the Port;
- All of the services needed to support the Processing Facility (gas, water, power, road, communications, sewerage) are available; and
- The site provides sufficient separation from residential areas.

4.3.2 Alternative Processing Methods

The proposed processing method, TIVAN®, has been developed by the Proponent (in collaboration with several technical specialists) primarily for hydro-metallurgical vanadium extraction from titano-magnetite ore, and also for separating the titanium and iron. Patents for the innovative process have been approved in Australia, United States of America and Russia, and are pending in several other jurisdictions including Canada, China, European Union, and Vietnam.

The TIVAN® process is designed to use conventional and existing equipment currently used in extracting resources. It is therefore unique in this approach as existing processes cannot extract all three of these elements as industrial commodity grade commercial products. The conventional means of extracting vanadium from titano-magnetite ore deposits, pyro-metallurgical salt roasting and water leaching, was also considered. That process is relatively energy intensive, however, and only suitable for a narrow range of selected ore compositions to recover a water-soluble vanadium compound.

The TIVAN® process chosen by the Proponent is energy efficient and maximises the extraction and, hence, value of the concentrate input, while reducing greenhouse gas (GHG) and thermal emissions. Other environmental impacts are generally similar for each processing method.

4.3.3 Alternative Infrastructure Designs and Layout

Infrastructure design for the proposed Processing Facility has been an iterative process. Concept plans from the original NOI have evolved to consider the biological aspects of the site, surface hydrology, noise, visual amenity, air emissions and dust.

The predominant infrastructure area has been moved from the northern peninsula of Lot 1817 to the southern peninsula in order to position the potentially noisiest aspects of the Facility as far away as possible from existing and proposed residential developments. Moving this infrastructure away from the north peninsula also reduces the aesthetic impacts of the development to passing traffic on Channel Island Road and from the Elizabeth River Boat Ramp.

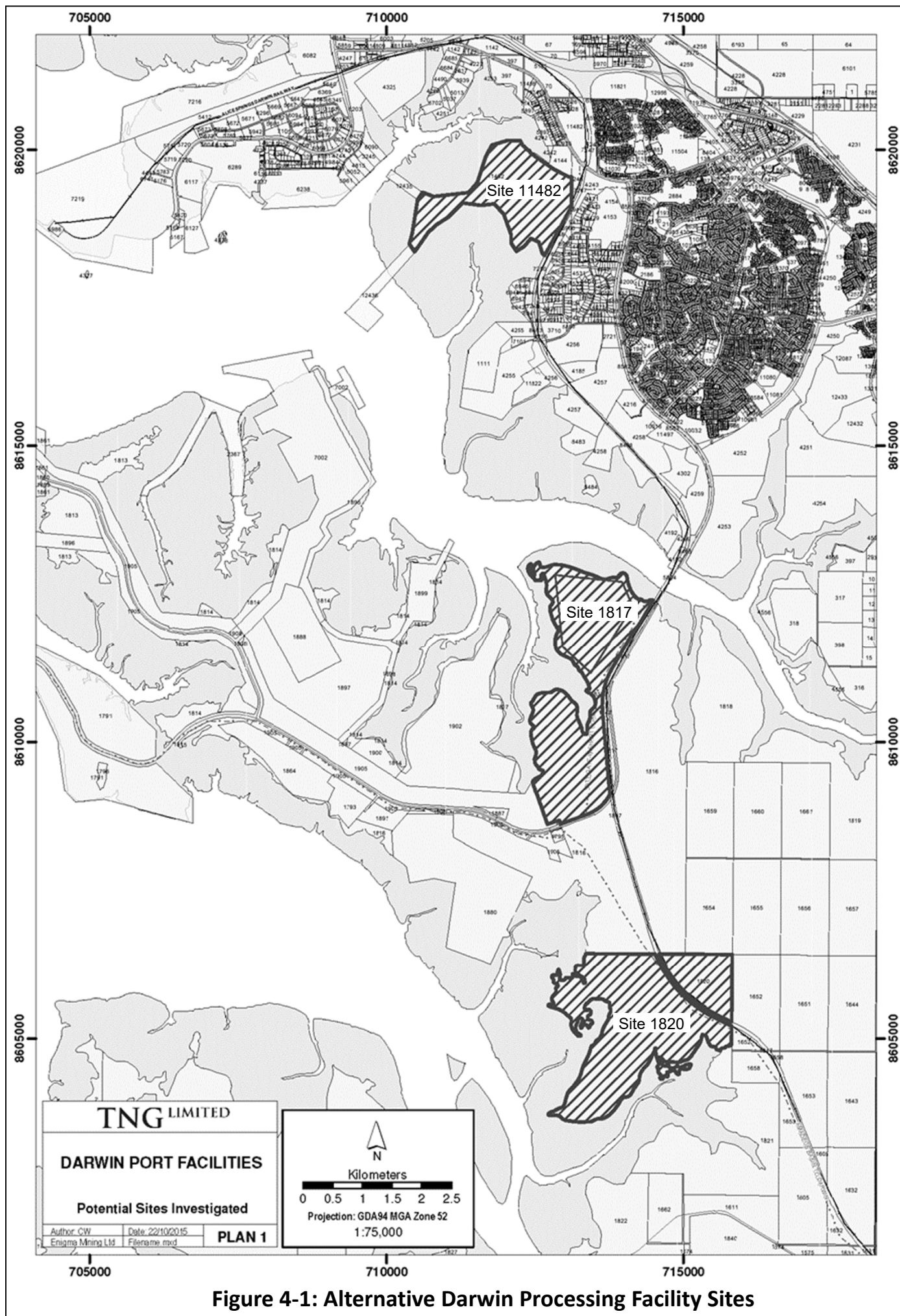
The location of infrastructure has been adjusted on the basis of the storm surge modelling data layers. Critical infrastructure is above the 1,000 year annual exceedance probability (0.1 % AEP) storm surge layer, while other supporting infrastructure is sited above the 100 year (1% AEP) storm surge layer.

The design of the rail siding has been altered to move from bottom tipping rail carts to containerised ore carts; minimising the potential for windblown ore (dust) and impacts of inclement weather on ore handling and storage (ore is not exposed to weather and cannot be carried as sediment in surface water flow across or off-site).

4.3.4 Alternative Environmental Management Techniques

4.3.4.1 Outfall locations

Several process water outfall locations were considered in the design of the Project. A location adjacent to the bridge over Elizabeth River was investigated, and potential diffusion of discharge water modelled. This demonstrated that the location would be unlikely to adequately diffuse the discharge water. The selected outfall location within East Arm was determined as the most environmentally feasible site due to the advantages of diffusion of the discharge water assisted by the tidal regime of East Arm.



4.3.4.2 Waste management

Investigation of disposal options for processing by-products has been considered. The potential for disposal of non-magnetic tailings involved investigating landfill options, on site disposal, and ultimately to utilise the return-rail movement to Mount Peake to transport the tailings to the place of its origin.

Other by-products of processing have been considered and where a marketable product can be produced, market access is being sought.

4.3.5 Alternative Energy Sources – Power Supply

Solar and wind energy generation options were investigated, with solar photovoltaic (PV) power considered superior for renewable energy generation within the Darwin region. Having determined that solar power generation would be more efficient than wind, solar photovoltaic power plants of various capacities were then compared to identify an optimum plant capacity.

A lifecycle cost methodology was used to compare the optimum solar photovoltaic plant capacity with the economic feasibility of other power generation options. Three energy supply scenarios were compared:

1. Direct purchase from Power and Water Corporation, the NTG owned electricity utility;
2. Direct to market agreement for gas generated electricity supply contract; and
3. Direct to market agreement for solar PV electricity supply contract (with shortages supplied by Power and Water Corporation).

Economic feasibility assessment indicated that scenario three has the lowest total Project life energy costs, as well as providing security from global gas price fluctuations. However, the capital investment and commercial and technical complexities associated with this power generation scenario are considered by the Proponent to be prohibitive in terms of time and cost when establishing the Project. It is likely that alternative power generation options will be reconsidered by the Proponent once the Project is established.

As a gas supply is also required at the Site for the heat generating metallurgical processes, a third party will build a natural fired gas power plant for the beginning of operations. Construction of a solar photovoltaic electricity supply facility may also become viable once the Facility is operational, further reducing expenditure and GHG emissions associated with electricity supply for the Project.

4.3.6 Alternative Decommissioning and Rehabilitation Methods

Options for eventual decommissioning and site rehabilitation include subsequent industrial use, as the Site is located within an area earmarked for medium to long term industrial use. Alternatively, depending on future local development patterns and surrounding land uses, it may be considered more desirable to rehabilitate and repurpose the Site for other land uses, such as conservation, recreation and/ or residential use.

4.4 LAYOUT OF THE PROCESSING FACILITY

The Processing Facility will be built predominantly on the southern peninsula of Lot 1817. Project support infrastructure will adjoin the Processing Facility on the southern peninsula and additional support infrastructure will also be established on the northern peninsula of Lot 1817. The layout of the Project appears as Figure 4-2.

4.5 SITE PREPARATION AND CONSTRUCTION PHASE

Construction is scheduled to commence late 2020 with first production in late 2022. Construction activities will occur over a 24-month period, continuing over both wet and dry seasons. Construction works will take place largely between 7am and 7pm, although it is anticipated that non-noise generating activities may be undertaken outside of these hours.

4.5.1 Site Preparation

Site preparation is required to ensure that ground conditions are appropriate for construction. Activities will primarily consist of the following:

- Establishing an all-weather access road from the south of the site;
- Delineating the areas to be cleared and those to be protected;
- Mobilising clearing and earthmoving plant, temporary facilities and other equipment;
- Vegetation clearing, with cleared vegetation stored for rehabilitation;
- Topsoil, where present, will be removed and stored for future use in rehabilitation. Where necessary stockpiles will be protected with erosion and sediment control structures and stabilised to prevent excessive wind erosion;
- Bulk site earthworks to create the required pads for installation of the Process Plant and infrastructure. Areas will be levelled and compacted;
- Installing drainage for the civil construction phase, including temporary sedimentation ponds for drainage and erosion control. Natural drainage lines will be retained where possible.

The Development Envelope is approximately 264 ha. All disturbance for the Project will be contained within this area. Indicative disturbance areas for the Project appear in Table 4-1.

Table 4-1: Development areas

Item	Disturbance Area (ha)
Process Facility buildings and storage areas	110
Rail siding	15
Access and site roads	25
Additional Facility infrastructure	70
Water pipeline	15
Miscellaneous (firebreaks, areas between buildings and roads, drainage infrastructure,	29
Total	264

712250.000

713250.000

714250.000

715250.000

8613250.000

8612250.000

8611250.000

8610250.000

8609250.000

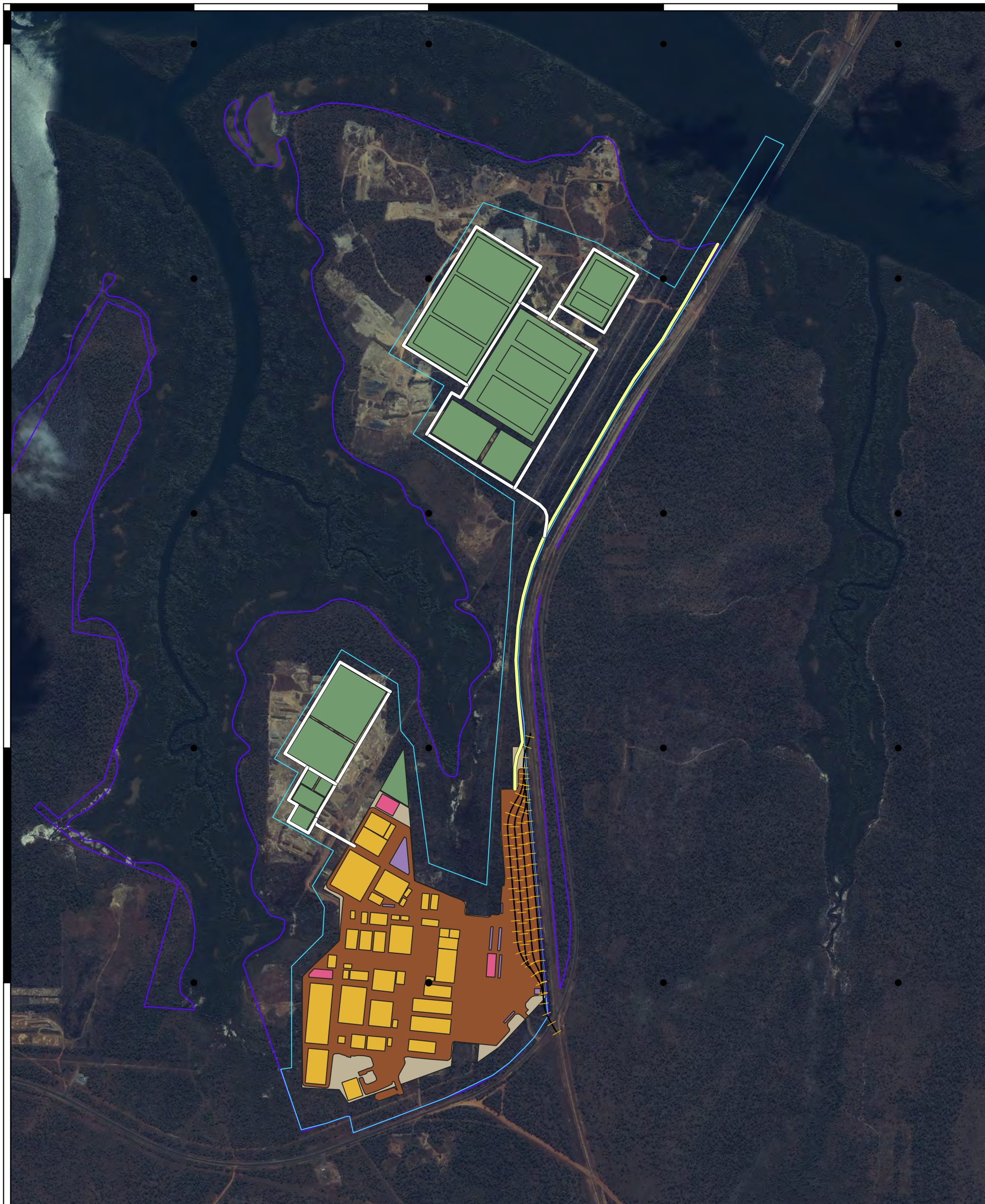


Figure 4-2: Lot 1817 and the Darwin Processing Facility Site Layout

Legend

Darwin Processing Facility EIS Envelope (TNG Oct 2019)	Proposed Access Road (SMS Sept 2019)
Processing Facility Buildings (SMS Sept 2019)	Rail Spurs (SMS Sept 2019)
Storage Areas (SMS Sept 2019)	Easement (Road Waste Pipeline TNG Sept 2019)
Ponds (SMS Sept 2019)	Lot 1817 Hundred of Ayers
Additional Plant Infrastructure (TNG Sept 2019)	

Date: 22/11/2019



0

1 km

GDA 94 MGA Zone 52

Scale 1:15,000

Drawn by ems@animalplantmineral.com.au

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4.5.2 Temporary Facilities and Laydown Areas

Throughout the construction phase, areas will be required for laydown to cater for a range of temporary facilities, construction materials and equipment. These potentially include:

- Storage areas for equipment and materials such as steel, piping and cables;
- Vehicle washdown areas;
- Temporary office and crib facilities;
- Ablution facilities;
- Parking areas and roadways for construction equipment and personnel vehicles;
- Bunded fuel storage and distribution areas;
- Water storage and distribution facilities;
- Temporary sewage treatment infrastructure;
- Temporary warehouses and workshops;
- Temporary power supply from generators;
- Liquid, chemical and waste storage areas;
- Evaporation and settling ponds;
- Welding, grinding, cutting and other hot-work fabrication facilities;
- Abrasive blasting and spray painting areas;
- Rock crushing and screening plant;
- Storage areas for soil and rock; and
- A concrete batching plant.

Temporary facilities and laydown areas will be located as close to the Processing Facility construction site as possible. Temporary infrastructure may also be located on areas which will be used at a later stage for permanent facilities.

4.5.3 Earthworks

Earthworks will involve clearing, grubbing, cut and fill, preparation of unsealed roads and hardstands and basic drainage works. Areas will be levelled and compacted prior to construction of infrastructure. Toward the end of the construction program a second phase of earthworks will be initiated. This work will involve trimming to final level, constructing final drainage profiles and installing culverts.

Final earthworks will be required to level and compact the site. Construction of pads may also be required to raise the footprints of certain plant and infrastructure above the surrounding ground level. Pilling will be installed in the following areas:

- Concentrate, coke and salt storage and conveyor tunnels;
- Processing Facility (including acid regeneration, tank farm and reagent storage);
- Workshop and stores;
- Offices, administration area, including kitchen/mess-hall, emergency services and first aid;
- Pigment plant;
- Rail siding;
- Oxygen Plant; and
- Oleum Plant.

The rail siding will be aligned in a north south direction parallel to the existing line, as close as possible to the Processing Facility, with tracks laid on foundations of clean imported ballast, such as coarse aggregate material. It will be approximately 3.8 km long to allow for the full length of the train (1.8 km) along the siding, where unloading to the feed stockpile will occur.

The concentrate (feed) stockpile will be housed in a storage building that sits over several prefabricated tunnels. Smaller diameter tunnel extensions will provide ventilation and several alternative escape routes. The tunnels and stockpile will be built on top of the existing terrain, rather than being excavated below ground level. This design avoids potential flooding impacts during periods of torrential rainfall and prevents the accumulation of any heavier than air gases.

Ponds will be generally built up, with only partial excavation below the prevailing ground level, followed by installation of a high-density polyethylene membrane. Raised embankments will be constructed around the pond edges to deflect wind-borne dust and sand, and fencing installed for safety.

The footprints for the offices, administration building, emergency services and gatehouse areas, will be located within the site. These buildings will be fitted out with power supply, external lighting, potable water supply, ablution (toilets, showers, wash basins) facilities and a sealed bitumen area for parking, including truck parking.

Earthworks and foundations will utilise dozers, loaders and dump trucks. Construction of the foundations will require pile driving rigs, compactors and concrete trucks.

4.5.4 Vegetation Clearing

The Development Envelope (the area enveloping all infrastructure required for the Project) is approximately 264 ha; of which 180 ha has been previously cleared or is in Degraded condition. Approximately 67 ha within the Development Envelope has been previously cleared and not rehabilitated, 20 ha is associated with existing infrastructure and is maintained with minimal vegetation cover, 93 ha has native vegetation that is either spontaneous or planned rehabilitation of various ages. The remainder (84 ha) is high quality native vegetation.

TNG have developed a vegetation clearing procedure as part of the Environmental Management Plan (**EMP**) (Appendix D). The objective is to minimise the extent of vegetation clearance, ensure the safety of threatened

fauna species present to the greatest extent possible, allow for the translocation of *Cycas armstrongii*, promote the retention of landscape function by appropriate topsoil and weed management, and reduce the risk of erosion. It covers the removal of vegetation, removal and storage of topsoil required for rehabilitation and has been prepared in accordance with the NT Land Clearing Guidelines.

Topsoil, cleared vegetation and translocated *C. armstrongii* will be used on-site to rehabilitate areas outside of the Development Envelope and improve the quality of vegetation in the wildlife corridor that fringes the north and west of the Project within Lot 1817 Hundred of Ayers.

4.5.5 Processing Facility Construction

The Processing Facility will typically consist of steel framed structures placed on reinforced concrete foundations.

Housed within these steel framed structures are various pieces of mechanical equipment including pumps, fans, ducts and pipes. Within each structure there will be platforms, stairs and landings, cabling and pipe trays.

The reinforced concrete foundations will have internal reinforcing steel fixed in place within formwork.

Wet concrete will be placed within the forms by direct discharge from a concrete truck or via the use of a concrete pump from an onsite concrete batching plant. The formwork will be removed when the concrete sets.

Structural steel will be fabricated off-site, brought to the site laydown area and laid out for identification. Structures will be erected by lifting of the structural steel into position by crane. Larger pieces of mechanical equipment will be installed during the steel erection process and small pieces will be brought in later.

Following structural steel erection, pipes, ducts and cable trays will be installed. The electrical cables will be placed in trays, run through to electrical substations and then connected to mechanical equipment.

All equipment will be tested for correct operation and safety at the end of the construction process.

The Processing Facility construction will utilise cranes, cherry pickers and scaffolding.

4.5.6 Construction Materials Required

Construction materials generally consist of typical industrial materials such as concrete, structural steel, aluminium, cladding, copper wire and cables.

The Project construction is expected to require approximately 10,000 cubic metres (**m³**) of concrete and 15,000 tonne (**t**) of structural steel. All equipment will be CE approved and comply with Australian Standards (**AS**). All buildings will be built in accordance with the construction codes of Australia. No Asbestos products will be used.

Most buildings will be clad. Hardstands and roads will be constructed of asphalt with concrete kerbs.

The expected water required is 2.5 gegalitres (**GL**) over the construction period, for dust suppression, batching concrete, soil conditioning and washdown requirements.

The estimated quantity of construction materials is listed in Table 4-2. Materials will be sourced locally where available.

Table 4-2: Materials required for the whole construction period

Material	Quantity	Origin
Steel	15,000 t	South East Asia
Plate work	5,000 t	South East Asia
Piping	60 km	South East Asia
Cable	120 km	South East Asia
Timber	Nil	Not Applicable
Aggregate	10,000 m ³	Northern Territory
Sand	10,000 m ³	Northern Tertiary
Cement	4,000 m ³	Darwin
Asphalt	12,500 m ³	Darwin
HDPE	20,000 m ²	South East Asia
Concrete	10,000 m ³	Onsite batch plant
Fuel	1.8 ML	Darwin

4.5.7 Construction Equipment

Construction activities will use standard construction machinery, general trade equipment and specialised equipment including excavators, scrapers, front-end loaders, graders, cranes, water tankers, concrete trucks / pumps, dozers, dump trucks, forklifts, busses and light vehicles.

Daily vehicle movements external to the site (primarily between East Arm Wharf and the site) will include:

- 4 crane movements;
- 8 flatbed truck movements;
- 4 fuel/lubrication truck movements; and
- 4 light vehicle movements.

The expected construction vehicle fleet is provided in Table 4-3.

Table 4-3: Indicative construction vehicle fleet

Vehicle	Indicative number
Excavators	2
Scrapers	2
Front End Loaders	2
Graders	2
Cranes	30
Water Tankers	2
Concrete Trucks	10
Cherry Pickers	2
Light vehicles (Land cruisers, utes, sedans)	30
Buses	10

4.5.8 Construction workforce

Peak workforce during construction is expected to be around 700-1000 personnel. It is expected that construction staff and external/FIFO contractor workforce will be accommodated at existing infrastructure that exists in Darwin.

This may include, but is not limited to, the following options:

- Existing housing accommodation in Darwin for short term/long term staff and management personnel as deemed necessary;
- Existing hotel/motel accommodation within the Greater Darwin region;
- Channel Island Camp operated by Trepang Services (can accommodate 1500); or
- Ahrens operated INPEX accommodation village (can accommodate over 2000).

All of the above are within proximity to the site with the Channel Island Camp approximately 2 km away. TNG's survey concluded that the existing infrastructure in Darwin is more than adequate to accommodate the workforce during the construction phase.

4.5.9 Traffic (road and rail)

The Project is located on Channel Island Road Wickham, south of the Elizabeth River Bridge. Two level rail crossings are also in proximity of the site; at Channel Island Road and Jenkins Road. As part of the proposed Facility, the following transport infrastructure will be required:

- Road access to/from the existing Channel Island Road.
- A rail siding running parallel to the Adelaide-Darwin railway.

The site will be accessed by heavy vehicles for delivery of consumables and light vehicles and/or buses associated with transporting workers to and from the site.

The rail siding will facilitate movement of materials to and from the Processing Facility. Site access and the rail siding will be completed during the construction phase of the Project.

4.5.10 Construction Phase Waste Streams

Construction phase waste streams will be limited to small quantities of hydrocarbons (e.g. lubricants, contaminated rags, and potentially contaminated spill kit material/ soil), wastewater (e.g. from ablution facilities and concrete batching plant) and domestic waste (e.g. kitchen waste (food scraps) and office waste). Domestic waste will be collected and disposed of by Darwin's municipal waste service.

Waste hydrocarbon materials will be temporarily stored on site in intermediate bulk containers (IBCs) (or similar), prior to removal by a licensed waste removal contractor.

Wastewater from ablutions will either be treated on site by a modular wastewater treatment plant and the biosolids removed by a licensed contractor, or wastewater stored on site for removal by a licensed contractor, until a permanent on-site sewage treatment plant is commissioned and functional. Wastewater from the concrete batching plant will also be contained and treated via a dedicated treatment plant, with treated water recycled and solid wastes removed from site.

4.6 OPERATIONAL PHASE (PRODUCTION PROCESS AND OPERATION)

Upon completion of the construction phase, usage of the site will consist of operational and maintenance related traffic. The Processing Facility will operate 24 hours per day, seven days per week.

4.6.1 Traffic

4.6.1.1 Road Traffic

Upon completion of the construction phase, usage of the site will consist of operational and maintenance related traffic. Vehicle movements within the site will be on purpose-built roads and have not been discussed further within this chapter.

Daily vehicle movements external to the site (primarily between the site and the East Arm Wharf) will include:

- 4 isotainer truck movements;
- 10 quad road train movements;
- 2 flatbed truck movements;
- 4 fuel/lubrication truck movements; and
- 16 light vehicle movements.

It is identified that the above (36) movements would occur outside of the peak hours for staff movements.

In addition to the above, there will be light vehicle and/or bus movements associated with employees travelling to and from the site.

The road routes that will be predominantly used for movement of goods, equipment and personnel appear on Figure 4-3. There will be two entry points to the site, one accessing the northern peninsula and one accessing the southern peninsula at the approximate locations on Figure 4-3. The southern entry point will be the main access for the site.

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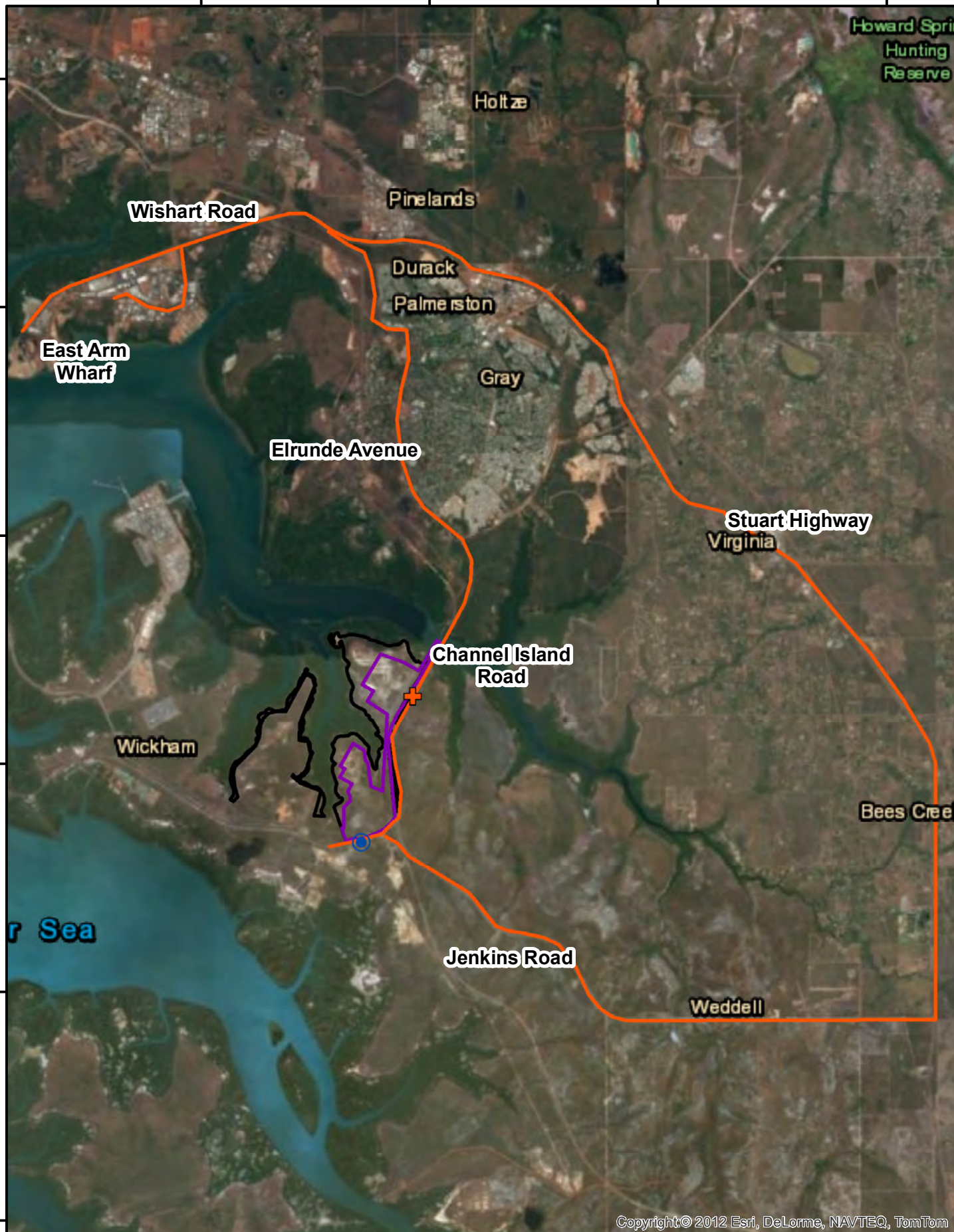
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Figure 4-3: Possible routes used to access the Darwin Processing Facility

Legend

Site Access Points

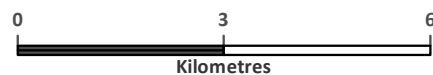
✚ Northern Peninsula Emergency Access Point

● Southern Peninsula Main Access Point

— Possible access routes

▭ Darwin Processing Facility Envelope

▭ Lot 1817, Hundred of Ayers



1:110,000 GDA 94 MGA Zone 52

Date: 22/11/2019

4.6.1.2 Rail Traffic

The Adelaide-Darwin railway runs parallel to the east of the Project area. On average three train loads of concentrate per week will be delivered to the Processing Facility from Mount Peake. It is also anticipated that seven train movements between the site and East Arm Wharf will occur weekly, for delivery of final products. Bulk cargo trains up to 1,800 m in length are handled at East Arm Wharf.

It is expected that rail will be utilised to return tailings back to the Mount Peake mine site. A new 3.8 km long rail siding will be constructed in the Project area, connecting it with the Adelaide-Darwin railway.

Concentrate unloading is expected to occur over a nine-hour period. Each train will have 90 wagons with two 20 foot containers per wagon with a capacity of 26 tonnes of concentrate in each container (4,680 tonnes total per train). Concentrate will be unloaded from train wagons onto a rail unloading conveyor at the concentrate unloading station, which transfers the concentrate to the magnetite concentrate stockpile. Each train will be unloaded in nine hours at an average rate of 520 tonnes per hour (**tph**). This is enough feed supply for 42 hours.

TNG has entered into a head of agreement with a third party for the provision of rail haulage services. They will be responsible for loading the magnetite concentrate onto rail at the Adnera rail siding, rail haulage from Adnera to the TIVAN facility on the Tarcoola-to-Darwin rail line and unloading of the magnetite concentrate at the TIVAN facility. They are also responsible for loading and transporting TNG's final products from the TIVAN facility to the Darwin Port, providing all necessary rail transport plant and equipment including locomotives, wagons, crew vans and fuelling equipment.

4.6.2 Feed Stockpile

The thermal processing feed stockpile, consisting of concentrate at a P₈₀ grind size of 150 microns, will be housed under cover to minimise incident rainfall increasing the concentrate moisture content (low concentrate moisture content is desirable) and to reduce wind generated dust emissions. The housed area will incorporate dust suppression measures to minimise dust emissions. As the roaster feed stockpile will be positioned on top of a tunnel, a chute beneath the centre of the stockpile will allow concentrate to be discharged onto a conveyor positioned inside the tunnel. The concentrate will be loaded onto the conveyor within the tunnel, with the conveyor also receiving carbon in the form of coke. The coke will be stockpiled in a separate warehouse next to the concentrate stockpile.

4.6.3 Processing

The following provides an overview of the key features of the proposed processing operations, with flow charts supplied as Figure 4-4. The description is provided in sufficient detail to afford the reader with an understanding of the various processes, transfer points and waste streams. The description is based on the Processing Facility operating at full capacity.

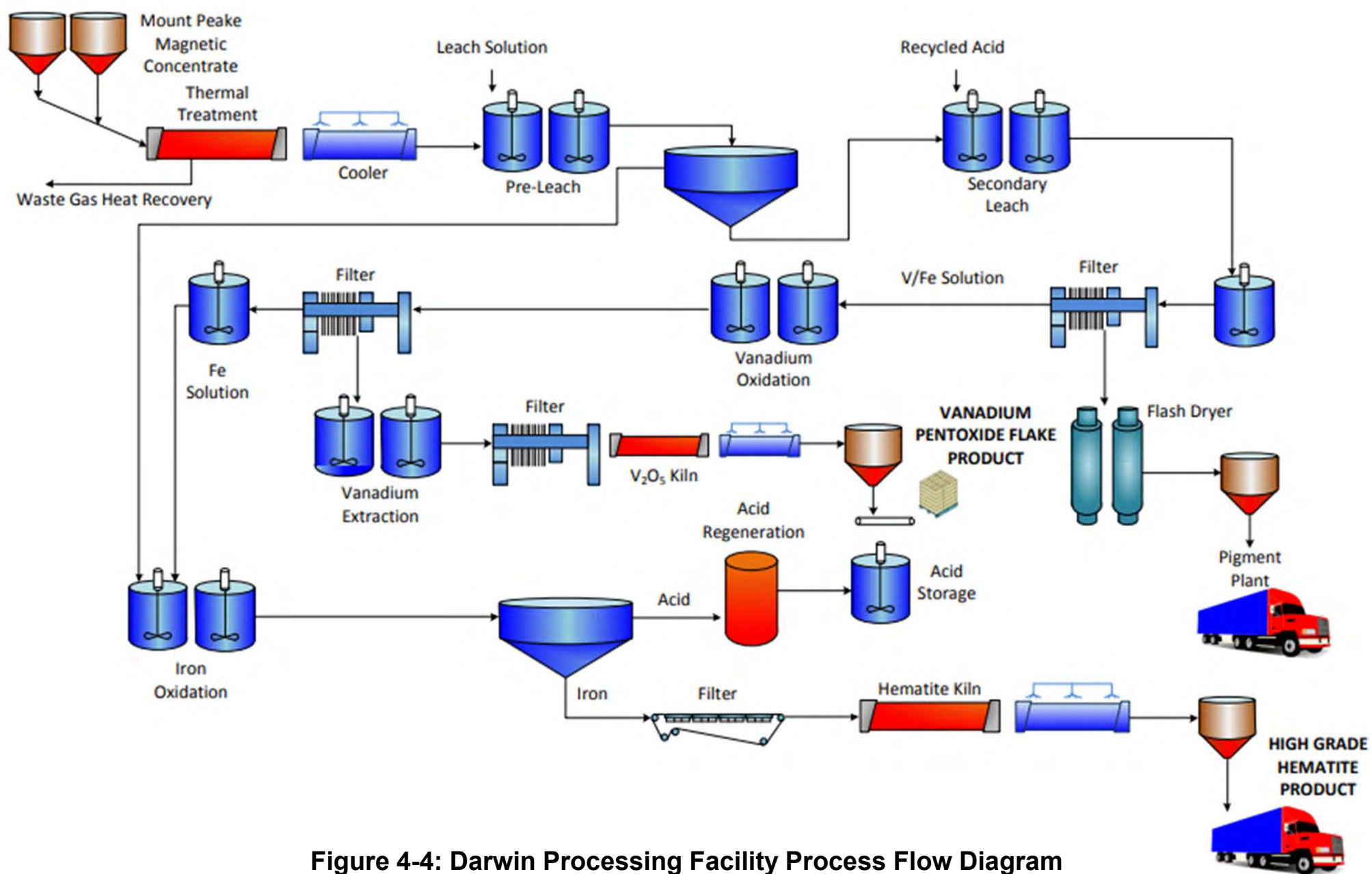


Figure 4-4: Darwin Processing Facility Process Flow Diagram

4.6.4 TIVAN® Process

From the feed stockpile, the concentrate is transferred to thermal processing where the concentrate is heated in a rotary kiln with low sulfur coke. The ore is discharged into a water cooler to reduce the temperature prior to feeding the leaching circuit. The off gas is fed to a boiler for heat recovery and scrubbed to reduce sulfur levels prior to release to the atmosphere.

The thermally treated ore is transferred to the pre-leach circuit where impurities are dissolved in a corrosive salt solution to prepare the feed for the TIVAN® leach. The leach slurry is thickened, generating a higher pulp density slurry and an overflow stream, which feeds the reagent recovery circuit.

The thickened slurry is transferred to the TIVAN® leach circuit where the feed is heated and acid is added to extract vanadium in a series of leaching vessels. The slurry from the leaching process is filtered to produce a filter cake ('feedstock') for the titanium pigment plant and a solution containing vanadium. The feedstock, which is high in TiO_2 , is dried in a flash dryer and pneumatically conveyed to the titanium pigment plant.

The TIVAN® leach solution is pumped to the vanadium oxidation process. In the vanadium oxidation process an impure vanadium solid is precipitated from solution through oxygen sparging in a pressure vessel. The precipitated solid is filtered and the filtrate is transferred to the tank farm before recycling back to the leaching circuit. The impure vanadium solid is transferred to the vanadium purification process.

In the vanadium purification process vanadium is leached from the impure vanadium solids using sodium hydroxide. The slurry is filtered and the residue conveyed to the hematite roast area.

The vanadium bearing filtrate is added to an ammoniated solution which, precipitates a vanadium salt. The slurry is filtered and the precipitate is fed to a furnace that decomposes the vanadium salt to V_2O_5 . The off gas from the process is scrubbed with acid to remove any ammonia and released to the atmosphere. The scrub solution is recycled back to the vanadium salt precipitation tanks. The V_2O_5 is packaged as the final vanadium pentoxide product in bulk bags.

The thickener overflow from the pre-leach circuit is split into two streams; one stream is fed to the hematite precipitation circuit and the second stream is fed to the acid regeneration circuit.

In the hematite precipitation process the filtrate is sparged with oxygen in a pressure vessel causing iron oxide to precipitate from solution, along with some impurity oxides. The slurry from iron oxidation is thickened and filtered to separate the Fe_2O_3 and the solution is recirculated back to the leaching circuit.

The second stream from the thickener overflow is stored in a tank farm prior to feeding the acid regeneration process. The acid is regenerated through the industry standard Ruthner acid regeneration process. In the process the waste acid is preconcentrated with the roaster off gas and injected into the roaster. Water and hydrochloric acid are evaporated and the metal chloride salts in solution are converted to their metal oxides. Hydrochloric acid in the off gas is recovered by absorption into a counter-current flowing stream of water. A secondary column reduces the hydrochloric acid in the gas to acceptable levels for release to the atmosphere. The oxide solids residue is predominantly hematite, with impurity oxides of aluminium, magnesium, vanadium and titanium. These solids are transferred by conveyor to the roasting area.

The three hematite products from the plant are processed in a rotary kiln at elevated temperatures to decompose any impurities and dry the hematite, the hematite product is cooled and stockpiled for transport to the East Arm Wharf. The off-gas is scrubbed prior to release to the atmosphere.

4.6.5 Titanium Pigment Plant

The simplified titanium pigment plant flowsheet is displayed in Figure 4-5. Processing broadly involves digestion of titanium from the TIVAN® leach residue, hydrolysis of titanium from solution, calcination of hydrolysed titanium, milling and surface treatment of raw TiO₂, followed by steam milling to produce the titanium pigment product.

In the process the TIVAN® leach residue will be pneumatically conveyed to the titanium pigment plant and stored in a silo. The feedstock is conveyed to the ore mill where the particle size is reduced prior to the sulfate digestion process.

Sulfuric acid for the digestion is produced by mixing recycled acid from the waste acid regeneration plant with sulfuric acid from the sulfuric acid plant. The feedstock is mixed with the sulfuric acid to produce a paste. The paste is fed to the digester which operates at elevated temperature, converting oxides to metal sulfates. Water formed in the sulfation reactions is evaporated due to the heat released in the exothermic reactions. The off gas from the process is scrubbed to remove sulfur dioxide (SO₂) prior to release to the atmosphere. The digester product is transferred to green liquor tanks where a dilute acid solution dissolves the metal sulfates formed. In a separate unit the slurry reacts with scrap iron to reduce the impurity elements in preparation for titanium precipitation.

The slurry is pumped to a thickener and pressure filter arrangement where the insoluble waste product that is primarily silica is separated from the titanium bearing liquor. The residue solids are neutralised with limestone and stockpiled before loading by front end loader into the rotating containers rail cars and railing to Mount Peake to be disposed of in the Integrated Waste Landform. The thickener overflow and filtrate are combined and further filtered to minimise particulate matter entering titanium precipitation. The filter cake formed is neutralised along with the pressure filter cake.

The remaining liquor is pumped to the titanium precipitation process. In the titanium precipitation process the hydrolysis seeds are added and the process is heated. Titanium hydrolyses from solution, while the impurities remain. The slurry is filtered and the cake is washed to remove residual solution in the cake. The filtrate is pumped to the waste acid concentration process and the cake is transferred to a tank, where aluminium powder and acid are added to bleach the solids. The slurry is again filtered and fed to the doping tank where a rutile seed is added. The slurry is filtered, and the doped titanium precipitate is transferred to the rutile kiln.

In the rutile kiln the seed and titanium precipitate will be calcined to produce a raw TiO₂ product. The off gas from the kiln containing dust and SO₂ is first cleaned of dust. The separated dust is recycled back to the calcination feed. The dedusted gas containing SO₂ is then scrubbed to remove the SO₂ and the cleaned off gas is released to the atmosphere. The TiO₂ from the kiln, which has agglomerated, is milled to achieve the desired particle size distribution for surface treatment. The slurry is filtered to separate the wet solids and dried in a flash dryer. The dried solids are milled further in a steam mill to achieve the final product size distribution and transferred to the packaging plant where it is stored in silos.

In the packaging plant the titanium pigment is packaged and stacked on wooden pallets. The wooden pallets are then double stacked in 20-foot shipping containers for transport offsite.

The waste acid concentration plant will reconcentrate process sulfuric acid to 60-70% through a multiple stage concentration process wherein excess water is removed. As the solution is concentrated metal sulfates precipitate from solution. The slurry is filtered to produce a “filter salt” by-product and a concentrated acid solution. The concentrate acid solution is recycled back to the digester. The filter salts are packaged in IBCs and loaded in 20-foot shipping containers.

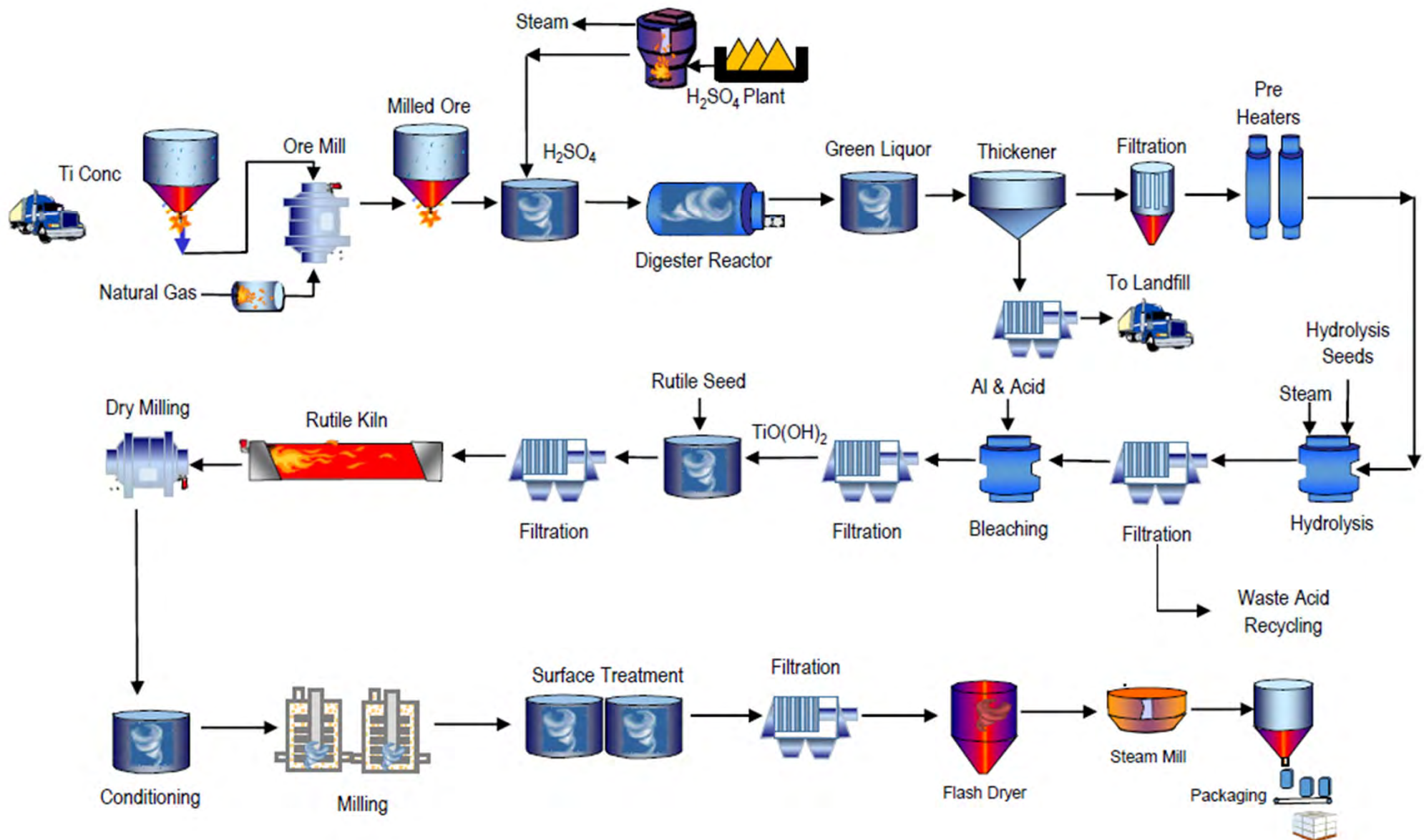


Figure 4-5: Titanium Pigment Processing Facility Process Flow Diagram

4.6.6 Oleum Plant

Solid sulfur is trucked into site and stored in a silo. The solid sulfur is fed from the silo to the molten sulfur pit, where it is heated and melted to produce molten sulfur. The molten sulfur from the pit is filtered to remove any solids and fed to the burner where the sulfur is oxidised with dry air to form sulfur dioxide gas.

Heat from the SO₂ gas is recovered in a waste heat boiler and the cooled gas is transferred to the converter beds. In the converter beds the SO₂ is oxidised to generate sulfur trioxide (SO₃). The converter beds are packed with a vanadium pentoxide catalyst that makes the formation of SO₃ gas from SO₂ thermodynamically favourable.

The SO₃ generated in the converter beds is absorbed in 98% sulfuric acid in the acid towers to produce 30% oleum and 98% sulfuric acid. The raw sulfuric acid solution is cycled to a drying tower, where it flows counter-current to air, absorbing any moisture. The product from this tower is a dry air suitable for feeding the sulfur burner.

The diluted sulfuric acid is cycled back to the SO₃ absorption towers for reconcentration. The oleum and acid are pumped to the pigment plant for the titanium digestion process.

4.6.7 Oxygen Plant

An oxygen plant will supply oxygen for the hydrometallurgical process and for the pigment plant by air liquefaction. The primary product will be gaseous oxygen. Gaseous or liquid nitrogen can be produced as a side stream, if necessary. The oxygen plant will require electricity and process water.

4.6.8 Steam

Steam is required for the titanium pigment plant, for heating in the hydrometallurgical process and for the vanadium purification circuit.

The steam for the plant will be generated from waste heat recovery of the off gas. Where required, natural gas will be used to make-up steam requirements for the plant. The steam will be generated in the waste heat recovery unit, located in the thermal pre-treatment area and distributed throughout the plant. Water for steam production will be a combination of recycled condensed steam and demineralised makeup water.

4.6.9 Cooling

Air cooling towers will provide cooling for the Processing Facility. 7,850 tph of cooling air will provide a heat sink for 1,270 tph of circulating cooling water required for process units throughout the plant.

4.6.10 Air

A pressurised air supply, required for instruments and pressure filters, will be supplied by two air compressors, with one online at any time. Compressed air will be filtered, dried to prevent condensation, and then supplied at 750 kilopascals (kPa) into two air receivers; one for instrument air and one for plant air.

4.6.11 Materials Handling and Storage

Third parties will provide services external to the lot boundary, including concentrate transport to the Project, the transport of products by rail from the Project to East Arm Wharf, port activities including the unloading, storage, handling and export of products, port importing activities for consumables such as coke, and the transport of consumables by rail to the Project. Third party services will assume responsibility for environmental management measures associated with their activities covering potential impacts such as spill management, air emissions and noise emissions.

4.6.11.1 Products

Titanium Pigment

The titanium dioxide pigment from the Darwin Process Facility is classified as non-dangerous goods by the criteria of the *Australia Dangerous Goods Code (ADG Code) for Transport by Road and Rail*. The substance is classified as a non-hazardous substance according to Safe Work Australia.

Titanium dioxide pigment will be transferred to the dedicated packing area where it is stored in multiple product hoppers. In the packaging plant the titanium pigment is packaged in 1 tonne and 25 kg bags and stacked on wooden pallets. The wooden pallets are then double stacked in 20-foot shipping containers at the packaging plant. The shipping containers are loaded onto a train at the rail siding and transported to the East Arm Wharf where they will be loaded onto ships for transport to overseas markets.

Personal protective equipment is required to minimise exposure risk to workers associated with inhalation or contact with dust.

Titanium dioxide deliveries to the port will be made three times every two weeks.

Vanadium Pentoxide

The final product from the TIVAN® Process will be a V₂O₅ flake. Vanadium pentoxide flake is classified as dangerous goods by the criteria of the *Australia Dangerous Goods Code (ADG Code) for Transport by Road and Rail*. The substance is classified as a hazardous substance according to Safe Work Australia.

Vanadium pentoxide generated in the vanadium upgrade process area will be transferred by conveyor to storage hoppers in a dedicated packing area. Personal protective equipment is required to minimise exposure risk to workers associated with inhalation or contact with dust.

In the packaging plant the vanadium pentoxide product is packaged in 1 tonne and 25 kg bags and stacked on wooden pallets. The wooden pallets are then double stacked in 20-foot shipping containers at the packaging area. The shipping containers are loaded onto a train at the rail siding and transported the East Arm Wharf where they will be stored prior to loading onto ships for transport to overseas markets.

Vanadium pentoxide deliveries to the port will be made three times every two weeks.

Ferric oxide (Hematite)

The hematite product from the TIVAN® Process is classified as non-dangerous goods by the criteria of the *Australia Dangerous Goods Code (ADG Code) for Transport by Road and Rail*. The substance is classified as a non-hazardous substance according to Safe Work Australia.

Hematite from the roasting process area will be transferred by conveyor to a bulk covered storage area where it will be stored in silos prior to shipping. There will be two weeks of storage capacity for the product. Dust suppression measures will be used to minimise dust formation during materials handling. Personal protective equipment is required to minimise exposure risk to workers associated with inhalation or contact with dust.

The hematite product will be loaded into rotating containers and loaded onto the train. At the port the rotating containers will be unloaded in a second bulk storage area prior nominated by Darwin Port Operations. Iron ore product handling will be undertaken using existing facilities by Darwin Port Operations nominated Stevedores.

The iron ore will be shipped as a loose bulk commodity to overseas markets.

Filter Salts

The filter salts from the Darwin Process Facility are classified as dangerous goods by the criteria of the *Australia Dangerous Goods Code (ADG Code) for Transport by Road and Rail*. The substance is classified as a hazardous substance according to Safe Work Australia.

The filter salts will be packaged in 1000 L IBC's and stacked in 20-foot shipping containers. The containers will be transported to the port by rail and loaded onto ships for overseas markets.

4.6.11.2 Reagents

A number of reagents are classified as dangerous goods by the criteria of the *Australia Dangerous Goods Code (ADG Code) for Transport by Road and Rail*. There are also a number of reagents classified as hazardous by Safe Work Australia and, as such, have specific requirements for storage and handling. Detailed procedures for storage and handling of hazardous substances will be provided as part of the risk management plan, which will be submitted to Worksafe NT for approval prior to commencement of operations.

The reagents list for the Project includes several acids, bases and oxidants which will be stored in individually bunded areas to prevent mixing in the event of spills. The Project also includes several solid reagents including metals, hydroxides, limestone, diatomaceous earth, sulfur, organic polymers (flocclulants) and inorganic salts. Solid reagents will be delivered in enclosed packages (25 kg bags, 1 t bags or drums) and stored in warehouses. During normal operations these reagents are not expected to be introduced to the environment.

Coke will be shipped in as a bulk commodity and trucked to site. The coke will be stockpiled in an enclosed warehouse equipped with dust suppression measures. This will minimise coke dust introduced to the environment.

Products/suppliers have not been chosen; however, it is envisaged that the reagents will primarily enter Darwin via the East Arm Wharf and from there will be delivered to the Process Facility by train and truck.

4.6.12 Infrastructure

The Project area is near existing infrastructure capable of meeting gas requirements of the Project. It was selected to minimise the distance from Channel Island Road, the Adelaide–Darwin train line, the Amadeus–Timor gas pipeline and power and water infrastructure in order to minimise impacts associated with construction and operation of services for the site.

In addition to power and gas, the Project requires access to rail, roads, water, communications, fuel, and waste management services. A communal corridor will link the Project area with these services, provided by established providers, utilities, routes and locations.

4.6.13 Water Requirements and Management

Water is required for processing and potable/non-potable water supply. TNG is working with the NTG to secure the necessary water supply for the Processing Facility in a manner that is both feasible and sustainable.

The predicted average water demand for the Processing Facility at 80% availability is 0.03 gigalitres per day (**GL/day**). The greatest demand expected is 0.0375 GL/day, if the Facility was to run at full capacity for 24 hours (equivalent to 13.6 GL/year).

Average Facility water requirements are summarised in Table 4-4.

Table 4-4: Average Project water requirements

Use	Volume (GL/day)	Volume (GL/year)
TIVAN® Process	0.0045	1.6
Pigment Facility	0.0185	6.8
Utilities	0.007	2.6
Total	0.03	11

Raw water is piped to site then stored in a process water dam within the Project area, prior to being pumped to storage tanks with a total of 12 hours residence time (Figure 4-6). Raw water is used for the production of demineralised water, potable water, mixing reagents, firewater, gland seal water, wash water and as makeup water in the used water tanks, if required. Water for the Processing Facility will be drawn from a selected point in the bottom half of the tank. Water below this draw point will be available as fire water, ensuring there is always raw water available for fires.

The TIVAN® section of the plant utilises recycled water for scrubbing and is added to unit processes in several areas of the plant. The circulating used water has a small bleed stream of 3 m³/ hour, which is pumped to the wastewater treatment plant to remove contaminants prior to release at the ocean outfall.

A reverse osmosis plant will produce 310 kL/h of demineralised water for the Processing Facility. The Facility produces a saline discharge that will be piped to the wastewater treatment plant for removal of impurities before discharging into the harbour.

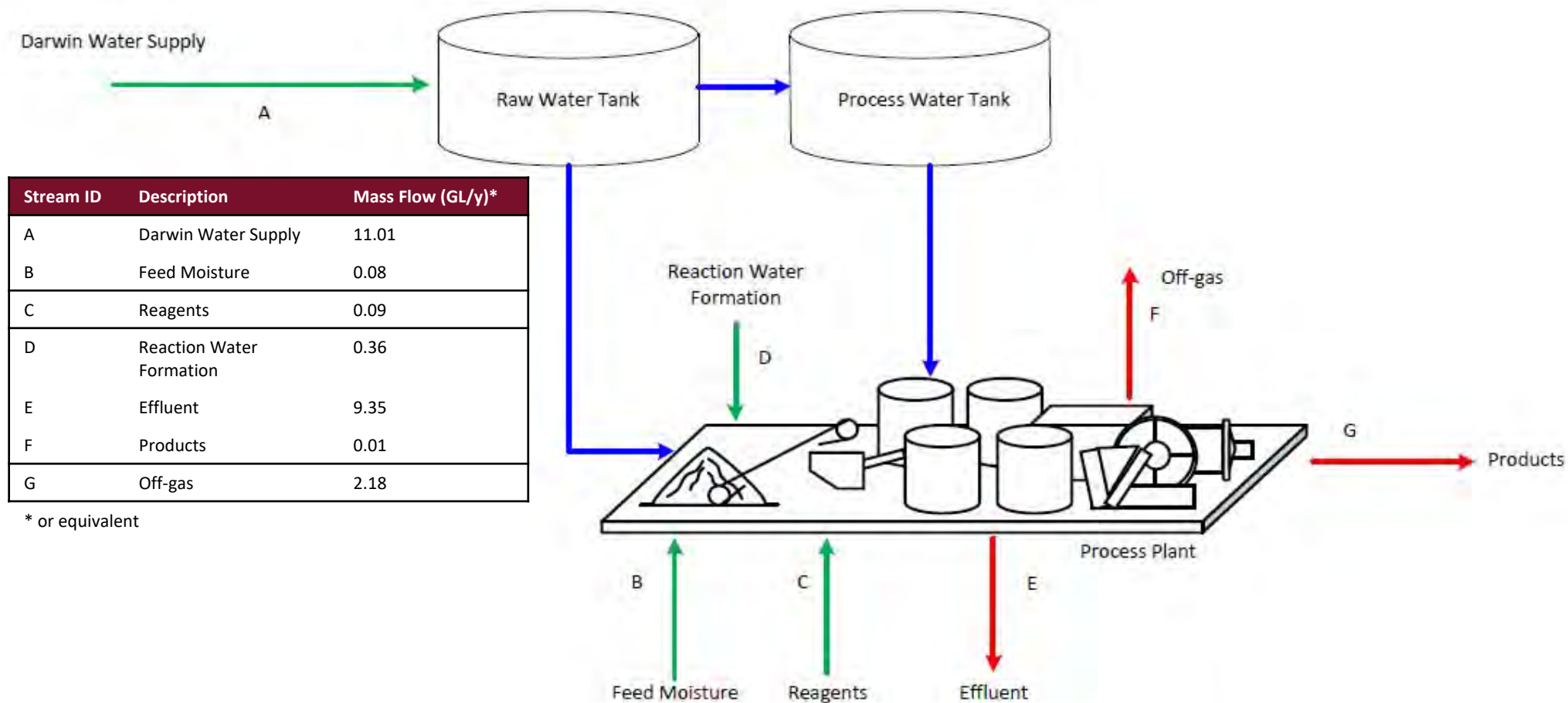


Figure 4-6: Overall Processing Facility Water Balance

4.6.14 Power Supply

4.6.14.1 Power Station

The onsite power requirements will be met by a natural gas fired power plant that will be built, owned and operated by a third party. It is estimated that approximately 5.4 petajoules (**PJ**) of natural gas will be required per year to meet the 54.3 megawatt hour (**MWh**) energy demand of the facility (1.368 PJ per annum). The system type and design are not finalised; TNG are in the process of selecting the third party to deliver the power station for the project.

An on-site electrical power substation will transform the High Voltage power supply to the Processing Facility.

4.6.14.2 Natural Gas

The Project will also require gas to fuel the following units:

- TIVAN™ rotary kiln and burner;
- Acid regeneration spray roaster;
- TIVAN™ residue flash dryer;
- Ferrous oxide roasting;
- Steam; and
- Pigment Plant.

The total gas requirement for Processing Facility equipment is approximately 4.82 PJ/y. This gas will be sourced from the Amadeus Gas Pipeline. The Amadeus Gas Terminal is located southwest of the proposed Processing Facility, and a gas pipeline from this terminal runs directly in front of the Facility location.

Gas pressure in the pipeline outside the Processing Facility is 9,600 kPa (Engineers Australia 2010). Facility equipment will run at 50 kPa. A gas pressure reducing system will be installed to reduce the pressure to the required 50 kPa in pipework coming off the main pipeline. The system design is not finalised but will be engineered to meet noise level requirements.

4.6.15 Communications

Communications infrastructure required for the Project includes:

- Telephone and data for internet;
- Television; and
- Radio communications.

Existing communication lines run directly in front of the Site.

4.6.16 Operational Phase Waste Streams

4.6.16.1 Liquid Waste Streams

Wastewater from the pigment plant, the TIVAN® Process and collected stormwater is pumped to an on-site wastewater treatment plant. In the wastewater treatment plant the pH is first raised by the addition of lime in mixing tanks to facilitate the precipitation of the heavy metals contained within the water along with the base metals. The precipitate predominately contains insoluble metal hydroxides and metal sulfates. The slurry undergoes sedimentation and filtration to produce a filter cake and filtrate.

The filter cake is conveyed to storage bins prior to filling into rotating containers and transported by train to the Mount Peake site for disposal.

The plant will release a single process liquid waste stream (filtrate) from the wastewater treatment plant. The wastewater treatment plant will reduce the toxicants to levels acceptable for discharge prior to disposal through the ocean outfall pipeline into East Arm.

The plant will discharge an average of 0.026 GL of wastewater per day (or 9.5 GL/yr) via the ocean outfall. The peak discharge rate for the plant is 0.032 GL per day.

4.6.16.2 Solid Waste Streams

There are two solid waste streams from the plant:

- Neutralised digest residue (~ 50,000 tpa);
- Dry magnetic separation non-magnetics (~ 570 tpa).

Further tailings characterisation work will be undertaken to confirm tailings characteristics during the detailed design phase.

Neutralised Digest Residue

The neutralised digest residue consists of insoluble waste from the process facility that has been neutralised by limestone to produce insoluble, benign metal hydroxides and gypsum. The neutralised digest residue tailings consist of commercially worthless material and will be disposed of in the Mount Peake Integrated Waste Landform. The neutralised digest residue tailings will be stockpiled before being loaded by front end loader into rotating containers and transported by train to Mount Peake mine site for placement in the integrated waste landform.

Alternatively, third party concrete users will be sought to receive the neutralised digest residue, potentially reducing the volume solid waste from the process facility.

Dry Magnetic Separation Non-Magnetics

The dry magnetic separation non-magnetics consist of entrained magnetic concentrate, non-magnetic ore that was not separated in the beneficiation plant and ash from the coke. The waste is inert and is not expected to contain any contaminants and will be transported by rail back to Mount Peake mine site, for placement in the integrated waste landform.

4.6.16.3 Non-Process Waste Streams

Non-process waste streams will include:

- Recyclables;
- hydrocarbons (e.g. oil and other lubricants);
- hydrocarbon (and other chemical) contaminated materials (e.g. spill kits, cloths and rags, soil);
- oily water;
- inert solid (including domestic) waste; and
- sewage.

Recyclables will be collected and transported by a waste disposal company to a recycling facility in the Darwin region. Separate bins are planned to collect paper, plastic, aluminium and glass. Scrap metal left over from processing and maintenance will also be collected for recycling. Labelled bins will be placed alongside conventional rubbish bins at the Processing Facility and in the mess/ office areas.

Waste oils will be stored in bulk tanks or drums for licensed collection and recycling. Hydrocarbons and other chemical contaminated materials will be stored in sealed containers for collection, treatment and disposal by a licensed contractor.

An oily water separator will be installed to handle water from the equipment wash-down area. Waste recovered from this system will be sealed in drums and removed from site for recycling or disposal by a licensed contractor.

Inert solid waste will be collected regularly by a waste disposal company and disposed off-site at an appropriately licenced landfill.

The offices, mess, administration and first aid areas will be connected to a sewage treatment plant located on-site. The design for the sewage treatment is not finalised but will comply with the *Code of Practice for On-site Wastewater Management* (Department of Health 2014a). It is envisaged that grey water from the sewage treatment plant will be used to irrigate the surrounding landscaping.

4.6.17 Workforce

The operations of the Processing Facility is estimated to require a workforce of approximately 600 personnel. Similar to the construction workforce, the operations workforce is expected to be accommodated by one or more of the following options:

- Existing housing accommodation in Darwin;
- Hotel/motel accommodation within the Greater Darwin area;
- Existing camp accommodation such as the Channel Island Camp operated by Trepang Services or Ahrens operated accommodation village.

4.7 DECOMMISSIONING AND REHABILITATION

TNG intend to leave the Project site in a condition that facilitates relinquishment without any future safety, financial or environmental liability for TNG, land managers, Government or the community. Given the longevity of the Project, it is proposed that TNG provide a full Closure Plan for the site 5 years prior to decommissioning and rehabilitation. The closure plan will be developed in consultation with all stakeholders to ensure an agreed final land use, closure objectives and relinquishment criteria are acceptable and can be met.

4.7.1 Closure objective and completion criteria

Closure objectives and completion criteria have been developed for the Project; these appear as Table 4-5. During the development of a closure plan for the Project the objectives and completion criteria, and the measurable standards to meet completion criteria, will be refined.

4.7.2 Future land use

An option for future land use of the site following decommissioning and rehabilitation is industrial use, given the site is located within an area earmarked for medium to long term industrial use. Alternatively, depending on future local development patterns and surrounding land uses, it may be considered more desirable to rehabilitate and repurpose the site for other land uses, such as conservation, recreation and/ or residential use.

4.7.3 Decommissioning activities

Regardless of the future land use, which will be determined in consultation with key stakeholders prior to completion of the Project, the following will be undertaken upon closure of the Facility:

- All infrastructure will be removed (including processing infrastructure, rail siding, support buildings, service infrastructure etc);
- Underground services will be cut off below surface and buried;
- All concrete footings will be removed, with concrete either disposed off-site or buried in a designated area within the site;
- Carpark areas, access roads and other hardstand areas will be removed and underlying compacted soils ripped;
- A Contaminated Site Assessment will be undertaken in accordance with the *National Environment Protection (Assessment of Site Contamination) Measure, 2013*. If contamination is identified, remedial works will be undertaken to ensure soils are within acceptable criteria prior to relinquishment of the site;
- The topography of the site will be levelled to allow for future land uses.

Table 4-5: Closure objectives and completion criteria for the Project

Aspect	Objective	Completion Criteria	Measurable Standards to Meet Completion Criteria
Safety and public health	Site closure activities undertaken safely.	All site excavations backfilled.	Site inspected by independent auditor and a completion report produced.
		Restricted access to open pits.	
	Public access to closed areas deterred.	Signage where appropriate. Roads no longer required will be rehabilitated.	

Aspect	Objective	Completion Criteria	Measurable Standards to Meet Completion Criteria
Infrastructure	Assets will be disposed or retained in accordance with requirements of stakeholders and regulatory agencies.	Infrastructure decommissioned and removed unless retention is agreed by stakeholders and regulatory agencies. Any buried infrastructure to be defined and markers maintained if required. A transfer agreement is in place for all residual assets.	No infrastructure remaining at closure unless transfer agreement in place; to be confirmed by post closure inspection.
Soils	Contaminated soils do not remain <i>in situ</i> at levels above those acceptable for the agreed post-closure land use.	Any remaining contaminated sites are identified and contaminated sites classification does not impact on suitability of the Project area for proposed post-Project land use. Contaminated soils are remediated, as warranted.	Any sites that pose or threaten to pose serious or material environmental harm, as defined in the <i>Waste Management and Pollution Control Act 1998</i>, are to be assessed in accordance with requirements for environmental audits in the Act and in accordance with the <i>National Environment Protection (Assessment of Site Contamination) Measure (NEPM)</i>. Contaminated soils to be remediated with regard to the <i>Northern Territory Contaminated Land Guidelines</i> where applicable.
Groundwater	Alteration to groundwater from the Project not affecting existing or future uses, users or offsite receivers.	Ground water quality from site monitoring bores is within target parameters established during baseline monitoring.	Post Project groundwater quality from mine site monitoring bores not exceeding contaminant thresholds established during baseline monitoring; or remaining within 10% of baseline levels.
Surface Water	Controlled surface water flows on rehabilitated landforms.	At a catchment and local scale, natural surface water drainage flow functionality is reinstated.	Audit of surface drainage infrastructure upon closure including assessment of connectivity of surface water flow against those established in baseline reports using survey and 'as-built' data.

Aspect	Objective	Completion Criteria	Measurable Standards to Meet Completion Criteria
	Surface water flows from rehabilitated land surfaces integrate with flows from adjacent undisturbed land surfaces ensuring continuity of surface hydrology across the disturbance.	Surface water diversion infrastructure, where retained by agreement with stakeholders, to be functional, effective to its design capacity, remain stable and resist erosion.	
Revegetation	Establish self-sustaining, resilient and stable vegetation comprised of local provenance taxa with minimal weed impacts	Final areas to include representative local provenance endemic flora that contributes to erosion stability, rainfall infiltration/run-off and nutrient cycling.	Rehabilitation to be considered successful when achieving 60% of comparable analogue site for three consecutive monitoring periods.
		Canopy volume, density and species diversity at rehabilitation areas achieving 60% of appropriate analogues.	
		No new weed infestations.	Area of weed infestation recorded annually post closure does not exceed pre Project infestations, for three consecutive (annual) monitoring periods post closure.
		All available topsoil is respread over rehabilitation areas.	Site inspection after rehabilitation works to survey previous soil stockpile locations.
Waste	All non-mineral waste is appropriately disposed or removed from site.	All non-mineral waste disposed in accordance with regulations. Recycling opportunities maximised for appropriate materials.	Completion report upon closure.

4.7.4 Rehabilitation activities

Rehabilitation activities will be staged where it is possible to do so, however it is acknowledged that rehabilitation will predominantly be carried at the conclusion of processing activities. Rehabilitation activities will differ depending on the final land use.

Assuming the site is to be used for industrial uses – the measures outlined above under decommissioning will be completed to leave the site in a state that is ready for the next land user to commence activities.

If the site is to be utilised for recreation or conservation, the following measures will be undertaken.

- Re-placing topsoil over the Project areas;
- Reinstating natural drainage lines in accordance with the site topography;
- Ripping areas to assist with infiltration and surface roughness;
- A combination of seeding the area and planting tube stock of local provenance indigenous native taxa across the site.

If the site is to be used for residential purposes there may be a requirement to provide fill over and above that available at the site. Investigation of requirements for rehabilitation for residential use will be explored further in the Project closure plan.

4.7.5 Unexpected closure

In the very unlikely event of unplanned closure, the following will be undertaken:

- all concentrate, reagents, hazardous materials, waste products and other consumables will be removed from the site;
- Infrastructure will be made safe and all buildings and the premise boundary will be secured to restrict unauthorised access;

Liaison will be undertaken with key stakeholders, particularly applicable Government agencies, to determine the fate of remaining infrastructure.

Where applicable, third parties would be approached to recommission the operation or closure activities would be enacted and the site decommissioned and rehabilitated.

TNG will provide notice to the NT Government at least five years before the end of production to allow discussions on site decommissioning to occur.

4.7.6 Future Land Tenure

It is expected that negotiations with NTG will be ongoing over the life of the Project with regard to future land tenure. Any developments will be noted in future iterations of the Project closure plan.

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**APPROVAL AND
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5. APPROVAL AND REGULATORY FRAMEWORK

5.1 ENVIRONMENTAL IMPACT ASSESSMENT

Formal assessment of environmental impacts potentially associated with significant developments is legislated by the Commonwealth and NT governments. The Commonwealth assesses potential impacts on Matters of National Environmental Significance (**MNES**) under the EPBC Act, while the states and territories have responsibility for matters of state and local significance.

The objectives of the EPBC Act are to:

- Provide for the protection of the environment, especially those aspects of the environment that are MNES;
- Promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources;
- Promote the conservation of biodiversity;
- Provide for the protection and conservation of heritage;
- Promote a cooperative approach to the protection and management of the environment involving governments, the community, land-holders and indigenous peoples;
- Assist in the co-operative implementation of Australia's international environmental responsibilities; and
- Recognise the role of indigenous people in the conservation and ecologically sustainable use of Australia's biodiversity; and
- Promote the use of indigenous peoples' knowledge of biodiversity with the involvement of, and in co-operation with, the owners of the knowledge.

The Proponent identified the potential for the Project to impact MNES and consequently referred it to the DoEE for consideration under the EPBC Act. On 4 January 2016 a delegate of the Commonwealth Minister for the Environment determined that the proposed Project was a controlled action and, as such, required assessment and an approval decision under the EPBC Act. The relevant controlling provisions under the EPBC Act included potential significant impacts on:

- Listed threatened species and communities (sections 18 & 18A); and
- Listed migratory species (sections 20 & 20A).

The NT environmental assessment process is currently administered under the EA Act, the *Environmental Assessment Amendment Act 1994*, and their Administrative Procedures. These Acts and Procedures establish the EIA framework in the NT. These legislative instruments will soon be replaced by the new *Environment Protection Act 2019 (EP Act)* and associated Regulations. Following commencement of the new EP Act, in accordance with sections 296, the Project will continue to be assessed under the EA Act, albeit with a modified process. The Project will also require an environmental approval from the Minister for Environment and Natural Resources, in accordance with section 301 of the EP Act. The object of the EA Act is to ensure that matters affecting the environment to a significant extent are fully examined and taken into account in decisions by the NTG. There are two levels of formal assessment defined under the NT assessment process: EIS and Public Environmental Report.

An NOI providing formal notification of the Project was submitted to the NT EPA on 27 October 2015 for consideration under the EA Act. The NT EPA considered that potential environmental impacts of the Project could not be adequately characterised “without further studies and a more comprehensive assessment”. Assessment of the Project under the EA Act at the level of an EIS was therefore recommended (15 January 2016). The NT EPA decision was based on the following risks and potential environmental impacts:

- Risks to biodiversity values of adjacent areas, including nationally significant mangrove communities, marine ecosystems, local fisheries and listed threatened species;
- Environmental risks associated with vegetation clearing, erosion and sediment control, uncontrolled discharges, dust, spills, disturbance of ASS, contamination of soils, surface water and/ or ground water;
- Potential for Project noise, lighting and emissions to impact on existing residents, potential for future residential development of the area, and other sensitive receptors;
- Potential for introduction and / or spread of weeds;
- Risks of exposure of workers to high biting insect numbers;
- Environmental risks associated with waste streams and waste management practices;
- Risks associated with transport, handling and/ or storage of reagents, products and/ or hazardous materials;
- Public health and safety risks associated with siting a potential major hazard facility adjacent to Darwin Harbour; and
- Potential for impacts on service infrastructure and service supply capacities, due to Project demands.

The 2015 NOI, and consultation with relevant agencies, informed preparation of the TOR by the NT EPA (Appendix A). The purpose of the TOR is to prescribe the environmental factors that must be addressed by the Draft EIS. The TOR was issued on 20 May 2016 and subsequently extended to 20 November 2019 on request of the Proponent.

This Draft EIS contains data gathered by the Proponent during the NOI process, information gathered subsequently during supporting studies and stakeholder consultation, environmental risk assessment and impact mitigation measures to fulfil the requirements of the TOR. It is now released for public and regulatory review. The public and government agencies have a minimum review period of twelve weeks from the date of submission of the draft EIS to submit comments to the NT EPA.

Any comments received by the close of the public review period will be addressed in a Supplement to the EIS, which will be prepared by the Proponent and submitted to the NT EPA for assessment. If the Supplement is submitted after commencement of the new EP Act (as anticipated), the Supplement will be made available for public comment for 15 business days (EP Act s296(2)). Upon completion of assessment, the NT EPA will prepare an Environmental Assessment Report and a draft Environmental Approval to be provided to the Minister for Environment and Natural Resources. If granted by the Minister, the Approval will regulate the management of environmental impacts potentially associated with the Project. Further approvals will also be necessary prior to commencement of the Project, including rezoning under the *Planning Act*.

In December 2014 an agreement between the Commonwealth and NT governments was signed to enable the bilateral assessment of an EIS, should one be considered necessary by both the Commonwealth and NT governments. This Project is being assessed by the NT EPA under the bilateral agreement. It is noted that the NT EPA will liaise with the DoEE throughout the approval process to ensure that EIA is undertaken at a standard satisfactory to both agencies.

5.2 ENVIRONMENTAL ASSESSMENT GUIDELINES

The NT EPA has prepared environmental assessment guidelines to assist in the preparation of EIS documents. This EIS has been prepared with reference to those of relevance to the Project, including:

- *General Guidance for Proponents Preparing an Environmental Impact Statement* (NT EPA 2019)
- *Guidelines for Assessment of Impacts on Terrestrial Biodiversity* (NT EPA 2013a);
- *Guidelines for the Preparation of an Economic and Social Impact Assessment* (NT EPA 2013b);
- *Guidelines for Consultants Reporting on Environmental Issues*
- *Guidelines on Environmental Offsets and Associated Approval Conditions* (NT EPA 2013c);
- *Guideline for the Preparation of an Environmental Management Plan* (NT EPA 2015a);
- *Guidance on Adaptive Management* (NT EPA 2018a);
- *Opportunities and Timeframes for Community Engagement in the Environmental Impact Assessment Process* (NT EPA 2018b); and
- *NT EPA Environmental Factors and Objectives* (NT EPA 2018c).

In addition to the EIA guidance listed above, the NT EPA has also produced a series of environmental guidelines relating to waste and pollution. This EIS has been prepared with reference to waste and pollution guidelines of relevance to the Project, including:

- *Australian and New Zealand Guidelines (ANZG) for Fresh and Marine Water Quality* (ANZG 2000)
- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG 2018)
- *Charter: National Water Quality Management Strategy* (Commonwealth of Australia 2018)
- *Water Quality Objectives for the Darwin Harbour Region: Background Document* (NRETAS 2010)
- *Guideline for Reporting on Environmental Monitoring* (NT EP 2016a);
- *Guideline: Recommended Land Use Separation Distances* (NT EP 2017a)
- *Guidelines for the Siting, Design and Management of Solid Waste Disposal Sites In the Northern Territory* (NT EPA 2013d);
- *Guidelines on Conceptual Site Models* (NT EPA 2013e)
- *Guidelines on Mixing Zones* (NT EPA 2013f);
- *Guidelines to Prevent Pollution from Building Sites* (NT EPA 2015b);
- *Noise guidelines for development sites in the Northern Territory* (NT EPA 2014);
- *Northern Territory Contaminated Land Guideline* (NT EPA 2017b); and
- *Northern Territory Noise Management Framework Guideline* (NT EPA 2018d).

As the Project is being assessed under the EPBC Act (as well as the EA Act), the following guidance published by the Australian Government was also referenced during the Project EIA process:

- *Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy* (Department of Sustainability, Environment, Water, Population and Communities 2012a);
- *EPBC Act Policy Statement 3.21: Industry Guidelines for Avoiding, Assessing and Mitigating Impacts on EPBC Act Listed Migratory Shorebird Species* (Department of the Environment and Energy 2017);
- *Matters of National Environmental Significance – Significant Impact Guidelines 1.1, Environment Protection and Biodiversity Conservation Act 1999* (Department of the Environment 2013);
- *Survey Guidelines for Australia's Threatened Birds* (Department of the Environment, Water, Heritage and the Arts 2010a);
- *Survey Guidelines for Australia's Threatened Fish* (Department of Sustainability, Environment, Water, Population and Communities 2011a); and
- *Survey Guidelines for Australia's Threatened Mammals* (Department of Sustainability, Environment, Water, Population and Communities 2011b).

Guidelines from other states and territories have also been consulted in the development of this Draft EIS and associated technical studies.

5.3 OTHER APPROVALS

5.3.1 Commonwealth Legislation

Commonwealth legislation applicable to the Project and the approvals/ permits required are summarised below.

5.3.1.1 Aboriginal Land Rights (Northern Territory) Act 1976

This Act provides for the preservation and protection from injury or desecration of areas and objects in Australia and in Australian waters, being areas and objects that are of particular significance to Aboriginals in accordance with Aboriginal tradition.

5.3.1.2 National Environment Protection (Assessment of Site Contamination) Measure 1999

The purpose of this NEPM is to establish a nationally consistent approach to the assessment of site contamination to ensure sound environmental management practices by the community, which includes regulators, site assessors, contaminated land auditors, landowners, developers and industry. The NEPM contains two schedules:

- Schedule A identifies the recommended process for the assessment of site contamination.
- Schedule B identifies 10 general guidelines for the assessment of site contamination.

5.3.1.3 Australian Heritage Council Act 2003

This Act establishes the Australian Heritage Council, a statutory body replacing the Australian Heritage Commission as the Australian Government's principal adviser on heritage matters. The Australian Heritage Council is administered by the Heritage Division of the DoEE and its main responsibilities are to:

- Assess places for the National Heritage List and the Commonwealth Heritage List;
- Nominate places for inclusion in the National Heritage List or Commonwealth Heritage List;
- Promote the identification, assessment, conservation and monitoring of heritage; and
- Advise the Minister on various heritage matters including the preparation and amendment of heritage strategies and management plans for Commonwealth areas and agencies.

The Australian Heritage Council also makes assessments under the EPBC Act, and performs any other functions conferred on it by the EPBC Act.

5.3.1.4 Australian Jobs Act 2013

An Australian Industry Participation Plan, outlining how the Proponent will provide opportunities for Australian goods and services providers, must be submitted to the Department of Industry, Innovation and Science for major projects (> \$500 million).

5.3.1.5 Environment Protection and Biodiversity Conservation Act 1999

Under the EPBC Act, actions that have, or are likely to have, a significant impact on a MNES require approval from the federal Minister for the Environment. The DoEE administers this Act and has established a formal referral and assessment process; proponents (or other interested parties) can refer a proposal to the DoEE for assessment under the EPBC Act if it is considered possible that the proposal will significantly impact one or more MNES.

The Project was referred by the Proponent on 11 November 2015 and was subsequently determined to be a controlled action requiring development of an EIS, which is being assessed under the Bilateral Agreement.

5.3.1.6 Hazardous Waste (Regulation of Exports and Imports) Act 1989

The export, import and transit of hazardous waste is regulated by this Act. It ensures that hazardous waste is managed in an environmentally sound manner so humans and the environment, both within and outside Australia, are protected from harmful effects of the waste.

5.3.1.7 National Greenhouse and Energy Reporting Act 2007

Corporations that emit GHG, produce energy, or consume energy at or above specified quantities are required to register and report under this Act. The Project will trigger energy consumption and GHG reporting thresholds in every year of operations.

5.3.1.8 Native Title Act 1993

Lot 1817 is vacant Crown Land. The Register of Native Title Claims, Register of Indigenous Land Use agreements, Native Title Register and unregistered applications indicate that section 1817, Hundred of Ayers was assessed under Native Title application DC96/4 Darwin Larrakia. It was determined that 'Native Title does not exist'.

5.3.1.9 Northern Territory Legislation

NT legislation applicable to the Project and the approvals/ permits required are summarised below.

5.3.1.10 Aboriginal Land Act

This Act provides access to areas which are on, border or are adjacent to Aboriginal Land, whether land or sea.

5.3.1.11 Biological Control Act

This act provides for the biological control of pests in the NT and related purposes. For the purposes of this Act, an organism of a particular kind is considered controllable by biological means if, and only if, the organism can be controlled by the release of a live organism of another kind.

5.3.1.12 Building Act

This Act establishes technical standards for buildings, the registration of building practitioners and certifiers, the regulation of building matters, the granting of building and occupancy permits and establishment of a building appeal process, and for related purposes. A person shall not carry out building work unless a building permit in respect of the work has been granted and is in force under this Act; the work must be carried out in accordance with the permit.

5.3.1.13 Bushfires Act

The NT Fire and Rescue Service is established by this Act, along with the operational and emergency response activities of the Service, the protection of life, property and the environment against fires and other emergencies, and related matters. The Act states:

- Fires must not be started in a declared Fire Protection Zone without a current permit, and
- Fires must not be started on a declared fire ban day, or in a fire ban area contrary to the fire ban.

5.3.1.14 Control of Roads Act

This Act provides for the administration and control of roads, including the maintenance of roads and construction of roads.

5.3.1.15 Dangerous Goods (Road and Rail Transport) Act

This Act makes provision for safety in the transport of dangerous goods by road as part of the system of nationally consistent road transport laws and to make provision for safety in the transport of dangerous goods by rail. Common guidelines are in place so that dangerous goods can be transported between states and territories. This eliminates confusion of knowing what procedures should be followed in the event of accident or spill.

5.3.1.16 Environmental Offences and Penalties Act

A penalty structure for environmental offences based around four offence levels is established by this Act. Penalties for infringement notices are also defined. These penalties are referenced in a variety of environmental statutes such as the *Waste Management and Pollution Control Act*, the *Water Act* and the *Mining Management Act*, which create the actual offence provisions. The effect is to create a penalty structure common amongst different legislation.

5.3.1.17 Energy Pipeline Act

This Act makes provision for the construction, operation, maintenance and cessation of use or abandonment of pipelines for the conveyance of energy-producing hydrocarbons, and for related purposes.

5.3.1.18 Fire and Emergency Act

The NT Fire and Rescue Service is established by this Act. It legislates the operational and emergency response activities of the Service: the protection of life, property and the environment against fires and other emergencies, and related purposes.

5.3.1.19 Fisheries Act

Flexible management of aquatic resources in the NT and stewardship of aquatic resources, as set out in this Act, promote fairness, equity and access to aquatic reserves. The Act outlines licensing provisions for a range of activities including taking aquatic life for research purposes.

5.3.1.20 Heritage Act

The object of this Act is to provide for the conservation of the NT's cultural and natural heritage by:

- Declaring places and objects of heritage significance to be heritage places and objects;
- Declaring classes of places and objects of heritage significance to be protected;
- Establishing the Heritage Council;
- Providing for heritage agreements to encourage the conservation, use and management of heritage places and objects;
- Regulating work on heritage places and objects; and
- Establishing enforcement and offence provisions.

5.3.1.21 Litter Act

Litter management in public places and vacant Crown land is provided for by this Act. It also requires the removal of a dead animal from a public place or vacant Crown land that is used by vehicular or pedestrian traffic.

5.3.1.22 National Environment Protection Council (Northern Territory) Act

The National Environment Protection Council (**NEPC**), which is responsible for preparing NEPMs, was established under this Act, and similar legislation in each state and territory. The object of this Act is to ensure that, by means of the establishment and operation of the NEPC:

- People enjoy the benefit of equivalent protection from air, water or soil pollution and from noise, wherever they live in Australia; and
- Decisions of the business community are not distorted, and markets are not fragmented, by variations between participating jurisdictions in relation to the adoption or implementation of major environment protection measures.

5.3.1.23 Northern Territory Aboriginal Sacred Sites Act

In recognition of the need to preserve and enhance Aboriginal cultural tradition, this Act establishes a procedure for the protection and registration of sacred sites. This includes providing for conditional entry onto sacred sites, establishing procedures for the avoidance of sacred sites in the development and use of land, establishing an Authority for the purposes of the Act, and establishing a procedure for Ministerial review of Authority decisions.

An Authority Certificate sets out conditions under which work may be carried out; TNG has been granted an Authority Certificate by the AAPA.

5.3.1.24 Planning Act

This is an Act to provide for appropriate and orderly planning and control of the use and development of land, and for related purposes. The objects of this Act are to plan for, and provide a framework of controls for, the orderly use and development of land. These objects are achieved by:

- Strategic planning of land use and development and for the sustainable use of resources;
- Strategic planning of transport corridors and other public infrastructure;

- Effective controls and guidelines for the appropriate use of land, having regard to its capabilities and limitations;
- Control of development to provide protection of the natural environment, including by sustainable use of land and water resources;
- Minimising adverse impacts of development on existing amenity and, wherever possible, ensuring that amenity is enhanced as a result of development;
- Ensuring, as far as possible, that planning reflects the wishes and needs of the community through appropriate public consultation and input in both the formulation and implementation of planning schemes; and
- Fair and open decision making and review processes.

The Project will require development consent from the Minister for Lands and Planning under this Act, with consideration given to the NT EPA's assessment of this EIS, prior to commencement of the Project.

5.3.1.25 Plant Health Act

The control of pests, certification of plant health and related matters are regulated by this Act. The objects of the Act are:

- To ensure appropriate actions can be taken for the control of pests; and
- To facilitate the production and trading of plants and plant products that are free from pests.

5.3.1.26 Public and Environmental Health Act

This Act has the following objects:

- To protect and promote the health of individuals and communities in the Territory;
- To provide a flexible capacity to protect the health of particular individuals and communities in the Territory from emerging environmental conditions, or public and environmental health issues, that may impact on their health and wellbeing;
- To enable special action to be taken to protect the health of particular individuals and communities in the Territory who are at public health risk or facing particular health problems;
- To improve the public and environmental health outcomes of all Territorians in partnership with individuals and the community; and
- To monitor, assess and control environmental conditions, factors and agents, facilities and equipment and activities, services and products that impact on or may impact on public and environmental health.

Of particular relevance to the Project, this Act is directed at preventing pollution of watercourses and water supplies in the NT. It also regulates management of biting insects. In carrying out the objects of this Act, regard should be had to the precautionary principle.

5.3.1.27 Rail Safety (National Uniform Legislation) Act

A national law regulating rail safety is applied as a law of the NT under this Act.

The Council of Australian Governments in 2012 committed to a national reform of rail safety regulation, which has seen the establishment of a single national rail safety regulator, the Office of the National Rail Safety Regulator, to administer a nationally consistent rail safety law, the Rail Safety National Law.

The Rail Safety National Law was first enacted in South Australia and each state and territory has passed a law – the *Rail Safety (National Uniform Legislation) Act* in the NT – explaining that the Rail Safety National Law (being

a schedule to the South Australian law) is the rail safety law in that state or territory or replicates that law. The law establishes the Office of the National Rail Safety Regulator as the body responsible for rail safety regulation in that state or territory.

5.3.1.28 Soil Conservation and Land Utilisation Act

This Act provides for the prevention of soil erosion and for the conservation and reclamation of soil. It makes provisions for restricted construction activities, that may result in land clearing, driving vehicles and causing water or other fluid to be drained or to flow over an area, which may cause further damage to the land that is not environmentally stable, such as areas suffering soil erosion or areas that have the potential to erode.

5.3.1.29 Territory Parks and Wildlife Conservation Act

Parks and Reserves are established under this Act. It also provides for the study, protection, conservation and sustainable utilisation of wildlife, and sets aside areas of the NT as parks and conservation areas that may not be developed.

5.3.1.30 Waste Management and Pollution Control Act

The objectives of this Act are:

- To protect, and where practicable to restore and enhance the quality of, the Territory environment by:
 - o Preventing pollution;
 - o Reducing the likelihood of pollution occurring;
 - o Effectively responding to pollution;
 - o Avoiding and reducing the generation of waste;
 - o Increasing the reuse and recycling of waste; and
 - o Effectively managing waste disposal;
- To facilitate encouragement of ecologically sustainable development; and
- The implementation of NEPMs under the *National Environment Protection Council (Northern Territory) Act*.

This Act is designed to prevent contamination of the surrounding environment, which includes soil, air, and water. It imposes a general duty on personnel who conduct an activity, or perform an action, that causes or is likely to cause pollution resulting in environmental harm, or that generates or is likely to generate waste.

5.3.1.31 Water Act

This Act provides for the investigation, use, control, protection, management and administration of water resources in the NT. Of particular relevance to the Project, under the Act it is an offence to:

- Cause waste to come into contact with water or water to be polluted, unless authorised to do so under this or any other law in force in the NT and in accordance with that authorisation;
- Engage in conduct that interferes with a waterway and is not authorised under this Act to interfere with the waterway;
- Do bore work without holding a drilling licence that authorises the bore work;
- Contravene a term or condition of a drilling licence; and
- Do bore work without a permit granted under section 57 of the Act.

A waste discharge licence may be granted under this Act, granting a person a licence to carry out an action that would otherwise be an offence against this Act.

Water quality standards are declared by notice in the Gazette under this Act.

5.3.1.32 Water Supply and Sewerage Services Act

This Act regulates the water supply and sewerage services industries in the NT. The objects of this Act are to:

- Promote the safe and efficient provision of water supply and sewerage services;
- Establish and enforce standards of service in water supply and sewerage services;
- Facilitate the provision of financially viable water supply and sewerage services; and
- Protect the interests of customers.

Of particular relevance to the Project, under the Act a person must not discharge trade waste, storm water, or any other object or substance that is not domestic sewage into sewerage infrastructure except with the written approval of the licensee.

5.3.1.33 Weeds Management Act

Weeds can potentially impact the economy, community, industry and environment. The purpose of this Act is to:

- Prevent the spread of weeds in, into and out of the Territory and to ensure that the management of weeds is an integral component of land management in accordance with the *Northern Territory Weeds Management Strategy 1996 – 2005* or any other strategy adopted to control weeds in the Territory;
- Ensure there is community consultation in the creation of weed management plans; and
- Ensure that there is community responsibility in implementing weed management plans.

The Minister may, by notice in the Gazette:

- Declare a plant to be a declared weed and may classify the declared weed for the purposes of preventing the plant entering into, or managing the plant in, the NT; and
- Approve a plan as a weed management plan.

The owner and occupier of land must:

- Take all reasonable measures to prevent the land being infested with a declared weed;
- Take all reasonable measures to prevent a declared weed or potential weed on the land spreading to other land; and
- Within 14 days after first becoming aware of a declared weed that has not previously been, or known to have been, present on the land, notify an officer of the presence of the declared weed.

The owner and occupier of land on which a declared weed or potential weed is present must comply with a weed management plan relating to the weed and must dispose of the weed only on the land or at a designated weed disposal area.

5.3.1.34 Work Health and Safety (National Uniform Legislation) Act 2011

This Act was developed based on Model legislation that has been adopted by the Commonwealth and most states to improve the work health and safety of all Australian workers and to standardise work health and safety legislation across Australia. Objectives of this legislation include, but not limited to:

- protecting workers and other persons against harm to their health, safety and welfare through the elimination or minimisation of risks arising from work;

- promoting the provision of advice, information, education and training in relation to work health and safety;
- securing compliance with this Act through effective and appropriate compliance and enforcement measures; and
- providing a framework for continuous improvement and progressively higher standards of work health and safety.

The Project, which will require a Major Hazard Facility license under the Act, will need to comply with all Work Health and Safety legislation.

5.3.2 Current Agreements

5.3.2.1 Extractive Industry

The site is currently leased from the NTG by private companies under extractive resources licence/s for quarrying activities. One Extractive Mineral Permit Northern licence and one Mineral Authority licence are current for the Site (NTG 2019):

- EMPN1136; and
- MA22264.

The NTG has advised the Proponent that a requirement of the existing extractive licence agreements on site (held by others) would be for the site to be clean filled, levelled and compacted. The locations of these appear in Figure 5-1: Location of extractive resources licences at Lot 1817 Figure 5-1.

5.3.2.2 Land Acquisition

The land site proposed for the Darwin Processing Facility is currently Crown Land; TNG is continuing discussions with the NTG on suitable terms for acquisition of Lot 1817.



Figure 5-1: Locations of extractive resources licences at Lot 1817



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6. STAKEHOLDER ENGAGEMENT AND CONSULTATION

Early consultation undertaken by TNG has been assisted through the engagement of local communication experts, Elton Consulting. This chapter provides an overview of the stakeholder consultation principles and approach undertaken to date and summarises the key findings. Opportunities for stakeholders to further engage with the project through the EIS and beyond are also discussed.

6.1 CONSULTATION APPROACH

6.1.1 Principles of Stakeholder Engagement

TNG has given consideration to five principles in developing a stakeholder engagement strategy; communication, transparency, collaboration, inclusiveness and integrity.

- **Communication** – Communication will be open, accessible, clearly defined, two-way and appropriate.
- **Transparency** – The process and outcomes of community and stakeholder engagement will, wherever possible, be made open and transparent, will be agreed upon and documented.
- **Collaboration** – A cooperative and collaborative approach will be adopted to seek mutually beneficial outcomes.
- **Inclusiveness** – Stakeholders will be identified early and involved throughout the engagement process.
- **Integrity** – Community and stakeholder engagement should establish and foster mutual trust and respect.

6.1.2 Objectives of Engagement

Broadly, stakeholder engagement objectives for the Project are to:

- Identify key risks at an early stage, ensuring they are promptly addressed;
- Ensure that community members, groups and surrounding land users are informed regarding progress of the Project and have an opportunity to comment;
- Establish a safe environment for staff and the public through early liaison regarding subjects such as traffic management on public roads;
- Establish key Project area attributes and mitigate impacts where practicable; and
- Establish long term relationships with key stakeholders.

The format and frequency of communications with stakeholders and decision-makers has varied depending on the nature of matters under discussion and the rate of progress of the Project aspects and technical studies.

6.1.3 Methods of Consultation

Methods of consultation employed by TNG include:

- Project briefings and presentations;
- Stakeholder workshops;
- Meetings and discussions;
- Written communications;
- Company announcements;
- Webpage updates;

- Fact sheets;
- Radio media;
- Telephone discussions; and
- Community displays and engagement events.

In addition to the above, Project information has been available through the NT EPA and EPBC Act referral processes, including release of the NOI and development of the TOR.

6.2 KEY STAKEHOLDERS

Stakeholders have been identified based on an assessment of the Project location, surrounding land users, significant elements of the proposed impact area that may be of interest to non-government organisations or community groups, and potential Project environmental impacts and risks.

Table 6-1 lists key stakeholders identified for the Project; this list is dynamic and will be updated throughout the Project life as necessary.

Table 6-1: Key stakeholders for the Darwin Processing Facility

Stakeholder Group	Specific Stakeholder
Political (State)	Chief Minister
	Deputy Chief Minister
	Minister for Northern Australia
	Minister for Trade and Major Projects
	Minister for Business and Innovation
	Treasurer
	Minister for Environment and Natural Resources
	Minister for Infrastructure, Planning and Logistics
	Minister for Climate Change
	Minister for Renewables, Energy and Essential Services
	Minister for Primary Industry and Resources
	Member for Daly (site electorate)
	Member for Blain (nearest residential area electorate)
	Member for Goyder (nearest rural electorate)
	Member for Spillet (adjoining electorate)
Political (Local Council)	Mayor
	Local Councillor (South Ward)
NT Government Departments	Department of Trade, Innovation and Business
	Department of Environment and Natural Resources
	Department of Planning, Infrastructure and Logistics
	Department of Primary Industry and Resources
	Department of Renewables, Energy and Essential Services
	Department of Tourism, Sport and Culture
	Power and Water Corporation
	Land Development Corporation

Stakeholder Group	Specific Stakeholder
NTG Boards and Committees	NT Environment Protection Authority
	Development Consent Authority
	Litchfield Division Development Consent Authority
	NT Planning Commission
	Major Projects Control Group
	Aboriginal Areas Protection Authority
Local Councils	Litchfield Council
	City of Palmerston
	City of Darwin
Industry Groups, Community Groups and Others	Landbridge Darwin Port
	Environment Centre NT
	Darwin Harbour Advisory Committee
	Planning Action Network
	Rural Residents' Rights Group
	Environmental Defenders Office
	Amateur Fishermen's Association of the Northern Territory
	Amadeus Gas Pipeline
	AustralAsia Railway Corporation
	Genesee Wyoming Australia
	Larrakia Nation Aboriginal Corporation
	Ichthys LNG Plant, Bladin Point
	Channel Island Power Station
	Darwin LNG, Wickham Point
	Bellamack Community and Residents
	Virginia Community and Residents
	Adjoining or nearby landowners
	General Community
	Extractive industry licence holders (x2)

TNG has undertaken active consultation with key stakeholders since 2015, with consultation continuing at present and beyond the submission of this Draft EIS.

6.3 TARGETED CONSULTATION

6.3.1 Social Impact Assessment

Targeted community engagement was undertaken as part of the preparation of the Project Socio-economic Impact Assessment (**SEIA**). A range of engagement activities were conducted by Elton Consulting and APM personnel during August 2019 to inform the SEIA and the EIS. Table 6-2 provides a summary of the consultation undertaken; the complete SEIA report is provided as Appendix F. Plate 6-1 includes photographs of community event displays.

Table 6-2: Stakeholder and community engagement conducted as part of the SEIA

Date	Stakeholder	Form of Engagement
15 April 2019	NT EPA NT Department of the Chief Minister	Meeting to discuss objectives and requirements of the SEIA.
8 August 2019	All Government Departments, Councils, and identified stakeholders	Written advice of the Project.
13 August 2019	Members of the Legislative Assembly (with local representation) - The Hon Kezia Purick, Member for Goyder. - The Hon Gary Higgins, Member for Daly. - The Hon Gerry Wood, Member for Nelson - The Hon Lia Finocchiaro, Member for Spillet - The Hon Terry Mills, Member for Blain	Written advice, and telephone contact.
14 August 2019	Litchfield Council	Meeting to review Project and specific SEIA focussed engagement.
16 August 2019	The Hon Tony Sievers, Member for Brennan	Discussion at Palmerston Market stall to introduce Project, and specific SEIA focussed engagement.
19 August 2019	The Hon Gerry Wood, Member for Nelson	Meeting to review Project and specific SEIA focussed engagement
19 August 2019	City of Palmerston, Planning and Economic Development Division	Provision of written notification and telephone engagement.
19 August 2019	Environment Centre NT	Meeting to introduce Project and discuss potential interest areas.
22 August 2019	City of Darwin, Planning Division	Meeting to review Project and specific SEIA focussed engagement.
23 August 2019	NT Chamber of Commerce	Meeting to review Project and specific SEIA focussed engagement.
27 August 2019	Darwin Harbour Advisory Committee	Presentation to introduce Project to committee members.
Community (No. of active discussions)		
15 – 17 August 2019	Palmerston Library (8) Gateway Shopping Centre (13) Smith Street Mall (13) Casuarina Square (13) Palmerston Markets (11) Elizabeth River Boat Ramp (15)	Information Displays Active discussions

6.3.2 Other Key Stakeholders

The Darwin Processing Facility has been nominated for Major Project status through the NTG. As such, TNG are in regular consultation with key Government departments through Project Control Group meetings and additional, specific consultation undertaken outside of that forum.



Plate 6-1: Community Consultation Displays

6.4 CONSULTATION OUTCOMES

Consultation has been successful in improving awareness of the Project, identifying areas of interest regarding Project activities and determining opportunities for environmental and social initiatives.

Table 6-3 provides a summary of feedback obtained for the Project, based on targeted and ongoing consultation undertaken to date.

Table 6-3: Summary of feedback provided by stakeholders between 2016 – 2019

Category	Stakeholder Group	Summary of Feedback	TNG Response
Fishing (amenity / lifestyle)	- General Community Members - Amateur Fisherman's Association of the NT - Darwin Harbour Advisory Committee - Department of Environment and Natural Resources (DENR)	- Concern regarding maintaining water quality in Darwin Harbour to support recreational fishing. - Concern regarding ongoing access to Darwin Harbour / Elizabeth River boat ramp	- Project activities managed to mitigate impacts on marine life with onward effects to the fishing culture. - Access to the boat ramp will not be affected by this proposal.
Traffic Impacts	- General Community Members - Litchfield Council	Concern regarding increased traffic associated with construction.	- Develop a construction and operational traffic management plan. - Consider use of buses during both the

Category	Stakeholder Group	Summary of Feedback	TNG Response
	- Department of Infrastructure, Planning and Logistics - Local Political Members - LDC	- Concern that self-driving to the Facility would significantly impact traffic in the area. - Consideration should be given to the use of buses. - Questions raised regarding number and timing of bus movements transporting workers to site. - Consideration should be given to peak traffic times when determining bus schedules. - Concerns that large areas of parking would change the rural character. - Information sought on proposed traffic routes into and out of site.	- construction and operational phases of the Project. - Consider utilisation of existing park and ride facilities in Darwin, wherever possible. - Undertake a Traffic Impact Assessment for the Project and present findings in the EIS - Liaise with applicable Government departments regarding the road network associated with the site.
Supporting Infrastructure	- General Community Members - Local Councils - Power and Water Corporation (PWC) - Environment Centre NT	- The need for supporting infrastructure during the construction stage was noted by, in particular, those with close knowledge of past major projects. - Utility requirements for the Project were raised, with ability to meet demand queried. - Impacts from increased rail operations.	- Investment in infrastructure in the right places. - Ensuring employees have transport to existing infrastructure (applicable to FIFO). - Investigate use of infrastructure remaining following the construction phase of INPEX – e.g. workers camp in Howard Springs. - Continual liaison with PWC regarding power and water demands and associated infrastructure requirements. - Liaison with a third party and Government departments regarding efficient rail operations.
Noise Impact	General Community Members	A limited number of community members questioned whether noise impacts will affect nearby residents.	Complete a Noise Impact Assessment for the Project. Incorporate results and any mitigating measures into the EIS.
Visual Impact	General Community Members	- A limited number of community members questioned what the extent of light impacts would be from the Project. - Amenity of the Elizabeth River Boat Ramp, and the sense of being away from the city, was raised as a concern.	- TNG relocated key Processing infrastructure to the southern peninsula of the site to reduce visual and noise impacts. - Retention of mangroves to limit visual impact from Elizabeth River. - Incorporate mitigation measures into the EIS.
Biological Impacts	General Community Members	A limited number of community members	No impact on mangroves from the Project, with the

Category	Stakeholder Group	Summary of Feedback	TNG Response
	- DENR - Environment Centre NT - Darwin Harbour Advisory Committee	were interested in biological aspects, predominantly mangrove impacts. - Interest in the biological attributes of the site and the use of existing disturbances. - Questions regarding the extent of the disturbance footprint. - Concerns raised regarding impacts to the marine biota.	exception of construction of a small pipeline corridor adjacent to the Elizabeth River Bridge. - Present findings of biological surveys and any proposed mitigation measures in the EIS. - Utilise existing disturbance wherever possible. - Undertaken marine impact assessments and present findings in the EIS. - Continue liaison with DENR regarding biological aspects of the site.
Stormwater Management	- Litchfield Council - DENR - Environment Centre NT - Darwin Harbour Advisory Committee	- Interest in the proposed management of stormwater from the site. - Concern regarding potential pathways for contamination of the Elizabeth River through stormwater.	Incorporate stormwater management into the EIS.
Employment	- General Community Members - Local Councils - Department of Trade, Business and Innovation - Local Political Members	- The need for economic stimulus and job creation within Darwin and the NT was raised and recognition that the Project could positively contribute to the economy. - Questions raised whether the Project would create local employment during both the construction and operational phases.	- Focus on the use of local personnel and businesses wherever possible, during both phases of the Project. - Develop a long term strategy for sourcing and upskilling local personnel.
Interaction with other Projects	- General Community Members - Local Industry Representatives - Local Political Members - Local Councils - LDC	- Concerns raised that Project activities could affect other operations in the area (e.g. water contamination impacts on industries downstream). - Cumulative impact when considering other operating projects. - Questions raised regarding potential synergies with other projects.	- Include consideration of cumulative impacts in the EIS. - Continue liaison with other major projects to identify synergies and mitigate any potential impacts on their operations.

The above is not an exhaustive list. Further detail is provided in the SEIA (Appendix F).

6.5 FUTURE ENGAGEMENT OPPORTUNITIES

Stakeholder consultation will be continuous throughout the Project life. Objectives of ongoing consultation include:

- Keeping community members, groups and nearby land users up to date on Project progress and amendments;
- Addressing any complaints or grievances that are raised during Project construction and operations;
- Ensuring Government departments are kept up to date with any Project changes or issues that may arise, including updating approval documents if required;
- Ensuring closure planning is informed by key stakeholders and that all relevant stakeholders have agreed to the proposed end land uses;
- Identifying whether any infrastructure will be retained for end land users and ensuring appropriate approvals and transfer agreements are in place; and
- Ensuring all completion criteria have been met to the satisfaction of Government Regulators.

Potential methods of consultation employed by TNG throughout the operational life of the Project are identified in Table 6-4.

Ongoing consultation throughout the life of the Project will be guided through the development of a Community and Stakeholder Engagement Plan. This plan will be dynamic and will be reviewed and updated regularly to ensure currency is maintained.

Table 6-4: Ongoing stakeholder consultation methodology

Method	Target Stakeholder	Purpose
EIS Public Comment Period	All Stakeholders	• Detail Project description, impact assessment and proposed mitigating measures • Provide an opportunity for all stakeholder to comment on Project aspects prior to approval. • Provide TNG an insight into areas of concern and mitigate those wherever possible.
Media Releases	All Stakeholders	• Increase awareness of the Project. • Provide company contact details for feedback. • Provide Project updates to stakeholders.
Company Website	All Stakeholders	• Provide a mechanism for stakeholders to contact TNG with any comments or concerns regarding the Project. • Present Project updates for interested stakeholders throughout the life of the Project.
Lodgement of Approval Documents	Government Departments	• Inform Government departments of Project activities, alterations, impacts and mitigating measures through a range of approval, license and permit applications.
Committee Participation	Government Departments Industry Representatives Community Members	• Inform key stakeholders about Project activities • Provide and receive input into aspects of the surrounding environmental, commercial and social contexts associated with the Project. • Provide an opportunity to develop mutually beneficial relationships with key stakeholders.
Complaints and Grievance Protocols	Community Members	• Develop a mechanism for community members to inform TNG regarding issues/impacts arising from Project activities. • Allow TNG an opportunity to understand implications of Project activities on stakeholders and implement mitigating measures to eliminate or reduce impacts.

Method	Target Stakeholder	Purpose
Ad-hoc Liaison	Government Departments Members of Parliament Industry Representatives Community Groups	- Undertake ad-hoc liaison as required to inform stakeholders and discuss Project aspects throughout operations, as the need arises. - Build long-term relationships with key stakeholders.
Annual Reporting	Government Departments Community Members Shareholders	- Inform stakeholders regarding company performance against requirements. - Detail activities undertaken within the reporting year and provide information on proposed activities for the coming period.

TNG LIMITED

DRAFT ENVIRONMENTAL IMPACT
STATEMENT

DARWIN PROCESSING FACILITY

**KEY
ENVIRONMENTAL
FACTORS**

7. KEY ENVIRONMENTAL FACTORS

7.1 ENVIRONMENTAL FACTORS AND OBJECTIVES

Environmental factors are elements of the environment that may be impacted by any aspect of a proposal. *NT EPA Environmental Factors and Objectives* (NT EPA 2018c) classifies 13 environmental factors to guide the structure of formal EIA in the NT. The potential impacts of a proposal are assessed against the NT EPA's (2018c) Objectives for each factor to determine whether the impacts of a proposal are likely to be significant.

As the TOR for the Project (NT EPA 2016b) was released prior to the publication of *NT EPA Environmental Factors and Objectives* (NT EPA 2018c), it does not identify specific environmental factors that the EIS must address. Discussions between the NT EPA and the Proponent subsequent to publication of the NT EPA (2018c) document have identified Environmental Factors that are applicable to this EIS.

These Environmental Factors, their objectives, and the EIS chapter in which potential impacts are assessed are listed in Table 7-1. Preliminary assessment of the potential for impacts on the remaining Environmental Factors was undertaken; Table 7-2 summarises the reasons further assessment of potential impacts to these Environmental Factors was considered unnecessary.

The existing condition of each environmental factor identified by the NT EPA as potentially being impacted by the Project is outlined below.

Table 7-1: Environmental Factors and objectives against which the Project impacts must be assessed

Theme	Factor	Objective	EIS Chapter
Land	Terrestrial Environmental Quality	Maintain the quality of land and soils so that environmental values are maintained.	7.2
	Terrestrial Flora and Fauna	Protect the NT's flora and fauna so that biological diversity and ecological integrity are maintained.	7.3, 7.4
Water	Hydrological Processes	Maintain the hydrological regimes of groundwater and surface water so that environmental values are protected.	7.5
	Inland water environmental quality	Maintain the quality of groundwater and surface water so that environmental values including ecological health, land uses, and the welfare and amenity of people are protected.	7.6
Sea	Marine Environmental Quality	Maintain the quality and productivity of water, sediment and biota so that environmental values are protected.	7.7
	Benthic Habitat and Communities	Protect benthic communities and habitats so that biological and functional diversity and ecological integrity are maintained.	7.8
	Marine Flora and Fauna	Protect marine flora and fauna so that biological diversity and ecological integrity are maintained.	7.9
Air	Air Quality and Greenhouse Gases	Maintain air quality and minimise emissions and their impact so that environmental values are protected.	7.10

Theme	Factor	Objective	EIS Chapter
People and Communities	Social, economic and cultural surroundings	Protect the rich social, economic, cultural and heritage values of the Northern Territory.	7.11
	Human Health	Ensure that risks to human health are identified, understood and adequately avoided and / or mitigated.	7.12

Table 7-2: Environmental Factors not requiring further assessment

Theme	Environmental Factor	Reason for not Continuing Assessment
Land	Landforms	The Project will not require significant alterations to landforms at the Site or elsewhere
Water	Aquatic Ecosystems	There are no freshwater bodies within the Project area; surface water dams on site are the result of historic extractive industry use. The streams in the vicinity of the site are estuarine. Potential impacts of the Project are therefore assessed under the <i>Sea</i> theme
Sea	Coastal Processes	Although the site is coastal, the Project will not require modification of the geophysical and hydrological processes that shape coastal morphology

7.1.1 Risk Assessment

The TOR (NT EPA, 2016) requires identification, analysis and mitigation of potential environmental impacts of the Project through a whole-of-project risk assessment. The risk and environmental impact assessment process informing this EIS is described in Appendix G.

Chapters 7.2 to 7.12 of the EIS describe each Environmental Factor potentially impacted by the Project and are structured to reflect the risk and environmental impact assessment process. The Project risk assessment is presented within Appendix G, which includes assessment of construction, operation and cumulative impacts.

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DRAFT ENVIRONMENTAL IMPACT
STATEMENT

DARWIN PROCESSING FACILITY

**ENVIRONMENTAL
FACTOR:
TERRESTRIAL
ENVIRONMENTAL
QUALITY**

7.2 ENVIRONMENTAL FACTOR: TERRESTRIAL ENVIRONMENTAL QUALITY

7.2.1 NT EPA Objective

The NT EPA's objective for the environmental factor Terrestrial Environmental Quality is to:

Maintain the quality of land and soils so that environmental values are protected.

Terrestrial Environmental Quality refers to the chemical, physical, biological and aesthetic characteristics of land and soils. The Terrestrial Environmental Quality objective recognises the essential link between soil quality and protection of the ecological and social values that good soil quality supports.

This chapter describes the potential impacts to terrestrial environmental quality that may occur within the Darwin Processing Facility Project area. The mitigation and management measures that TNG will implement to avoid and/or reduce impacts are summarised. A statement of residual impact has also been made detailing the extent to which the proposed mitigation and management measures will ensure that the NT EPA's objective for this environmental factor is met.

The content of this chapter has been developed specifically to address Section 3.1 of the EIS TOR (Appendix A).

7.2.2 Technical Studies

Technical studies undertaken to inform assessment of potential impacts of the Project on Terrestrial Environmental Quality are listed in Table 7-3.

Table 7-3: Terrestrial environmental quality studies undertaken for the Project

Date	Study Title	Consultant	Description	Report
April, May and September 2019a	Preliminary Site Investigation and Shallow Soil Baseline Assessment – Proposed TNG Plan Lot 1817 Hundred of Ayers, Darwin, NT	Golder Associates Pty Ltd	Baseline assessment of the terrestrial environment including soils and surface water quality.	Appendix H

7.2.3 Existing Environment

7.2.3.1 Existing Land Uses

Lot 1817 has many existing land uses. Presently the site hosts major infrastructure corridors such as the Adelaide-Darwin Railway corridor, a gas pipeline, a number of major power infrastructure corridors and is adjacent to Channel Island Road. These infrastructure corridors have associated vehicle access and areas that are maintained in a vegetation free state to allow for monitoring and maintenance activities.

Historic quarrying activity at the site has left much of the land cleared without rehabilitation and large piles of cleared soil and bunding are heavily infested with grassy weeds. Where rehabilitation has occurred, there is little ground cover and, despite good shrub cover in places, soils remain exposed in most areas.

There is evidence of heavy use of the site for recreational purposes and illegal rubbish dumping with at least 22 dumped cars, asbestos, tyres and other assorted rubbish on the site (Plate 7-1).

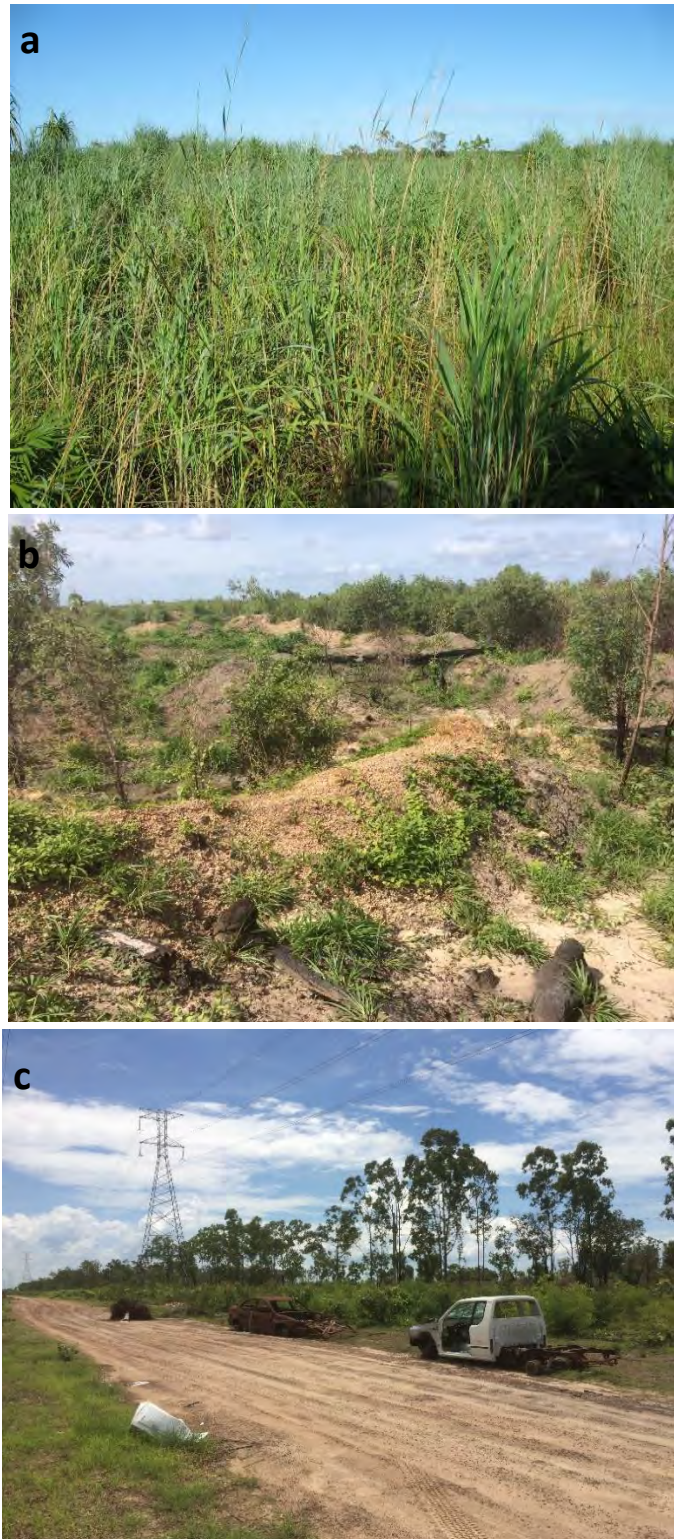


Plate 7-1: Current land uses (a) The grassy weed Gamba Grass covers unrehabilitated land (b) soil piles and bunds in unrehabilitated land (c) illegally dumped cars and waste beside a road and power corridor at the site

7.2.3.2 Topography and Geomorphology

The development of land surfaces in the north of the NT has traditionally been attributed to successive episodes of uplift, erosion and weathering, including the Wave Hill and Koolpinyah surfaces that dominate the landscape in the Darwin region (Hays 1967).

The Project area is in a low-lying area of the Middle Arm Peninsula adjacent to the Elizabeth River. The intertidal areas associated with the Elizabeth River estuary are 50 to 200 m from the edge of the Development Envelope and drain into the Darwin Harbour after periods of regular rainfall. During periods of prolonged rainfall (particularly during the wet season) the clayey nature of the underlying soils limits infiltration rates, resulting in the surface soil layer becoming saturated. This leads to overland flow in some areas of the site and localised pooling of surface water in other areas.

The site is generally level with some undulating areas. The site boundary ranges between 0.1 and 20 mAHD, with the land sloping down toward the river and upward inland. The topography of the surrounding region is similar. The site is largely vegetated with trees and other vegetation; although there are several tracks and previously cleared areas throughout. The coastline of the site is fringed by mangroves to the north and west.

The Land Units present in and around the Project are detailed in chapter 3.4.4.

7.2.3.3 Geological Setting

The Darwin region forms part of the Australian Precambrian Shield, which has been comparatively stable since middle Proterozoic times (Stuart – Smith et al. 1980). Metasediments of the Pine Creek geosyncline that overlie the Archaean basement were successively folded and uplifted during the early to middle Proterozoic. Flat-bedded Mesozoic and Cenozoic strata were deposited following erosion of the Proterozoic rocks.

Proterozoic strata in the Darwin region vary according to metamorphic grade. Near Cox Peninsula to the west, the unconformable Cretaceous strata overlie upper greenschist to amphibolite facies, quartzofeldspathic and mica schists, gneiss and minor quartzite. To the east, near Gunn Point, lower greenschist facies metasediments occur. The Proterozoic strata underwent one major deformation approximately 1800 million years ago, resulting in tight folds with limbs dipping steeply at more than 50° (Pietsch 1986).

The Bynoe, Northern Territory, Australia, 1:100,000 Geological Series (Figure 7-1) indicates that the Site is underlain by the following:

Quaternary (Q):

- Qcl – Sand; silt; clay: colluvial sediments deposited by unconcentrated surface runoff; and
- Qca – Mud; clay; silt: intertidal marine alluvium.

Tertiary (Cz):

- Czs – Unconsolidated sand; ferruginous, clayey, sandy and gravelly soil; common limonite pisolites; and
- Czl – Pisolitic and mottled laterite; Ferricrete: in situ and reworked remnants of standard laterite profile.

Early Proterozoic – Finniss River Group – Burrell Creek Formation (Pf):

- Pfb – shale, siltstone and phyllite in places colourbanded fine to very coarse sandstone (quartz arenite, sublitharenite, arkose); quartzite; quartz pebble conglomerate; minor graphitic phyllite; quartz -mica schist and gneiss.

The Burrell Creek Formation consisting of shale, siltstone and phyllite is present across the whole site. These rocks are understood to be steeply dipping and tightly folded, having undergone metamorphism altering the parent rock to phyllite. Slates, mica schist, and gneiss are also believed to be present in the Burrell Creek Formation.

Hard black mica schist has been encountered at a depth of approximately 50 metres below ground level (**mbgl**). The upper portion of the formation has undergone significant weathering and is in some areas described as residual soil. In the upper reaches of the tributaries flanking the Project area, colluvial sediments (Qcl) from surface runoff are present. Quarrying has been focussed on removal of the laterite material (CzL) and also some of the sand (Czs). The current disturbed soil profile is 0-2 m of disturbed soil/sand on weathered Burrell Creek Formation (Pb).

7.2.3.4 Soil Types

The exposed Burrell Creek Formation in a tropical monsoonal climate environment has resulted in chemical weathering producing lateritic soils. The geological map (Figure 7-1) indicates that lateritic soils (CzS, CzI) are present over most of the Site, predominantly consisting of sand and gravel.

The expected subsurface conditions at the site are:

- Sandy gravel/gravelly sand (inferred to be lateritic soils) extending from surface to depths of 2.5 mbgl (maximum thickness of 2.5 m); overlying
- Silt and clay (inferred to be weathered Burrell Creek Formation) extending to the end of investigation depth at 21.5 mbgl (maximum thickness of 17 m).

The sub-surface conditions encountered during the soil sampling were broadly in accordance with those expected from the geological mapping (Golder 2019a; Appendix H).

The encountered shallow strata comprised superficial coastal alluvium (including estuarine deposits) and can be summarised as:

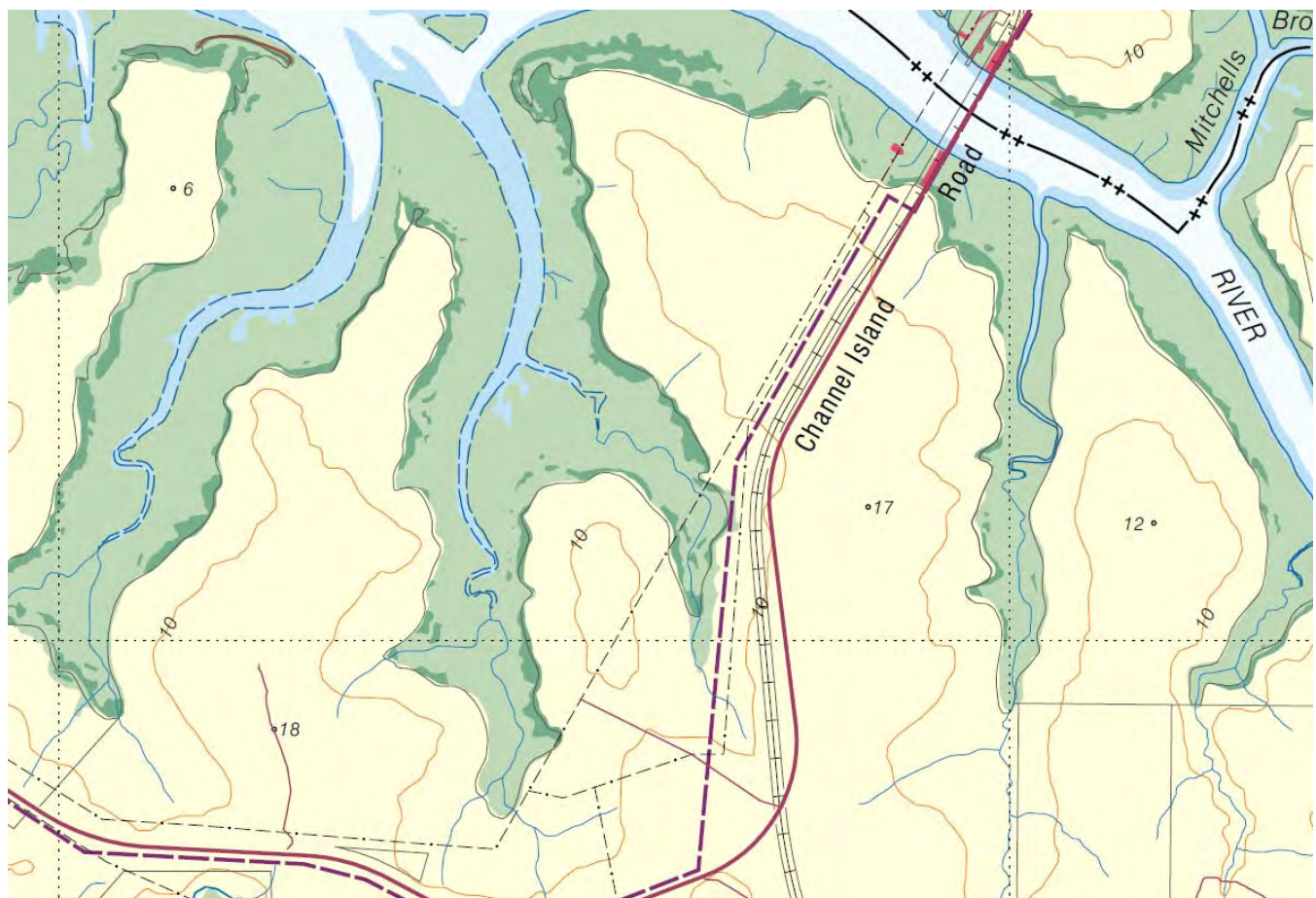
- 1 Clay – Medium plasticity, sandy, slightly gravelly red-grey mottled clay. Sand is brown, fine, sub-rounded to sub-angular. Gravel is medium grained, sub-angular to sub-rounded with variable moisture, no odour;
- 2 Clayey sand – Brown, fine to medium, slightly clayey, sub-rounded to sub angular sand with variable moisture, no odour; and
- 3 Sand – Yellow, fine to medium grained, slightly gravelly, sub-rounded to sub-angular sand. Gravel is medium grained, sub-angular to sub-rounded with variable moisture, no odour.

The original soil and weathering profiles have been modified by historical quarrying activities, which removed the gravels from the laterite weathering profile areas as well as sand and soil. Many areas are now comprised of sandy re-laid soils on weathered bedrock.

The encountered lithologies were noted to be variably clayey and gravelly, and the extent of grey/red mottling was also noted to vary across the site. No elevated levels of nutrients were detected and the low levels of chloride measured were consistent with the geography of the land and proximity to the marine environment (Golder 2019a). All soil samples were acidic with a pH ranging from 4.9 to 6.1 (average pH 5.4).

Acid Sulfate Soils (**ASS**) were detected at numerous locations. The distribution of the identified ASS indicates that the ASS is generally driven by the typical high-weathering potential and the site's climatic conditions. ASS are naturally occurring soils, sediments and peats that contain iron sulfide, predominantly in the form of pyrite materials. These soils are commonly found in estuarine and river settings and low-lying land bordering the coast.

ASS materials are benign when in a waterlogged state. However, when these soils or sediments are drained or excavated, oxygen from the atmosphere reacts with the iron sulfide in the soil; resulting in the production of sulfuric acid. Potential Acid Sulfate Soils (**PASS**) are those soils that have the potential to oxidise if disturbed and are generally below the water table. There is a high potential for ASS to be encountered near the estuarine edge of the Project however, the majority of the Development Envelope has not been assessed for ASS presence (Figure 7-2). During the construction phase, assessment for ASS will need to be conducted prior commencement of works.



High Probability of Occurrence of Acid Sulfate Soils

TIDAL ZONES

Bottom sediments; PASS material	
Intertidal; PASS present within upper 1 metre	
Supratidal; PASS present within upper 1 metre	
Extratidal; PASS present within upper 1 metre	

NON-TIDAL ZONES; Floodplains

ASS or PASS generally within upper 1 metre	
ASS or PASS generally below 1 metre	
ASS or PASS generally below 3 metres	
Profoundly disturbed	

Low Probability of Occurrence of Acid Sulfate Soils

NON-TIDAL ZONES; Floodplains

If present ASS or PASS generally within upper 1 metre	
If present ASS or PASS generally below 1 metre	
If present ASS or PASS generally below 3 metres	

NON-TIDAL ZONES; Sandplains, Dunes and Beach Ridges

If present ASS or PASS generally below 1 metre	
Profoundly disturbed	

No Known Occurrence of Acid Sulfate Soils

No known occurrence of ASS or PASS	
Not assessed	

Limit of survey

Figure 7-2: Acid Sulfate Soils of the Project Area (Source: NRETAS 2008)

7.2.3.5 Existing soil quality

The site's historic use for quarrying and current use for infrastructure corridors (such as power and gas corridors) results in a high level of accessibility to the general public. A substantial amount of fly-tipping has occurred on the site; with a number of vehicles, dumped tyres, asbestos cement material and other waste materials currently present.

Golder (2019a; Appendix H) conducted a Preliminary Site Investigation to identify potential contamination sources, provide an indicative assessment of soil contamination and baseline quality data. Targeted sampling occurred at 17 locations for soil quality. Table 7-4 lists the assessment criteria that were used to assess soil with respect to human health and ecological receptors.

Table 7-4: Assessment criteria for soil quality.

Receptor	Soil
Human Health	NEPC (2013) Human Health Investigation Levels (HIL's) – Commercial and Industrial HIL-D
	NEPC (2013) Commercial/Industrial D Soil Health Screening Level (HSL) for Vapour intrusion – Sand.
	DoH (2009) Asbestos HSL-D: Commercial/Industrial
Ecology	NEPC (2013) Ecological Investigation Levels (EIL's) – Commercial and Industrial Land Use
	NEPC (2013) Ecological Screening Levels (ESL's) for TPH fractions in soil (coarse) – Commercial and Industrial Land Use

Despite the fly-tipping and quarrying activities, no contamination was found in the preliminary soil investigation. Based on the outcomes of the Preliminary Site Investigation, a detailed site contamination investigation is not required.

A Preliminary Conceptual Site Model was developed to assess potential sources, transport pathways and potential receptors to risks to human health, the environment or the environmental values.

7.2.4 Potential impacts and risks

The Preliminary Conceptual Site Model is summarised in Table 7-5. Potential impacts and risks posed by ASS are discussed in more detail in chapter 0 below. The potential impacts and risks posed by hazardous substances used during the operations phase are discussed in chapter 7.2.5.1.

Table 7-5: Preliminary conceptual Site model

Sources	Contaminants of potential concern (COPC's)	Pathways	Receptors	Likelihood/Risks
Areas of historical quarrying activities and historical/ongoing fly-tipping	Metals	• Dermal contact between site users and areas of gross contamination • Lateral migration of surface water/runoff • Vertical infiltration of COPC's from the surface to groundwater • Lateral migration of COPC's via groundwater	• Site users (including workers engaged in site clearance and construction works). • Ecological receptors of the Elizabeth River (flora/fauna). • Human receptors of the Elizabeth River (recreational users and consumers of fish/shellfish).	Low (based on findings of the Preliminary Investigation)
	Petroleum hydrocarbons	• Inhalation of COPC derived vapours • Dermal contact between site users and areas of gross contamination • Lateral migration of surface water/runoff • Vertical infiltration of COPC's from the surface to groundwater • Lateral migration of COPC's via groundwater	• Ecological receptors of the Upper Darwin Harbour Estuary (flora/fauna) • Human receptors of the Upper Darwin Harbour Estuary (recreational users and consumers of fish/shellfish).	
	Asbestos	• Inhalation of fibrous asbestos (through presence of friable asbestos, fibrous asbestos, or asbestos fines).	• Site users (including workers engaged in site clearance and construction works).	
Areas of derelict quarry buildings	Asbestos	• Inhalation of fibrous asbestos (through presence of friable asbestos, fibrous asbestos, or asbestos fines).	• Site users (including workers engaged in site clearance and construction works).	Low (subject to implementation of industry health and safety practices)
	ASS/PASS	• Acid drainage	• Ecological receptors of the Elizabeth River (soil/flora/fauna).	Moderate to Low (subject to implementation)

Sources	Contaminants of potential concern (COPC's)	Pathways	Receptors	Likelihood/Risks
Site excavation during Project construction phase	Toxic metals	Leaching due to acid drainage	Ecological receptors of the Elizabeth River (soil/flora/fauna).	of the ASS Management Plan)
Hazardous substances used in operations phase	Petrol, oils and lubricants (POL), hazardous materials, paints and thinners, concrete wastewater and litter	- Dermal contact between site users and areas of gross contamination - Lateral migration of surface water/runoff - Vertical infiltration of COPC's from the surface to groundwater - Lateral migration of COPC's via groundwater	- Site users (including workers engaged in site clearance and construction works). - Ecological receptors of the Elizabeth River (flora/fauna). - Human receptors of the Elizabeth River (recreational users and consumers of fish/shellfish). - Ecological receptors of the Upper Darwin Harbour Estuary (flora/fauna) - Human receptors of the Upper Darwin Harbour Estuary (recreational users and consumers of fish/shellfish).	Moderate to Low (subject to implementation of the Hazardous Substances Procedure)

7.2.5 Acid Sulfate Soils

Cut-and-fill earthworks will be required to provide level ground surfaces for the construction of the Processing Facility, with approximately 500 mm of surface soil removed as part of this process. The majority of infrastructure will be built on pads above ground; however, process water ponds and wastewater storage ponds may be partially excavated below ground level. The main potential terrestrial environmental quality impacts of these earthworks are disturbance of ASS and soil erosion.

The oxidation of metal sulfide is a natural weathering process that generally occurs slowly and does not pose an environmental concern. However, excavation and drainage can exponentially increase the rate of acid generation. Additionally, water draining from oxidised ASS can be strongly acid, which acts on soils and sediment to produce high solution concentrations of toxic metals, especially aluminium and iron. These high concentrations of metals may have a deleterious effect on human health, the environment and potentially damage infrastructure.

Unmanaged disturbance of ASS and consequent acid drainage from these areas can cause adverse impacts to the terrestrial environment, including:

- Adverse changes to the quality of soil and water;
- Degradation of wetlands, water-dependent ecosystems and ecosystem services;
- Loss of habitat, ecosystem complexity and biodiversity;
- Invasion and dominance of wetlands and waterways by acid-tolerant water plants and plankton species;
- Reduction of soil stability and fertility;
- Deterioration in water quality sources by increasing acidity and heavy metal concentrations;
- Acidification of surface water bodies increasing mosquito breeding, which may increase the prevalence of mosquito-borne diseases such as Ross River virus;
- Loss of visual amenity due to rust coloured stains from iron precipitates at the soil surface;
- Long term infrastructure damage through acidic water corroding metallic and concrete structures; and
- Increased financial burden of treating and rehabilitating affected areas and maintenance of infrastructure.

The above impacts can, however, be mitigated through implementation of appropriate management measures, as described in Table 7-6 and the ASS Management Plan (Appendix I).

7.2.5.1 Hazardous substances used in Processing Facility operations

TNG are proposing to construct a state-of-the-art Facility that incorporates best practice materials handling and storage infrastructure and protocols; consistent with both Australian and International standards. Magnetite concentrate and handling of final products will also be strictly managed to avoid impacts from unintentional release.

Pollution can, however, occur as a result of accidental spills or unintentional release of polluting substances onto the ground or into waterways. Polluting substances used on site may include POL, reagents and other hazardous materials, paints and thinners, wastewater from concrete batching during construction and litter.

Where minor spills occur, impacts would be localised and easily managed. In the event of an unforeseen, significant spill, the terrestrial environment would provide a pathway to the Elizabeth River, which is a sensitive receptor. The impact would depend on a series of factors including the type and volume of material released, extent of contamination, climatic conditions at the time of the incident. TNG is cognisant of the potential significance of an uncontrolled discharge of hazardous substances and will implement appropriate mitigation strategies (Table 7-6) to address the risk.

7.2.6 Mitigation and management

Table 7-6 lists the risks to terrestrial environmental quality, the mitigation hierarchy used and the proposed mitigation measures. An ASS Management Plan has been prepared (Appendix I) which discusses the mitigation measures associated with ASS in detail. The EMP (Appendix D) also addresses materials management and handling, including spill containment protocols.

Table 7-6: Mitigation measures for terrestrial environmental quality

Issues	Mitigation hierarchy	Mitigation measure
Exposure of humans and the environment to COPC's from fly-tipped waste	Avoid, minimise	- Removal of fly-tipped waste from the site using accredited waste specialists - Inspection of disturbed areas and fly-tipped waste for the presence of asbestos; removal, transport and disposal of asbestos using licensed specialists.
Disturbance of ASS during clearing and earthworks	Avoid, minimise, rehabilitate	- Undertake a geotechnical assessment prior to construction, to identify areas of occurrence of ASS. - Disturbance of ASS to be avoided where possible, including constructing infrastructure on piles above ground level. - Excavated ASS to be treated during construction in accordance with requirements of the ASS Management Plan to prevent acidic fluids leaching into surface water or groundwater.
Incorrect handling of ASS/PASS	Avoid, minimise, rehabilitate	- Material free of ASS will be used to construct any bunds that may be required. - Preparation of compliant ASS treatment pads. The area will be fully contained/constructed such that drainage/runoff water from the pad is directed to an appropriate receptacle for testing and treatment (if required). - Any spilled ASS material is to be transferred to the treatment pad immediately. - Awareness training of ASS handling requirements will be provided to personnel involved with the movement of soils, particularly during the construction phase.
Incorrect treatment of ASS/PASS	Avoid, minimise, rehabilitate	- ASS treatment pads will have a guard layer of agricultural lime applied at a nominal rate of 10kg/m². - ASS material will be transferred to the treatment pad and placed on top of the guard layer. If ASS is to be treated in more than one layer, enough time will be allowed for validation testing and compliance of a layer before addition of extra material. - ASS material is to be spread out in windrows of 300 mm loose thickness for drying. Once dry, fine agricultural lime will be applied evenly over the surface and thoroughly mixed into the soil. - The Acid Neutralising Value of the agricultural lime supplied may not be 100% (as assumed for pure lime) and will be identified from documentation provided by the lime supplier. If less than 100%, a correction factor of 100/ Acid Neutralising Value will be applied to reach the equivalent of pure fine agricultural lime. - Treated ASS shall not be removed from the site until validation monitoring indicates that performance indicators have been met.
Retained water becomes acidified	Avoid, minimise, rehabilitate	- All stormwater or ASS leachate from stockpiles or other exposed areas shall be diverted to a retention ponds for monitoring and treatment (if required). - pH, water level, Electrical Conductivity, total iron and aluminium concentrations to be monitored within any pond of retained water in current operation. - Hydrated lime to be available for pH adjustment of water if required.

Issues	Mitigation hierarchy	Mitigation measure
		Monitoring of wastewater conducted prior to discharge must indicate parameters comply with the performance indicators.
Soil erosion resulting in disturbance of ASS or sedimentation of the adjacent environment	Avoid, minimise	- Implementation of the Erosion and Sediment Control Plan (ESCP) and Water Management Procedure (EP-10) in the EMP (Appendix D) to avoid erosion. - Vegetation clearing to be undertaken in stages and in dry season conditions wherever possible. - Erosion protection measures (bundling, spoon drains, silt fencing and sediment ponds) will be installed to contain any erosion.
Incorrect storage of lime and hydrated lime leading to death of vegetation	Avoid	- Lime will be stored in a containment area adjoining the treatment pad (so that any discharge from the area is directed into the treatment pad). - Appropriate weatherproof storage of hydrated lime.
Integrity of infrastructure compromised due to exposure to acidic environment	Avoid	- Disturbance of ASS to be avoided where possible, including constructing infrastructure on piles above ground level. - Project design to incorporate corrosion resistant materials where required.
Contamination during Project operations phase	Avoid, minimise	Implement the Hazardous Material Management Procedure (EP-13), in the EMP (Appendix D), including the following: - Ensure stockpiles of bulk materials are located well clear of any waterway or drainage systems. - Construct bunds around fuel and chemical storage areas according to Australian Standards 1940: 2017 – <i>The Storage and Handling of Flammable and Combustible Liquids</i> (unless quantity of the liquid stored is within that allowable as minor storage), environmental protection licence or Major Hazard Facility licence requirements. - Train personnel in implementation of safe work practices to minimise risks and impacts of spillage of fuels, chemicals and other contaminants. - Train personnel in incident reporting and emergency management procedures and encourage the reporting of issues and near misses. - Record and report all POL, chemical and hazardous substance spills. - Ensure personnel have access to spill kits that contain an absorbent material, clearly marked oily waste disposal drum and a shovel. - In the event of a chemical or hazardous substance spill, containment measures should be enacted and Material Safety Data Sheet (MSDS) requirements complied with. - In the event of a POL spill less than 20L on soil, remove the soil and dispose of in oily waste disposal drum. - In the event of a POL spill of between 20 and 80L, soak up as much as possible using absorbent, and turn/aerate the soil to allow natural processes (i.e. aeration and microbial systems) to breakdown the organic compounds (i.e. hydrocarbons). Remove contaminated soil if the spill occurs in the vicinity of drainage lines and waterways. If on a hard surface such as road or concrete, use absorbent and dispose in the oily waste disposal drum.

Issues	Mitigation hierarchy	Mitigation measure
		- In the event of a POL spill greater than 80L, all contaminated soil is to be removed, and disposed of in a clearly marked oily waste disposal drum. - MSDSs are to be located within storage areas, as well as centrally located and readily available to staff for use in case of an emergency. MSDSs are to remain current at all times. - Undertake validation sampling of soil if the spill, or combined record of spills, is greater than 80L to confirm all contaminated soil has been removed. - All contaminated soil and absorbent in the oily/chemical waste disposal drum should be disposed of by a licensed waste contractor. - Keep sites free from build up of waste materials by directing regular clean ups; - Avoid storing large volumes of materials on site; - Ensure equipment and vehicles have been washed down and inspected for POL leaks, prior to being transported to work sites; - Ensure wastewater from concrete batching plant (used during the construction phase only) is contained and treated; - Ensure herbicides used for weed control are registered and only applied by appropriately trained personnel.

7.2.7 Monitoring and reporting

Monitoring activities will be undertaken throughout the life of the Project. The detail of monitoring activities will be determined once infrastructure design and associated construction methodologies have been finalised, following completion of geotechnical investigations and relevant project approvals. Monitoring activities will be reported through the EMP reporting schedule and as per the specialist management plans, as outlined below in Table 7-7.

Table 7-7: Monitoring actions for terrestrial environmental quality

Action	Timing	Methods used	Criteria
Acid Sulfate Soils monitoring.	As needs basis (prior to ground disturbance).	pH, water level, Electrical Conductivity, total iron and aluminium concentrations to be monitored within any pond of retained water in current operation. Chromium Reducible Sulfur analyses to potentially indicate the presence of PASS Titrateable Actual Acidity analyses to potentially indicate the presence of ASS	As per Acid Sulfate Soils Management Plan (Appendix I).

		National Association of Testing Authorities (NATA) accredited laboratories will be used for analysis.	
Soil contamination and validation monitoring	As required following spills greater than 80 L, or where residual soil contamination is suspected.	Analytes sampled will depend on constituents of material released to terrestrial environment. NATA accredited laboratories will be used for analysis. Sampling methods will be consistent with <i>National Environment Protection (Assessment of Site Contamination) Measure 2013</i> and NT EPA <i>Northern Territory Contaminated Land Guideline</i>, June 2017.	Refer to Table 7-4.

Table 7-8: Other inspection and reporting for terrestrial environmental quality

Relevant Plan	Monitoring/Inspection	Reporting
Environmental Management Plan	Daily inspection to ensure site is cleared of waste, all chemicals/POL have been stored and disposed of correctly, and all spills have been identified and dealt with (see Daily Inspection Checklist, EMP Appendix D). Regular inspection of any bunds to check integrity and detect leaks and spills (see Weekly Inspection Checklist, EMP Appendix D). Regular inspection and testing of leak detection equipment to ensure effective operation at all times. Regular inspection of stormwater drains for any sediment capture (see Weekly Inspection Checklist, EMP Appendix D). Keep waste tracking/disposal records for all HAZMAT in Daily Site Diary.	Monthly Environmental Performance Report. Half Year Report. Annual Report and Performance Review. Incidents are to be reported and records maintained/retained (see Incident, Accident and Near Miss Report, Appendix D). Investigate incidents and implement any preventative actions. Report any waste management issues to the Site Supervisor.
ASS Management Plan	Inspection of work areas during excavation to ensure all potential ASS has been removed to the treatment area. Inspection of lime-treated soil for successful neutralisation before being moved or covered.	Monthly Environmental Performance Report. Annual report, incorporating volumes of ASS material treated and monitoring results.

Relevant Plan	Monitoring/Inspection	Reporting
		Statutory incident reporting to NT EPA in the case of a significant incident resulting from ASS liberation.
Erosion and Sediment Control Plan	Weekly inspection of erosion and sediment controls during the wet season.	Monthly Environmental Performance Report.

7.2.8 Statement of residual impact

As a result of the presence of ASS there are potential risks to terrestrial environmental quality associated with the proposed development. Management controls are presented in Table 7-6. After implementation of these controls, impacts from ASS are considered to present a medium to low risk, with any potential effects on the surrounding environment being localised and minor. A monitoring and reporting schedule will be implemented to ensure risks are identified and managed rapidly and effectively.

Use of hazardous materials comes with a risk of seepages, leaks and spills. Implementation of the appropriate transport, storage and handling procedures reduce the risk to people and the environment. The proposed monitoring and reporting schedules ensure risks will be identified rapidly and managed effectively.

Given the proposed controls it is anticipated that the Project will not compromise the terrestrial environmental quality at the site and the Factor objectives can be met.

TNG LIMITED

DRAFT ENVIRONMENTAL IMPACT
STATEMENT

DARWIN PROCESSING FACILITY

**ENVIRONMENTAL
FACTOR:
TERRESTRIAL
FLORA**

7.3 ENVIRONMENTAL FACTOR: TERRESTRIAL FLORA

7.3.1 NT EPA Objective

The NT EPA's objective for the factor Terrestrial Flora is to:

Protect the NT's flora so that biological diversity and ecological integrity are maintained.

Terrestrial flora refers to vegetation communities and plants that occur on land. This objective recognises the value of maintaining ecosystem services to ensure that the diversity, distribution and productivity of flora from species to ecosystem levels are maintained. It recognises the importance and value of sensitive and significant vegetation communities and is supported by the protection of listed threatened species and ecological communities under the *Territory Parks and Wildlife Conservation Act (TPWC Act)*.

This chapter describes the potential impacts to terrestrial vegetation and flora that occur within the TNG Processing Facility Project area. The mitigation and management measures that TNG will implement to avoid and/or reduce impacts are summarised. At the end of the chapter, a statement of residual impact is made detailing the extent to which the proposed mitigation and management measures will ensure that the NT EPA's objective for this environmental factor is met.

The content of this chapter has been developed specifically to address section 3.1 and 4.2 of the EIS TOR (refer to Appendix A). This chapter has been informed by a range of biodiversity surveys to describe and assess the floral assemblage present at the site and determine the presence or absence of threatened or significant species (Appendix J). Biodiversity surveys were conducted by qualified botanists from both GHD and APM over a number of years and seasons.

7.3.2 Technical Studies

Technical studies undertaken to inform assessment of potential impacts of the Project on Terrestrial Environmental Flora are listed in Table 7-9.

Table 7-9: Biodiversity studies undertaken for the Project

Date	Study Title	Consultant	Description	Report
3 – 13 Jun 2017	Mid-dry season Terrestrial Flora Survey	GHD*	Survey to collect baseline data on the vegetation and flora assemblage at the site.	N/A
10-19 Apr 2018	Late-wet season Flora and Vegetation Survey	APM	Vegetation description and mapping, flora inventory, weed mapping and targeted searches for conservation significant flora.	Appendix J
24-26 Nov 2018	Early-wet season Targeted Searches	APM	Targeted searches for conservation significant flora particularly <i>Atalaya brevialata</i> .	Appendix J
8-14 Feb 2019	Wet season Targeted Searches	APM	Targeted searching for conservation significant flora species and systematic measurement of tree diameters.	Appendix J

* GHD data for the Darwin Processing Facility were never reported. As such the data is presented as part of the combined survey effort in the APM (2019) Biological Survey (Appendix J).

7.3.3 Existing Environment

A range of botanical surveys have been conducted at the site since 2016 (Table 7-9) and have included the mangroves adjacent to the site. The biological work refers to a 'Study area' which includes Lot 1817, the fringing mangroves and the adjacent waterways (Figure 7-3).

The surveys have used a range of methods to describe the floral assemblage present in the Study area and determine the presence or absence of threatened or significant species. These studies have used database searches, as well as field methods including vegetation quadrats, species specific targeted search transects and systematic tree size measurements.

7.3.3.1 Vegetation Mapping

No Threatened Ecological Communities, as defined under the Commonwealth *EPBC Act*, occur in the Study area.

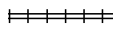
Eleven Vegetation Associations (**VA's**) were identified and described from the Study area. Table 7-10 details the VA's and the comparable unit identified from previous survey work of the Greater Darwin region.

Mapped vegetation communities are shown in Figure 7-4. Vegetation condition closely aligned with VA's and is described in Table 7-10. Figure 7-5 displays previous disturbance, which totals 315 ha or 64.5% of the terrestrial part of the Study area.



Figure 7-3: Biological Study Area

Legend

 Study area	 Gasline
 Lot 1817 Hundred of Ayres	 Railway Line
	 Road



0 0.2 0.4 0.8
 km

1 centimeter = 150 meters
Date: 11/10/2019
Coordinate System: GDA 1994 MGA Zone 52
Author: ems@animalplantmineral.com.au

Table 7-10: Vegetation association descriptions and condition of the study area

Code	Vegetation Association	NVIS V Description	Comparable Unit	Vegetation Condition
VA1	Eucalyptus woodland	U+ [^] <i>Eucalyptus tetradonta</i> , <i>E. miniata</i> , <i>Corymbia bleeseri</i> / [^] tree/7/i; M [^] <i>Livistona humilis</i> , <i>Cycas armstrongii</i> , <i>Acacia latescens</i> / [^] cycad, shrub/3/r; G [^] <i>Heteropogon contortus</i> , <i>Sorghum intrans</i> , <i>Microstachys chamaelea</i> / [^] tussock grass, forb/2/c.	<i>Eucalyptus</i> mid woodland/ <i>Livistona</i> unknown palm/ <i>Sorghum</i> mid tussock grassland (Wilson et al. 1990); and Land Unit 1c Eucalyptus Open Woodland as described by Fogarty et al. (1984) (mapping extent DENR 2000).	Very Good – Some relatively slight signs of damage caused by human activities. For example, some signs of damage to tree trunks caused by repeated fire, the presence of some relatively non-aggressive weeds, and/or occasional vehicle tracks. Exploratory digging by current or former lease holders with large machinery that has not been rehabilitated, leaving pits up to 2 m deep at intervals as close as 50 m apart in places. This vegetation type is in the drier parts of the site and accessible from the major roads and as such has accumulated a larger portion of the illegally dumped rubbish than other undisturbed vegetation types.
VA2	Regenerating Eucalyptus woodland	U+ [^] <i>Eucalyptus tetradonta</i> , <i>E. miniata</i> , <i>Erythrophleum chlorostachys</i> / [^] tree/7/i; M [^] <i>Planchonia careya</i> , <i>Terminalia ferdinandiana</i> , <i>Livistona humilis</i> / [^] tree, palm/6/i; G [^] <i>Heteropogon contortus</i> , <i>Sorghum intrans</i> , <i>Mnesithea formosa</i> / [^] tussock grass/2/c	<i>Eucalyptus</i> mid woodland/ <i>Livistona</i> unknown palm/ <i>Sorghum</i> mid tussock grassland (Wilson et al. 1990); and Land Unit 1c Eucalyptus Open Woodland as described by Fogarty et al. (1984) (mapping extent DENR 2000).	Good – Disturbances include land clearing, fragmentation and frequent fire. Some obvious impact on the vegetation structure being the reduced cover and height of Eucalypt overstory.
VA3	Melaleuca woodland/ open forest	U+ [^] <i>Melaleuca viridiflora</i> , <i>M. leucadendra</i> , <i>M. nervosa</i> / [^] tree/7/c; M [^] <i>M. viridiflora</i> , <i>M. leucadendra</i> <i>Livistona humilis</i> / [^] shrub/4/r; G [^] <i>Fimbristylis acuminata</i> , <i>Ectrosia sulfide</i> , <i>Sorghum plumosum</i> / [^] sedge, tussock grass/1/c.	<i>Melaleuca viridiflora</i> (Broad Leaved Paperbark), <i>Eucalyptus</i> low open-woodland with <i>Chrysopogon fallax</i> (Golden Beard Grass) grassland understorey, and Land Unit 8b as described in Fogarty et al. (1984) (mapping extent DENR 2000).	Excellent to Good – Across most of the distribution there is no evidence of disturbance. Across the northern boundary there is obvious evidence of historical land clearing due to the presence of large soil bunds. However, vegetation is mature, diverse, and does not differ substantially from undisturbed areas in basic vegetation structural diversity.
VA4	Grevillea open shrubland	U+ [^] <i>Grevillea pteridifolia</i> , <i>Pandanus spiralis</i> , <i>Planchonella arnhemica</i> / [^] tree/7/i; M [^] <i>Livistona humilis</i> , <i>Grevillea dimidiata</i> , <i>Calytrix extipulata</i> / [^] palm, shrub/3/bl; G [^] <i>Themeda triandra</i> , <i>Ectrosia leporina</i> , <i>Heteropogon contortus</i> , / [^] tussock grass/2/c	Land Unit 6b Tall shrubland to low open woodland of <i>Grevillea pteridifolia</i> (Fogarty et al. 1984)	Degraded – Soil disturbances are prevalent including evidence of extensive soil ripping for rehabilitation, the presence of large soil bunds associated with infrastructure such as roads, powerlines and gas pipelines which intersect this vegetation. The sandy topsoil layer is not present in many areas with clay rich subsoils at the surface. Some invasive species present. Scope for some regeneration but not to a state approaching good condition without intensive management.

Code	Vegetation Association	NVIS V Description	Comparable Unit	Vegetation Condition
VA5	Closed Grassland	M [^] <i>Ampelcissus acetose</i> , <i>Ludwigia hyssopifolia</i> /^shrub/2/bl; G [^] * <i>Cenchrus polystachyos</i> , <i>Mnesithea Formosa</i> , <i>Sorghum intrans</i> /^tussock grass/2/d	This vegetation type is derived from disturbance and management techniques and has no natural analogue.	Degraded – Severely impacted by land clearing. Contains a number of invasive species. Scope for some regeneration but not to a state approaching good condition without intensive management.
VA6	Disturbed rehabilitated Acacia shrubland	U+ [^] <i>Acacia pellita</i> , <i>A. difficilis</i> , <i>A. sulfide</i> /^shrub/3/c; G [^] <i>Heterachne sulfide</i> , <i>Mnesithea formosa</i> , <i>Ectrosia sulfide</i> , <i>Heteropogon contortus</i> , /^tussock grass/1/r	This vegetation type is derived from disturbance and management techniques and has no natural analogue.	Degraded – Severely impacted by land clearing. Contains a number of invasive species. Scope for some regeneration but not to a state approaching good condition without intensive management.
VA7	Disturbed not rehabilitated	U+ [^] <i>Calytrix extipulata</i> , <i>Acacia latescens</i> , <i>Pandanus spiralis</i> /^shrub, palm/3/r; G [^] * <i>Andropogon gayanus</i> , <i>Ectrosia sulfide</i> , <i>Heteropogon triticeus</i> /^tussock grass/3/c	This vegetation type is derived from disturbance and management techniques and has no natural analogue.	Completely degraded – Severely impacted by land clearing. Contains a number of invasive species. Scope for some regeneration but not to a state approaching good condition without intensive management.
VA8	Mangrove closed forest	Sub-association 1: Mixed species low closed forest/open forest (hinterland) Sub-association 2: <i>Ceriops tagal</i> low closed forest (mid tidal flat) Sub-association 3: <i>Tecticornia</i> open samphire shrubland	1: Mixed species low closed-forests (hinterland) (unit 6) 2: <i>Ceriops tagal</i> low closed forest (mid tidal flat) (unit 4) 3: Samphire/Saltpan (unit 11) (Brocklehurst & Edmeades 1996).	Excellent – No evidence of disturbance
VA9	Monsoon closed forest	U+ [^] <i>Corymbia ?polycarpa</i> , XX, <i>Ficus ?scobina</i> /^tree/6,7/i; M [^] <i>Bridelia sulfide</i> , <i>Acacia neurocarpa</i> , <i>Erythrophleum chlorostachys</i> /^shrub/4/i; G [^] XX, <i>Passiflora foetida</i> /^tussock grass, vine/3/i.	Closed Forest Unit 1a Seasonal Coastal Habitats (Wilson et al. 1990) and (Russell-Smith 1991) Floristic Group 3: Dry Coastal/subcoastal Monsoon Forest Group 10: Semi-deciduous rain forests associated with the levees of seasonally flooded, north-western lowland river systems	Good – Inland of this very small pocket of this vegetation there is extensive landscape change. Large soil bunds occur which may be altering the flow of surface water towards this vegetation. Disturbances include the presence of the aggressive weed * <i>Passiflora foetida</i>
VA10	Tussock Grassland	U [^] <i>Xanthostemon paradoxus</i> , <i>Erythrophleum chlorostachys</i> , <i>Pandanus spiralis</i> /^tree, palm/6/i; M [^] <i>Livistona humilis</i> , <i>Acacia plectocarpa</i> subsp. <i>Plectocarpa</i> /^cycad, shrub/4/r; G+ [^] <i>Heteropogon contortus</i> /^tussock grass/3/c.	Land Unit 4d Grassland with areas of emergent shrubs (Fogarty et al. 1984)	Excellent – No evidence of disturbance
VA11	Slashed for Infrastructure	Not assessed	This vegetation type is derived from disturbance and management techniques and has no natural analogue.	Degraded – Severely impacted by land clearing. Contains a number of invasive species. Scope for some regeneration but not to a state approaching good condition without intensive management.

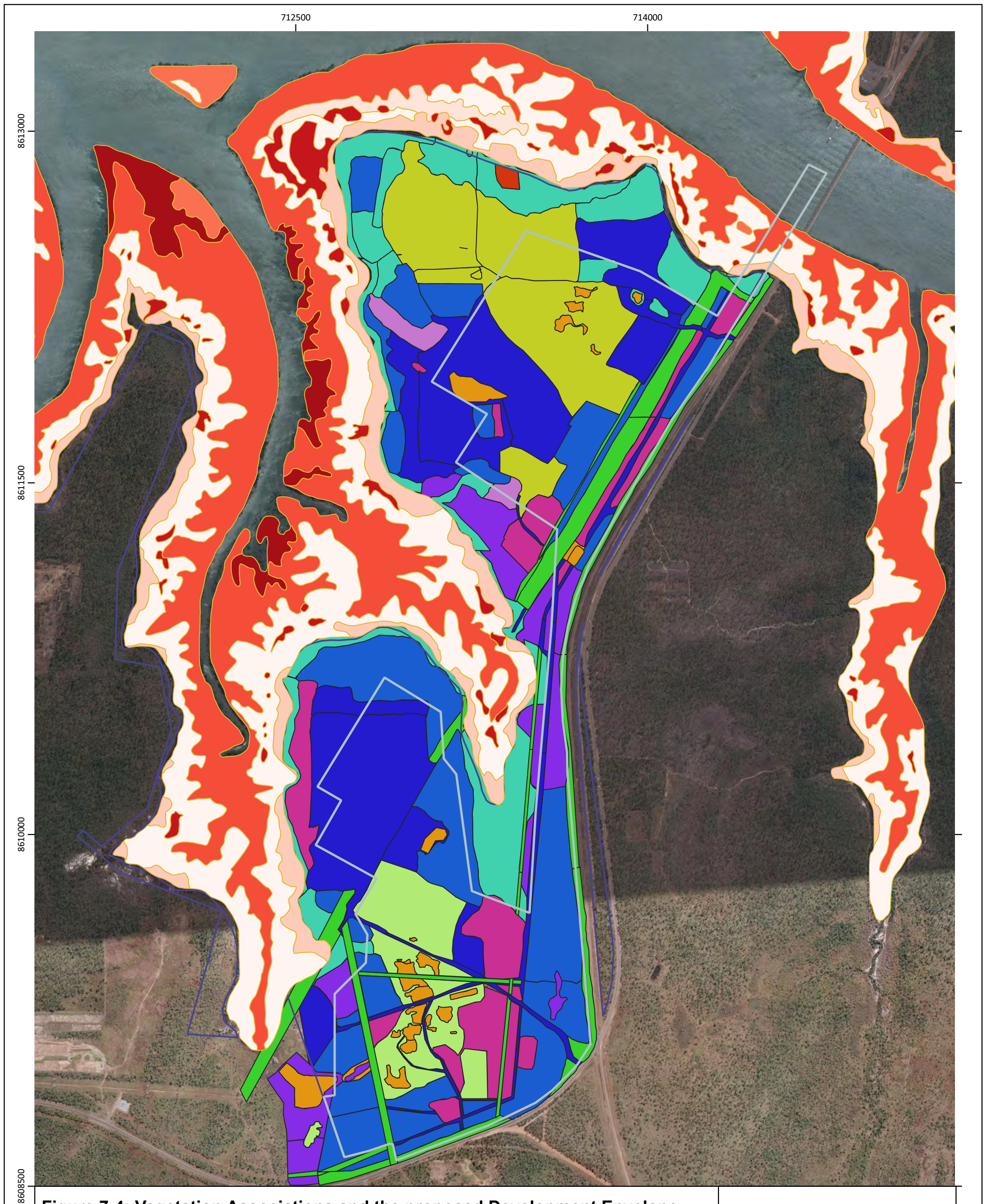


Figure 7-4: Vegetation Associations and the proposed Development Envelope

Legend

Development Envelope	Grevillea open shrubland	Mangrove sub-associations
Lot 1817 Hundred of Ayres	Melaleuca woodland/open forest	Ceriops tagal low closed-forest (mid tidal flat)
Vegetation Associations	Monsoon Closed Forest	Mixed species low closed forest /open-forest (hinterland)
Closed Grassland	Regenerating Eucalyptus woodland	Rhizophora stylosa/Campostemon schultzei closed-forest (tidal creek)
Disturbed - not rehabilitated	Seasonal inundation	Samphire/Saltpan
Disturbed - rehabilitated	Slashed for infrastructure	
Eucalyptus woodland	Tussock Grassland	



0 400 800 m

1 centimeter = 150 m (when printed A3)
 Date: 13/10/2019
 Coordinate System: GDA 1994 / MGA Zone 52

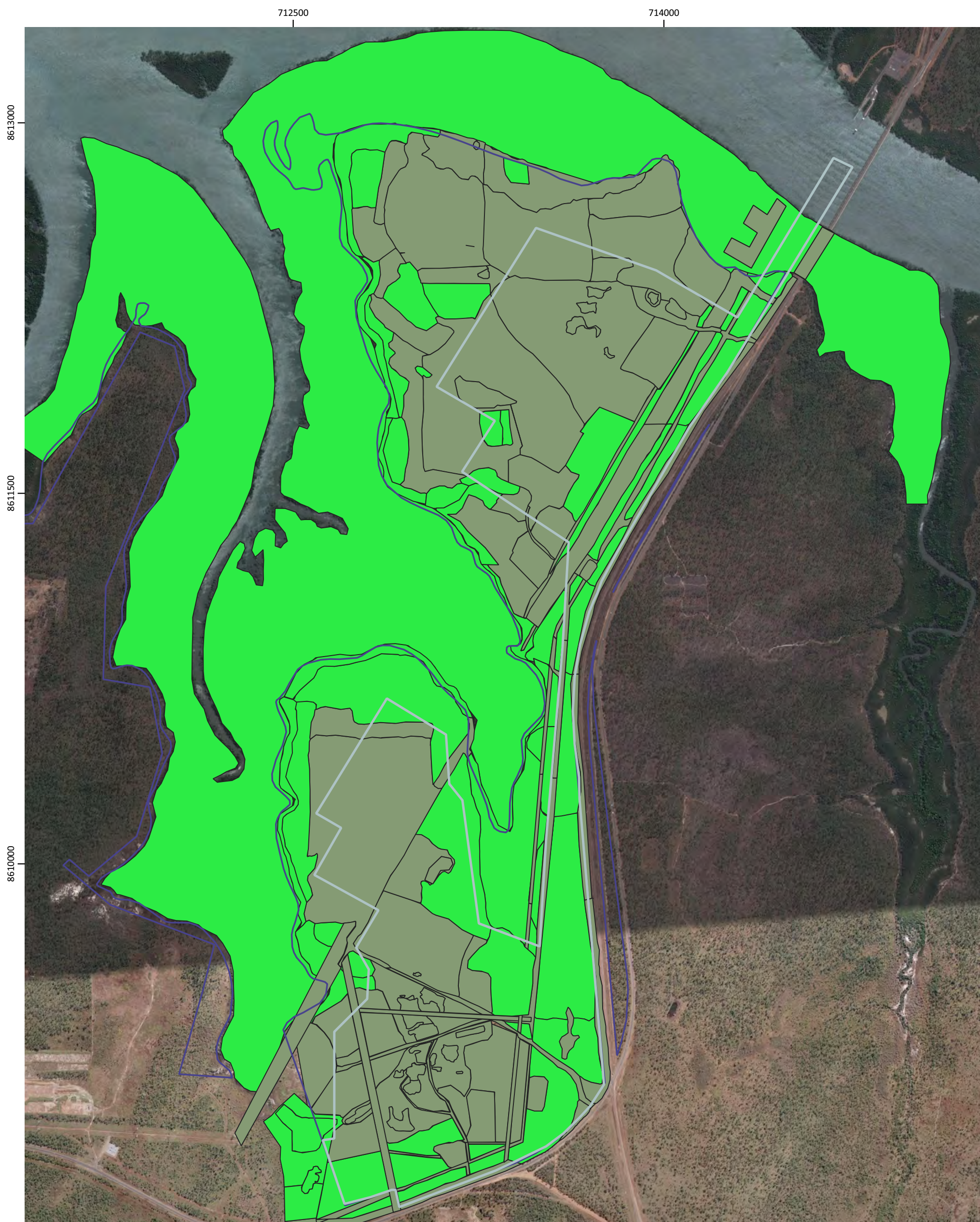


Figure 7-5: Previously disturbed vegetation and the Development Envelope

Legend

- Darwin Processing Facility Development Envelope
- Lot 1817 Hundred of Ayres
- Not previously disturbed
- Previously disturbed



0 400 800 m

1 centimeter = 150 m (when printed A3)
 Date: 13/10/2019
 Coordinate System: GDA 1994 / MGA
 Zone 52

7.3.3.2 Sensitive and Significant Vegetation

Sensitive and significant vegetation are defined by the *Northern Territory Land Clearing Guidelines* (DENR 2019). Sensitive vegetation is a term applied to ecosystems easily impacted by neighbouring or adjacent land uses or management. Significant vegetation also includes spatially restricted habitat types that are important to a relatively large number of wildlife species including rainforest, monsoon vine forest or vine thicket; sandsheet heath; riparian vegetation; mangroves; and vegetation containing large trees with hollows suitable for fauna.

Sensitive and/or significant vegetation types that occur within the Study area are:

- Vegetation containing large trees with hollows suitable for fauna (small areas within VA1) (Figure 7-6);
- Riparian vegetation (VA3) (Figure 7-4); and
- Mangroves (VA8) (Figure 7-4).

Areas of seasonal inundation occur in the Study area; however, these are entirely previously disturbed through use as a quarry (Plate 7-2). The removal of the upper layers of the soil profile have resulted in a low topographic area that receives seasonal runoff. Due to the disturbance history it is not considered here to be sensitive or significant vegetation.

Ordinarily, sensitive and significant vegetation has a requirement for a 250 m buffer under the *Land Clearing Guidelines*. In most instances within the Study area, previous activities have resulted in disturbance of these buffer zones.

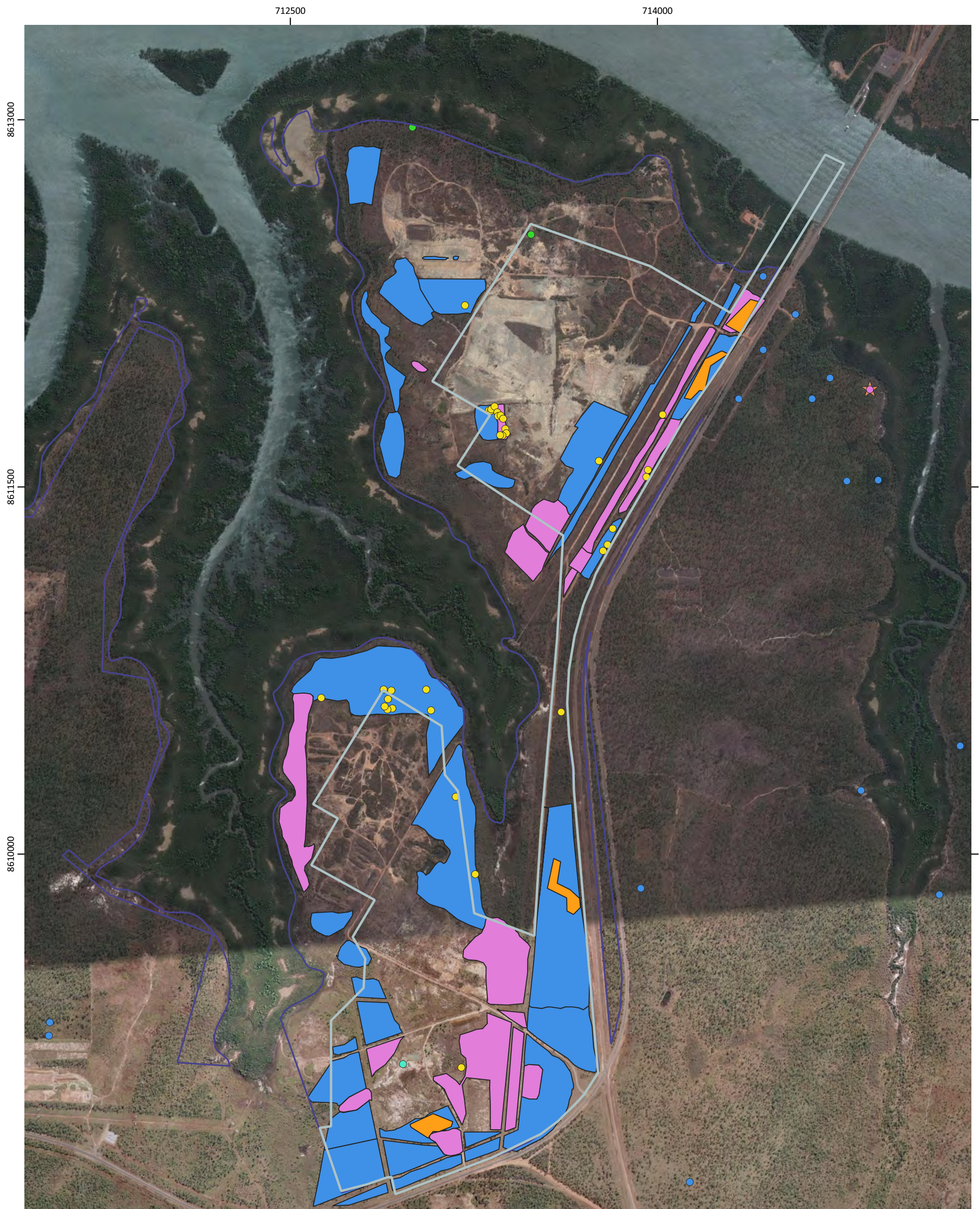


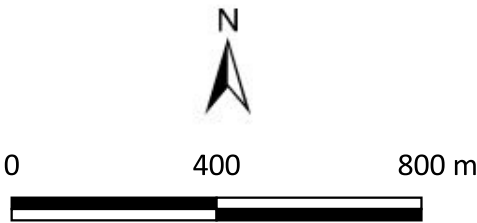
Figure 7-6: Locations of conservation significant flora and large habitat trees

Legend

- Darwin Processing Facility Development Envelope
- Lot 1817 Hundred of Ayres

- *Tricoryne elatior* NT
- *Buchnera* sp. ciliate bracts
- DD *Polymeria pusilla* DD
- Cycas armstrongii* 300 ha-1
- Cycas armstrongii* 50 ha-1
- Large habitat trees

- NT Flora Atlas records
- *Cycas armstrongii* VU
 - *Scleria biflora* DD
 - ★ *Scleria biflora* subsp. *biflora* DD



1 centimeter = 150 m (when printed A3)
 Date: 13/10/2019
 Coordinate System: GDA 1994 / MGA
 Zone 52



Plate 7-2: Examples of previously disturbed areas of seasonal inundation within the Study area

7.3.3.3 Threatened Flora

Threatened flora species search tools identified seventy-four Commonwealth and/or NT listed species that occur within 100 km of the Study area. Database searches show no records of Threatened flora exist within the Study area.

Desktop assessment of threatened species habitat requirements compared to field observation of habitats present at the Study area and known distribution records was undertaken by a qualified botanist (Appendix J, Table 4-1). Seventeen species of threatened flora were considered to be possibly present in the Study area, due to the presence of suitable habitat and proximity of known distributions. Track logs of targeted searches made in multiple seasons to identify these taxa in suitable habitat are shown in Appendix J, Figure 4-8.

No flora species listed under the *EPBC Act* were recorded in the Study area.

Four NT conservation significant flora species were recorded during field surveys and are detailed below. A large number of the species that were included in targeted searches have suitable habitat in areas of seasonal inundation. All of the seasonally inundated areas in the Study area are previously disturbed and have been artificially lowered by the former extractive industries working the site, which may explain the lack of conservation significant flora present.

Cycas armstrongii -Vulnerable (*TPWC Act*)

The VA1 contains *C. armstrongii* at a density of 300 plants per hectare and VA2 contains 50 plants per hectare (Figure 7-2).

In the Study area there is an estimated 30,850 individuals of *C. armstrongii*. Records on the NT Flora atlas indicate *C. armstrongii* is locally common to the west of the Study area (Figure 7-3).

Trichoryne elatior – Near Threatened (*TPWC Act*)

Trichoryne elatior is a perennial lily which was identified in scattered distribution through VA1 and VA2. The total number of plants recorded during targeted searching of all suitable habitat was 132.



Plate 7-3: *Trichoryne elatior*. Source NT flora online. Image D.E. Albrecht

***Polymeria pusilla* – Data Deficient**

Polymeria pusilla is considered Data Deficient and was located at a *Melaleuca* woodland site as an aquatic herb at 1% cover, and as a prostrate herb in waterlogged areas of a Rehabilitated *Acacia* shrubland site at <1% cover.

***Buchnera* sp. Ciliate bracts – Data Deficient**

Buchnera sp. Ciliate bracts is an undescribed species considered Data Deficient and was located in the *Grevillea* open shrublands low density. The taxon has 6 records on NT flora online, all west of Jabiru.



Plate 7-4: *Buchnera* sp. Ciliate bracts. Source NT flora online. Image B.M. Stuckey

***Typhonium praetermissum* – VU (TPWC Act)**

Targeted searches in February 2019 did not locate this species however suitable habitat exists in the woodland/forest areas of the site mapped by Department of Land Resource Management (**DLRM**) (2019). High resolution searching confirmed the absence of the species but confirmed the suitability of the habitat (using the description in DLRM, 2016).

7.3.3.4 Introduced Flora

Fourteen Weeds of National Significance (**WoNS**) were identified from the Protected Matters Search Tool as occurring within 100 km of the Study area. The Introduced Flora layer of the NT Flora Atlas identified 202 pest plants from within a 4 km radius of the site. No records of WoNS or weeds listed under the NT *Weeds Management Act* have previously been recorded in the Study area.

Field survey determined that weed density is high in the previously disturbed areas and low in the undisturbed vegetation (Figure 7-7). **Andropogon gayanus* (Gamba grass) is a Class B weed in the Greater Darwin Region. In the Study area Gamba grass reaches densities of over 60% projected foliage cover in areas that have been

disturbed and not rehabilitated and along roads. Growth and spread of Class B weeds is required to be controlled under the NT *Weeds Management Act*.

The Class B weed **Cenchrus polystachyos* (Mission Grass) was recorded in small patches across the Study area and in clumped distributions on roadsides. Control of growth and spread will need to eradicate plants on roadsides and all recorded locations as the distribution is currently small and patchy and able to be effectively eradicated through timely action.

**Cenchrus ciliaris* (Buffel grass) is a WoNS but it is not a Class A or B weed under NT legislation; therefore, there are no mandatory actions required to control it. The presence of **C. ciliaris* in the Study area is limited to one occurrence.



Figure 7-7: Weeds of National Significance and weeds listed under the NT *Weeds Management Act* in the Study area

Legend

Darwin Processing Facility Development Envelope

Lot 1817 Hundred of Ayres

**Andropogon gayanus* > 60 % cover

**Cenchrus polystachyos* and **Andropogon gayanus*

● **Cenchrus ciliaris*

● **Cenchrus polystachyos*



0 400 800 m

1 centimeter = 150 m (when printed A3)
 Date: 13/10/2019
 Coordinate System: GDA 1994 / MGA
 Zone 52

7.3.4 Potential Impacts and risks

Development of the Darwin Processing Facility (including clearing of vegetation and future operations) has the potential to impact vegetation and flora. Table 7-11 uses the Source – Pathway – Receptor model to identify potential impacts to flora and vegetation. The individual pathways are detailed in the chapters below.

Table 7-11: Potential impact pathways for flora

Source	Pathway	Receptor
Construction activities	Loss of vegetation through clearing.	Conservation significant flora
	Project design resulting in disturbance of conservation significant flora and vegetation	
	Alteration and sedimentation of surface water flows and water quality from erosion.	
	Uncontrolled fire.	
	Increase in weed infestations or invasion by new weed species.	Sensitive and significant vegetation
	Dust generated from vehicle movements, cleared surfaces and soil stockpiles.	
Operations activities	Saline or contaminated water used for dust control or water that has leaked from pipelines or water storage facilities contaminating soil and impacting vegetation.	
	Uncontrolled fire.	
	Dust generated from vehicle movements, cleared surfaces, loading and unloading and material stockpiles.	

7.3.4.1 Loss of vegetation

To allow for refinement of the Project layout, the potential impacts have been calculated from a Development Envelope of 264 ha.

Table 7-12 details the VA's present within the Development Envelope. Many of the VA's within this area are previously disturbed. The amount of degraded or previously cleared vegetation within the Development Envelope is 179.9 ha (Figure 7-5). This represents 69 percent of the Development Envelope.

No conservation significant vegetation types (critical habitats under the *TPWC Act*, or ecological communities under the *EPBC Act*) are present in the Development Envelope.

Of the eleven VA's in the Study area VA5, VA6, VA7 and VA11 are not representative of natural ecosystems and are a product of the past use and management of the site. They are considered to be of no conservation concern for their floristic composition. These VA's make up 125 ha, or 47 percent, of the Development Envelope. The remaining VA's are well represented regionally (Table 7-12). It is expected that the impact of clearing within the Development Envelope will be localised and at a regional level the impact will be low.

Table 7-12: Impacts to vegetation associations as part of the proposed clearing in the development envelope

Veg Code	Veg Association	Veg Condition	Extent within Lot 1817 (ha)	Extent to be disturbed by the proposed clearing		Regional extent	
				ha	%	ha	% loss
VA1	Eucalyptus woodland	Very Good	99.4	67.1	67.5	7,543*	0.01
VA2	Regenerating Eucalyptus woodland	Good	20.6	11.9	54.3		
VA3	Melaleuca woodland/ open forest	Excellent	51.6	17.1	28.9	4,770*	0.01
	Melaleuca woodland/open forest – previously disturbed	Good	34.8	10.1	33.1		
VA4	Grevillea open shrubland	Degraded	30.7	30.5	99.2	21,739*	0.001
VA5	Closed grassland	Degraded	4.3	0.7	15.9	NA	
VA6	Disturbed rehabilitated Acacia shrubland	Degraded	61.5	35.2	57.2	NA	
VA7	Disturbed not rehabilitated	Completely degraded	106.8	67.3	63.1	NA	
VA8	Mangroves Sub association 2	Excellent	-	0.3		273+	0.001
	Mangroves Sub association 4			0.1	-	1509+	<0.001
	Mangroves Sub association 6			1.1		1267+	<0.001
VA9	Monsoon closed forest	Good	0.8	0	0		0
VA10	Tussock grassland	Excellent	15.2	0.6	3.9	3122*	<0.001
VA11	Slashed for infrastructure	Degraded	28.8	19.3	67.1	NA	

Figures sourced from *DENR (2000); +Brocklehurst and Edmeades (1996).

7.3.4.2 Loss of Sensitive and Significant Vegetation

Sensitive and significant vegetation within the Development Envelope includes VA3, VA8 and small pockets of VA1 that contain large habitat trees at threshold density (Figure 7-6). Whilst every effort has been made to avoid clearing within these areas, some impact to sensitive and significant vegetation is inevitable. Table 7-13 details the area within the Development Envelope that intersects with sensitive and significant vegetation, along with an assessment of the impacts.

Table 7-13: Sensitive and significant vegetation in the development envelope

Sensitive and significant vegetation	Area in the Development Envelope (ha)		Area remaining outside of Development Envelope within Lot 1817 (ha)	Impact Assessment
	Previously disturbed	Not previously disturbed		
Mangroves	0	2.1	260*	Whilst the importance of the mangrove belt is recognised, the minimal proposed clearing is not expected to significantly affect adjacent mangrove areas or the functionality of this ecosystem. *The mangroves are not within Lot 1817 but immediately adjacent to the site.
Riparian vegetation (VA3)	17.1	10.1	59.2	Of the 27.2 ha of VA3 to be cleared on site, 3.5 ha is considered Riparian Vegetation. Of this, only 1.1 ha has not been previously disturbed. The total site clearing of VA3 constitutes 0.01% of the regional extent. It is not anticipated that significant impact will arise from the proposed clearing activities.
Large Habitat Trees	0	3.7	0	Removal of large habitat trees from the site is required for development of the Project; however, good quality vegetation with large habitat trees exists in surrounding areas and the total clearing extent is 0.01% of regional vegetation. Fauna mitigation measures, such as pre-clearance trapping and relocation, will also reduce impacts from this clearing.

Mitigation measures described below and in the Biodiversity Management Plan (**BMP**) (Appendix L) and EMP (Appendix D) will further reduce impacts on sensitive and significant vegetation and associated buffer zones.

7.3.4.3 Loss of conservation significant flora

No flora species listed under the EPBC Act have been recorded in Lot 1817 Hundred of Ayres.

Four flora of conservation significance under the TPWC Act occur within the Development Envelope (Figure 7-6). Table 7-14 lists the number of each species within the Development Envelope, the number of each species in Lot 1817 that remain outside of the Development Envelope and comments about the overall species distribution. In most cases the impact of the loss of the individual plants in the Development Envelope is considered to be local. It is not expected that the overall local or regional sustainability of these species will be reduced. On a regional scale the impact is considered to be low. The exception is *Buchnera sp.* Ciliate bracts for which the local record is a significant range extension on other known specimens. The specimen from the Study area was lodged with the NT Herbarium to assist with further taxonomic determination.

Table 7-14: Conservation significant flora in the development envelope

Species	Conservation Code	Number of plants in Development Envelope	Number of plants in Lot 1817 outside of Development Envelope	Overall species distribution
<i>Cycas armstrongii</i>	VU	20,725	30,850	Common across the Greater Darwin Region and locally common (Figure 7-2). Reaches densities of 1000+ per hectare in suitable habitat.
<i>Typhonium praetermissum</i>	VU	0	0	23 ha of suitable habitat exists in the Development Envelope which is < 0.001% of the estimated 70,708 ha across the Greater Darwin Region (DLRM 2019).
<i>Trichoryne elatior</i>	NT	110	22	Records exist of local populations outside of the Project area, across the Greater Darwin Region, in the south of NT and in the Kimberly region of WA.
<i>Polymeria pusilla</i>	DD	5	100	Seven specimens are lodged with the NT Herbarium from across the Top end of the NT and Greater Darwin Region.
<i>Buchnera</i> sp. Ciliate bracts	DD	2	0	Not formally described, but 6 records exist west of Jabiru. The record made from Lot 1817 is a range extension.

7.3.4.4 Increase in weed infestations or invasion by new weed species

Introduction and spread of weeds by machinery and equipment has the potential to reduce habitat quality in the surrounding area due to competition with native species. The disturbed areas of the site have a great propensity for weed species; the undisturbed vegetation in the Project area currently has low levels of existing weed infestation. Fragmentation of remnant vegetation increases the potential risk from weed incursion. In the Greater Darwin Region the prevalence of grassy weeds increases the risk of uncontrolled fire. Weed numbers and cover can increase by:

- Windblown seed from existing weed populations spreading to adjoining areas;
- Weed seed in existing seed banks being spread during soil movement or disturbance; and
- Weed seed entering the site or being spread through contaminated vehicles, earthmoving equipment or construction materials.

For the proposed Project, the above factors are all risks that could apply. Gamba Grass (**Andropogon gayanus*) is a particular risk as it is common through the Project Area. These risks will be mitigated through the application of routine weed monitoring, topsoil management practices and hygiene/treatment procedures applied to vehicle and equipment movements as outlined in the Weed Management Procedure (EP-08).

7.3.4.5 Uncontrolled fire

Fire is a natural feature of the local environment which can occur as a result of lightning strikes. However, fire at Lot 1817 is currently more frequent and uncontrolled than is suitable for land so close to residential and industrial areas. Fires at Lot 1817 are generally human lit because the area is frequently used for recreational activities. Fire on Lot 1817 can quickly become uncontrolled late in the dry season due to the presence of weedy grass. Reduction in weedy grasses across the site and the reduction in general public access is likely to decrease the risk of fire at the site from its present high levels.

Establishment of industry can lead to an increased risk of fire through the introduction of ignition sources, such as grinding and welding. Electrical arcing or shorting is the largest cause of fire on industrial sites generally, although surrounding areas are not usually affected.

All industrial sites have fire protection measures as a matter of course. Typically, these include:

- Training of personnel in fire protection;
- Equipping of the site with fire extinguishers and other fire prevention measures; and
- Implementation of a hot work permit system.

A regime of fire management will be implemented at the Processing Facility in accordance with the site specific Fire Management Plan (**FMP**) (Appendix K).

7.3.4.6 Impact to flora through dust

Sources of dust from development of the site could include:

- Unloading, loading and haulage of materials
- Wheel-generated dust from vehicles
- Dust from concrete batching plant during the construction phase
- Wind-blown dust from disturbed, open areas and material stockpiles

A range of management strategies can be implemented to reduce dust impacts on vegetation; chapter 7.9 discusses the risks and mitigation of risk relating to dust. Significant measures are proposed to avoid dust generation through use of specialised rail carts, placing high risk dust generation processes inside sheds, and covering loads during internal road transport.

As the site is small and traffic will be operating at low speeds on internal roads, wheel generated dust is likely to be minimal.

Mitigation of risk of dust generation will occur over two phases – construction and operation.

The development envelope has been allocated in such a way that vegetation is retained around the site, particularly towards the Elizabeth River and Darwin Harbour. Any dust generated on the site is likely to remain localised due to the remnant vegetation acting as a wind break and physical barrier. Any impact incurred through fugitive dust is likely to be local and minor.

7.3.4.7 Modification or sedimentation of surface water flows that may impact remnant vegetation

The potential impact of the proposal on flow regimes has been modelled by suitably qualified hydrologists at Appendix M and reported in chapter 7.5.

The site has low to moderate erosion risk due to the low gradients of the site, and soil testing nearby classifying soils as non-dispersive. Monitoring at the nearby Ichthys LNG Project has demonstrated that given the appropriate controls, no impact to remnant vegetation is experienced due to changes in surface water flows or quality.

Appropriate controls are discussed below, including a conceptual ESCP (Appendix N) and procedures for managing stormwater/surface water, developed as part of the EMP (Appendix D).

As discussed in chapter 7.4, the surface water catchment of the site is small. Loss of surface water to the fringing vegetation as a result of the Project is likely to be small and any impacts would be localised.

Due to retention of vegetation around the site, particularly towards the Elizabeth River and Darwin Harbour, any sedimented surface water on the site is likely to remain localised due to the remnant vegetation acting as a physical barrier. Any impact incurred on vegetation at the site is likely to be localised, with no significant impact expected on regional values.

7.3.4.8 Contaminated water impacts to vegetation

Various sources of potential contamination exist from the Processing Facility. Detailed assessment for potential spills and leakages appears in chapter 7.2. Daily monitoring of high-risk infrastructure, as outlined in the EMP, will identify new and emerging risks and trigger remedial action.

Impacts from contaminated water on vegetation would be accidental in nature and not anticipated to occur through normal operation of the Facility.

7.3.5 Mitigation and management

The mitigation measures appearing in Table 7-15 will be implemented to reduce the risk of impacts on flora and vegetation. More detail is provided in the management plans and procedures developed through the EMP (Appendix D) and BMP (Appendix L).

Table 7-15: Flora and vegetation – potential impacts and mitigation measures

Pathway	Mitigation hierarchy	Mitigation measure
Vegetation clearing	Avoid, minimise, rehabilitate	- Vegetation clearing is undertaken only in approved areas. - Existing disturbed areas will be utilised wherever possible for development of infrastructure. - Implementation of the Ground Disturbance and Vegetation Clearing Procedure (EP-05) contained within the EMP (Appendix D). - Development and implementation of an internal Ground Disturbance Permit system whereby no land clearing is undertaken without completing a series of checks to ensure: - The proposed clearing has been approved; - Conditions in relation to soil and subsoil recovery, weed management, fauna clearing and other requirements have been assigned;

Pathway	Mitigation hierarchy	Mitigation measure
		- o Approved permits are assessed for compliance with permit conditions; and - o Proposed area of clearing is demarcated prior to clearing to avoid excessive or prohibited clearing. • Recover topsoil and utilise the seed bank to conduct rehabilitation of disturbed areas as they become available.
Decrease of populations of conservation significant flora	Avoid, minimise	• Prior to commencement of construction review the Development Envelope of the Project to ensure, wherever possible, populations of the following flora species are excluded where possible: - o <i>Cycas armstrongii</i> (VU); - o <i>Tricoryne elatior</i> (NT); - o <i>Polymeria pusila</i> (DD); and - o <i>Buchnera sp.</i> Ciliate bracts (DD). • Ensure vegetation clearing occurs only in approved areas.
Alteration and sedimentation of surface water flows from erosion	Avoid, minimise	• Implementation of the ESCP (Contained within Appendix N) and Implementation of the Water Management Procedure (EP-10) contained within the EMP (Appendix D) including: - o Use of swales and sediment basins where required; and - o Use of minor diversions where required. • Maintain natural flow paths wherever possible.
Uncontrolled fire	Avoid	• Implementation of the FMP (Appendix K) including: - o Mine personnel will be trained in fire protection; - o The site will be equipped with fire suppression equipment; - o A hot work permit system will be implemented; and • Grassy weeds will be controlled.
Spread of existing weed infestations or introduction of new weed species	Avoid, minimise, rehabilitate	• Implementation of the Weed Management Procedure (EP-08) contained in the EMP (Appendix D) including: - o Review existing weed mapping and signpost areas of significant weed infestation; - o Educate mine personnel on the identification and management of key weed species; - o Implement weed hygiene procedures; - o Use the Ground Disturbance Permit System in the Ground Disturbance and Vegetation Clearing Procedure (EP-05) as specified in the EMP to assess the risk of spreading weeds when undertaking land clearing; and - o Routinely undertake site infestation control measures and monitoring of infestations.
Increase of dust loads on vegetation arising from construction	Avoid, minimise	• Implementation of the Dust Emission Management Procedure (EP-11) contained within the EMP (Appendix D) including: - o Regular watering of active, potentially dust generating areas and stockpiles; - o Efficient and effective machinery operation; - o Limit vegetation and soil clearing; and - o Biannual photographic monitoring of vegetation health at site.
Low quality, saline and/or contaminated water	Avoid, minimise	• Water storage facilities and /or hazardous materials will be restricted to designated impermeable storage areas located at least 50m from any vegetation. Storage areas will be bunded and have appropriate drainage systems designed to capture any potential spills or leaks.

Pathway	Mitigation hierarchy	Mitigation measure
contaminating soil and impacting vegetation		Water used for dust suppression will be of a quality that does not negatively impact flora and vegetation.
Increase of dust loads on vegetation arising from operation	Avoid, minimise	- Implementation of the Dust Emission Management Procedure (EP-11), in the EMP (Appendix D), including: - Maintain the concentrate at Dust Extinction Moisture level; - Use of water sprays or misting nozzles during stacking operations; - Misting sprays on reclaim feeders; - Fogging sprays at transfer points; - Physical enclosure of transfer points and operating equipment; - Select operational procedures to take place inside sheds; - Open areas not required for vehicle access for operations will be sprayed with hydro mulch or sealed through the application of dust suppressant chemicals; and - Active road surfaces sealed, treated with a dust suppressant chemical or sprayed with water. - Biannual photographic monitoring of vegetation health at site.

7.3.6 Monitoring and reporting

The EMP and associated sub-plans detail objectives, monitoring procedures and performance indicators, as well as corrective actions and reporting requirements. Specific monitoring actions are outlined in Table 7-16, and other inspection and reporting activities are outlined in Table 7-16.

Table 7-16: Monitoring actions for terrestrial flora

Action	Timing	Methods used	Criteria
Weed Survey	Prior to Ground Disturbance activities. Survey to be conducted quarterly. Quarterly and/or within 4 weeks after control.	Visits to known locations, searches for new populations.	As per Environmental Management Plan (Appendix D).
Vegetation health monitoring	Prior to Ground Disturbance activities. Biannual throughout Project life.	Establish permanent photographic monitoring points across various vegetation associations within the site.	Comparative assessment against previous monitoring results.

Table 7-17: Other inspections and reporting for flora and vegetation

Relevant Plan	Procedure (if relevant)	Monitoring	Reporting
Environmental Management Plan	NA	Daily inspection of high-risk locations to identify any new risks / unmanaged risks	
	Ground Disturbance and Vegetation Clearing Procedure	Daily inspection (using GPS) during vegetation clearing activities to confirm clearing is within the approved envelope.	Monthly Environmental Performance Report
	Water Management Procedure	Weekly inspection of swales and sediment traps.	Half Year Report
	Air and Dust Management Procedure	Review complaints and grievance register to identify if excessive dust have been noted.	Annual Report and Performance Review
	Weeds Management Procedure	Monthly weed surveys and follow-up control.	
Erosion and Sediment Control Plan		Weekly inspection of erosion and sediment controls during the wet season.	Monthly Environmental Performance Report
FMP		Weekly inspections of fire response equipment.	Annual Review
		Weekly inspection if site for fire hazards.	

7.3.7 Statement of Residual Impact

In consideration of the outcomes of the EIA and proposed management measures, TNG considers that the EPA's objective for terrestrial flora and vegetation can be achieved. The following outcomes are predicted:

- No change to the conservation status of significant flora;
- Loss of vegetation is negligible at the regional scale; and
- Loss of sensitive and significant vegetation is negligible at the regional scale.

TNG acknowledges the flora and vegetation values of the area in which it proposes to operate and believes implementation of the targeted mitigation measures proposed suggests that the EPA's objective for flora and vegetation can be met. No offsets are considered to be required.

TNG LIMITED

DRAFT ENVIRONMENTAL IMPACT
STATEMENT

DARWIN PROCESSING FACILITY

**ENVIRONMENTAL
FACTOR:
TERRESTRIAL
FAUNA**

7.4 ENVIRONMENTAL FACTOR: TERRESTRIAL FAUNA

7.4.1 NT EPA Objective

The NT EPA's objective for the factor Terrestrial Fauna is to:

Protect the NT's fauna so that biological diversity and ecological integrity are maintained.

Terrestrial fauna refers to animals that occur on land. This objective recognises the value of maintaining ecosystem services to ensure that the diversity and distribution of fauna species and productivity of fauna habitat is maintained. It is supported by the protection of listed threatened species, migratory species and critical habitats under the TPWC Act.

This chapter describes the potential impacts to terrestrial fauna that occur within the TNG Processing Facility Project area. The mitigation and management measures that TNG will implement to avoid and/or reduce impacts are summarised. At the end of the chapter, a statement of residual impact is made detailing the extent to which the proposed mitigation and management measures will ensure that the NT EPA's objective for this environmental factor is met.

The content of this chapter has been developed specifically to address section 3.1 and 4.2 of the EIS TOR (refer to Appendix A).

7.4.2 Technical Studies

Technical studies undertaken to inform assessment of potential impacts of the Project on Terrestrial Environmental Fauna are listed in Table 7-18.

Table 7-18: Fauna studies undertaken for the Project

Date	Study Title	Consultant	Description	Report
7 – 11 Mar 2016	Wet season Threatened and Migratory species – Shorebird Survey	GHD*	Targeted surveys at the site for the Eastern Curlew and Curlew Sandpiper.	N/A
3 – 13 Jun 2017	Mid-dry season Terrestrial Fauna Survey	GHD*	Survey to collect baseline data on the vertebrate fauna assemblage at the site.	Appendix J
8 – 11 Dec 2018	Early-wet season Fauna Survey	APM	Targeted migratory bird survey, terrestrial bird survey as well as deployment of camera traps, and active foraging.	Appendix J
27-30 Mar 2019	Wet season Bird Survey	APM	Targeted migratory bird survey and terrestrial bird survey.	Appendix J
23 Apr – 2 May 2019	Late-wet season Terrestrial Mammal survey	APM	Baseline survey of the Terrestrial mammal assemblage.	Appendix J

* GHD data for the Darwin Processing Facility were never reported. As such the data is presented as part of the combined survey effort in the APM (2019) Biological Survey (Appendix J).

7.4.3 Existing Environment

The Darwin Processing Facility site incorporates multiple fauna habitats, along with extensive areas of previous disturbance due to historic extractive industry use and effects of prolonged authorised access to the site.

Numerous biodiversity surveys have been conducted at the site since 2016 (Table 7-18) and have included the mangroves and waterways adjacent to the site. The complete Biological Survey Report is available in Appendix J. The biological work refers to a 'Study area' which includes Lot 1817, the fringing mangroves and the adjacent waterways (Figure 7-3). The surveys have used a variety of methods to describe the faunal assemblage and habitat types present in the Study area and determine the presence or absence of threatened or significant species. These studies have used a range of database searches, as well as field methods, including:

- Live trapping (cages, boxes, funnels and pitfalls);
- Camera trapping;
- Acoustic bat detectors;
- Diurnal hand foraging;
- Nocturnal spotlight surveys;
- On-ground bird surveys; and
- Mobile platform (helicopter or boat) bird surveys.

7.4.3.1 Threatened Fauna

Fauna species search tools were used to identify conservation significant species that have been previously recorded from the Study area and the wider region. The search tools identified no records from the Study area. Records from the surrounding area returned 54 bird species, 16 mammal species, 13 reptile species and one amphibian (excluding sea turtles, fish and cetaceans which are addressed in a separate study).

A full assessment of likelihood of occurrence is in Appendix J Table 5-2, which details the fauna species identified from the Database searches and their habitat requirements in comparison to habitats present in the Study area.

From field survey work it was identified that eighteen fauna species listed as threatened under the EPBC Act and/or the TPWC Act in the categories Critically Endangered (**CR**), Endangered (**EN**), Vulnerable (**VU**) and Near Threatened (**NT**) were found to occur in the Study area or were assessed as likely to occur. A number of these species were also identified as Migratory (**Mi**) or Marine (**Ma**) species. Conservation Code Categories are described in Appendix J. These species are described below.

Eastern Curlew (*Numenius madagascariensis*) – CR/Mi/Ma (EPBC Act), VU (TPWC Act)

The Eastern Curlew is the largest migratory shorebird in the world. Within Australia they occur from Barrow Island in Western Australia across the north to the NSW coast. This species is endemic to the East Asian – Australasian Flyway, breeding in Russia, Mongolia and north-eastern China. Around 73 percent of the population spends the non-breeding season (July to April) in Australia.

The Eastern Curlew inhabits sheltered coasts, including estuaries, bays, harbours, and lagoons with intertidal mudflats or sandflats, and some records exist of birds within mangroves. This species is threatened by human disturbance, habitat loss, and degradation. Eastern Curlews take flight if humans approach within 30-100 m (DoE 2015), which may lead them to a reduction in condition due to lost foraging time, increasing the chance of unsuccessful migration. Coastal development and land reclamation can destroy feeding habitat for this species (Close & Newman 1984).

The Eastern Curlew has been recorded within the Study area in 2016, 2018, and 2019. This species is restricted to the tidal mudflats and mangrove habitat, on the fringes of the site.

Curlew Sandpiper (*Calidris ferruginea*) – CR/Mi/Ma (EPBC Act), VU (TPWC Act)

The Curlew Sandpiper is medium sized migratory wader, found predominantly in coastal regions of Australia, throughout the Australian summer (August to April). Non-breeding individuals often overwinter in Australia rather than migrating north. This species occurs in tidal mudflats, saltmarsh, salt fields, wetlands (fresh, brackish, or saline), and sewage ponds (Pizzey and Knight, 2012).

The Curlew Sandpiper has not been recorded within the Study area, however it has been recorded previously within the Darwin region. Suitable habitat exists within the Study area, however the relative scarcity of records within the Darwin area result in the occurrence of the Curlew Sandpiper only being considered possible (as opposed to likely).

Great Knot (*Calidris tenuirostris*) – CR/Mi/Ma (EPBC Act), VU (TPWC Act)

The Great Knot is a medium-sized shorebird, with a wingspan of approximately 58 cm (TSSC 2016a). The plumage of this bird has three distinctive types; breeding, non-breeding, and juveniles (Higgins & Davies 1996). Non-breeding plumage (as usually seen in Australia) is grey upperparts and white underparts, while juveniles are darker and browner (Higgins & Davies 1996). Whilst in Australia, the Great Knots occupy sheltered coastal habitat, with mudflats or sandflats, including estuaries and lagoons (TSSC 2016a). The Great Knot is a non-breeding visitor to Australia, present from August until April.

The Great Knot has not been recorded within the Study area. In 2016 it was recorded in high numbers at other sites throughout the Greater Darwin area. Suitable habitat exists in the Study area and it is considered likely that the Great Knot uses the habitat in the Study area at some time.

Northern Quoll (*Dasyurus hallucatus*) – EN (EPBC Act), CR (TPWC Act)

The Northern Quoll is Australia's smallest species of quoll, while being the largest mammal species known to undergo a male die-off after mating (Van Dyck & Strahan 2008). The species is brown with white spots on the rump and head, with five toes and striated pads on hindfeet. The Northern Quoll is found in east and north Queensland, northern parts of the Northern Territory, the Kimberley and the Pilbara.

This species has suffered significant decline in areas where Cane Toads (*Rhinella marina*) are established, particularly in the Northern Territory. Mating occurs in winter, with young being carried by the female for 8-10 weeks after birth; they then stay with their mother until they can fend for themselves. Northern Quolls inhabit savanna woodlands and grasslands with rocky crevices, tree hollows and hollow logs (Hill & Ward 2010).

While not having been recorded in the Study area, the Northern Quoll has been previously recorded 500 m south of the site. Northern Quolls have also been recorded during biological surveys for the Blackmore River Aquaculture Project (URS 2001) approximately 10 km to the south-east of the site. The Study area likely provides appropriate habitat and the apparent absence is probably due to the very low density of quolls, resulting from the decline caused by Cane Toads.

Red Knot (*Calidris canutus*) – EN/Mi/Ma (EPBC Act), VU (TPWC Act)

Smaller than its close relative the Great Knot, the Red Knot is a robust, short necked species with a straight bill and long wings (Higgins & Davies 1996). This species has brownish grey non-breeding plumage with dark streaks on the head and neck. During breeding, the Red Knot plumage becomes boldly marked, contrasting against the

chestnut-red body. This species has a global distribution and breeds at a range of locations around the Arctic (TSSC 2016b).

The Red Knot inhabits intertidal mudflats, sandflats and beaches on sheltered coasts. They will forage in soft substrates near the water edge on intertidal mudflats or sandflats, lakes and floodwaters (Higgins & Davies 1996). The Red Knot was not recorded in the Study area but was recorded in 2016 in the broader Darwin area.

Lesser Sand Plover (*Charadrius mongolus*) – EN/Mi/Ma (EPBC Act), VU (TPWC Act)

The Lesser Sand Plover is a grey-brown and white shorebird with a dark eye-stripe and short black bill (Marchant & Higgins 1993). This species is often difficult to distinguish from the Greater Sand Plover (*C. leschenaultii*) (TSSC 2016c). This species breeds in the northern hemisphere and migrates annually to southern breeding grounds between September and May. The Lesser Sand Plover is found in all states of Australia but mainly in northern and eastern regions (TSSC 2016c).

This species is strictly coastal, including sandy beaches, mudflats of coastal bays and estuaries, and occasionally mangrove mudflats (TSSC 2016c). This species has not been recorded at the Study area, however in 2016 was recorded in the broader Darwin area.

Black-footed Tree-rat (*Mesembriomys gouldii gouldii*) – EN (EPBC Act), VU (TPWC Act)

The Black-footed Tree-rat is a nocturnal, medium-sized mammal and one of the largest rodents in Australia. It has shaggy grey-black fur with a distinctive long hairy tail with a terminal white brush (DoE 2015). It is restricted to forests and woodlands of the north Kimberley and mainland Northern Territory. The Black-footed Tree-rat nests in dense foliage, especially *Pandanus* sp.. This species forages on the ground and in trees, sometimes over 500 m from the roost site, feeding on fruit and seeds as well as invertebrates, flowers and grasses (DoE 2015).

The Black-footed Tree-rat has been recorded during 2017, 2018 and 2019 within the Study area. The Eucalyptus Woodland and Monsoon Closed Forest habitats are likely to provide important habitat for this species. The Black-footed Tree Rat has suffered a significant decline in the Northern Territory, likely due to habitat fragmentation, inappropriate fire regimes (Price et al. 2005) and predation by feral cats (DoE 2015).

Greater Sand Plover (*Charadrius leschenaultia*) – VU/Mi/Ma (EPBC Act), VU (TPWC Act)

The Greater Sand Plover is a medium sized shorebird, with a long straight bill that bulges towards the end (TSSC 2016d). This species breeds in the northern hemisphere and approximately 75 percent of the entire population spends the non-breeding season in Australia. During the non-breeding period its distribution within Australia is widespread but they mainly occur in coastal northern Australia (TSSC 2016d).

Like many migratory shorebirds, this species occurs on sandy or muddy beaches, intertidal mudflats, sandbanks and saltmarshes. This species is susceptible to development due to their high site fidelity, tendency to aggregate, very high energy demands for migration, and requirement for areas containing both roosting and foraging sites (TSSC 2016d). Many of the most pressing threats to this species occur at the East Asian staging areas.

The Greater Sand Plover was recorded within the Study area during 2016 and has also been recorded in the broader Darwin area.

Howard River Toadlet (*Uperoleia daviesae*) – VU (TPWC Act)

This small species is endemic to the Northern Territory and was discovered in 2000. The dorsal surface is pale brown with numerous tubercles and a cream ventral surface (Ward et al. 2012). As suggested by its recent

discovery, little is known about the biology of this species. It is known only from locations in the Howard and Elizabeth River catchments. This species appears to be confined to sandsheet heathland associated with alluvial plains, drainage lines and seepage zones.

Specimens suspected to be the Howard River Toadlet was collected during 2017, although the identification was never confirmed. This species is identified by its call and cannot be physically identified by its appearance. Fifteen small toadlets were recorded during the survey in Monsoon Closed Forest and Melaleuca Woodland habitat types (Figure 7-8). Further survey is required in the 2019-2020 wet season to confirm the taxonomy.

Pale Field-rat (*Rattus tunneyi*) – VU (TPWC Act)

This attractive rodent is generally known from grassland savannahs across northern Australia (Van Dyck & Strahan 2008). This species prefers areas with small, often seasonal watercourses, is strictly nocturnal and excavates diurnal refuge burrows in loose sandy soil. The requirement to excavate burrows may determine its distribution at a local scale. Their diet consists of grass stems, seeds, and roots, particularly *Alloteropsis* grass, Sorghum seeds and *Pandanus* roots. The Pale Field-rat has undergone a 90 percent reduction in distribution as, in many areas, preferred creek line habitats are vulnerable to destruction by introduced herbivores (Van Dyck & Strahan 2008).

The Pale Field-rat has been trapped in 2017 within the Monsoon Closed Forest habitat in the Study area.

Whimbrel (*Numenius phaeopus*) – Mi/Ma (EPBC Act), NT (TPWC Act)

The Whimbrel is a medium sized curlew that is dark brown on the upper half of its body and a lighter underside with dark brown streaks. This species occupies intertidal mudflats, lagoons and estuaries, often with mangroves (DEE 2018). The Whimbrel is one of very few shorebirds that roost in mangroves (DEE 2018). This species has been recorded across the coastal regions of the Top End. Like many migratory shorebirds the Whimbrel is threatened by habitat loss and degradation as a result of development, predominantly in staging areas in east Asia.

The Whimbrel has been recorded within the Study area during 2016 and 2018, and with the broader Darwin area in 2016.

Bush Stone-curlew (*Burhinus grallarius*) – NT (TPWC Act)

The Bush Stone-curlew is well known and iconic throughout much of northern Australia but has suffered a significant decline in settled areas of southern Australia. The Bush Stone-curlew has broad habitat requirements however individuals pair and form stable territories, displaying long term site fidelity (Birdlife International 2016).

The Bush Stone-curlew has been recorded in the Study area in 2017, 2018 and 2019.

Grey-tailed Tattler (*Tringa brevipes*) – NT (TPWC Act)

The Grey-tailed Tattler is a medium sized wader with longer wings and tail than other wader species. The species is plain grey above, with lighter underwings and yellow legs (DEE 2018). This species is found on sheltered coasts with reefs and rock platforms, or intertidal mudflats and usually roosts in the branches of mangroves. This species is found throughout the coastal regions of northern Australia between August and April. The Grey-tailed Tattler is threatened by habitat loss and degradation as a result of development, predominantly in staging areas in east Asia.

The Grey-tailed Tattler has been recorded within Study area in 2016, 2018, and 2019, as well as in the broader Darwin area in 2016.

Northern Brown Bandicoot (*Isoodon macrourus*) – NT (TPWC Act)

The Northern Brown Bandicoot is a common urban adapted species in northern Australia. This species occurs in areas with low ground cover, including tall grass and dense shrubbery, but may also live in areas with open understorey (Van Dyck & Strahan 2008). Bandicoots are generally nocturnal and spend the night foraging in leaf litter and topsoil for invertebrates and fruits. While being well suited to deal with disturbance and unstable environments, this species is threatened by development for farming and inappropriate fire regimes (Van Dyck & Strahan 2008).

The Northern Brown Bandicoot is common in the Study area, being trapped using either cage traps or camera traps in 2017, 2018, and 2019, throughout all habitat types.

Western Chestnut Mouse (*Pseudomys nanus*) – NT (TPWC Act)

The Western Chestnut Mouse is a large and stout mouse with short limbs and ears (Menkhorst & Knight 2009). The species is named for its orange-fawn upperparts and chestnut eye-ring. The Western Chestnut Mouse is found throughout northern WA and the top end of the NT, inhabiting woodlands with a shrubby or dense tussock understorey, often along water courses (Menkhorst & Knight 2009). This species is thought to eat grasses and build grassy nests. It is unknown if it excavates a burrow (Van Dyck & Strahan 2008).

This species has been recorded within the Study area during 2019.

Orange Leaf nosed Bat (*Rhinonictis aurantia*) – NT (TPWC Act)

The Orange Leaf-nosed Bat is distinctively coloured with uniformly rich golden orange fur (Menkhorst & Knight 2009). This species is found in northern WA, the Top End, and north-western Queensland. As they are unable to compensate by entering torpor, this species is vulnerable to cooling and desiccation and require roost sites with hot and humid conditions (Van Dyck & Strahan 2008). This species feeds on moths and beetles, flying in a fast characteristic zigzag, generally low to the ground (Van Dyck & Strahan 2008).

The Orange Leaf-nosed Bat has been recorded within the Study area in 2017 and 2019.

Arnhem Sheath-tailed Bat (*Taphozous kapalgensis*) – NT (TPWC Act)

The Arnhem Sheath-tailed Bat may have been recorded during 2019 however the identification of the call is uncertain and the call may have been from the Common Sheath-tailed Bat (*Taphozous georgianus*) (see Appendix J for details). The Arnhem Sheath-tailed Bat is a medium brown colour with band of whitish fur along each flank (Menkhorst & Knight 2009). This species is known only from the Top End of the NT, inhabiting floodplains, mangroves and patchy monsoon forests (Van Dyck & Strahan 2008). This species forages relatively high whether over a canopy or open habitats.

This species may have been recorded over three nights in 2019 however due to poor quality recordings or similar calls from other species it could not be reliably identified.

Northern Brushtail Possum (*Trichosurus vulpecula arnhemensis*) – NT (TPWC Act)

The Northern Brushtail Possum is a subspecies of the Common Brushtail Possum (*T. vulpecula*) and is found in the Kimberley area of WA and the top end of the NT. They are generally smaller (1.5 kg) than their southern

counterparts and have a slightly different colouration (Menkhorst & Knight 2009). This species is highly adaptable and able to live in a variety of habitats including residential areas, vine thickets, forests, woodlands and areas without trees that offer caves and burrows for shelter. The species has suffered a decline throughout much of the arid regions of Australia due to habitat modification from introduced herbivores, predators and fire regimes (Pavey & Ward 2012).

The Northern Brushtail Possum was recorded within the Study area during 2017 and 2018 in the Monsoon Closed Forest, Eucalyptus Woodlands and Melaleuca Woodlands habitats.

Mulga Snake (*Pseudechis australis*) – NT (TPWC Act)

The Mulga Snake, sometimes known as the King Brown Snake, is one of Australia's largest venomous snakes, growing up to 2 m long and is found across the majority of the mainland (Cogger 2014). This species can be copper coloured through to dark olive-brown, with each individual scale generally having a darker tip. The Mulga snake occurs in a range of habitats from tropical forests to the arid interior (Cogger 2014). Mulga snakes often eat the poisonous Cane Toad (*R. marinus*) and are likely to be under threat in northern Australia; however, the response of Mulga snake populations following Cane Toad invasion have not been as clearly negative as predicted (Brown et al. 2011).

The Mulga snake has been recorded within the Study area in 2017.

7.4.3.2 Other Fauna of conservation significance

Twelve other fauna species of conservation significance recorded from the Study area include those that have been assessed by the NT Government as being Data Deficient (DD), or are listed under the EPBC Act as Marine (Ma), Migratory (Mi) or both. These are described below.

Green Tree Snake (*Dendrelaphis punctulata*) – DD

This species is found through a diverse range of habitat types from mangroves, rainforests, dry and wet sclerophyll forests, coastal heaths and riparian margins. The Green Tree snake occupies coastal and hinterland regions of northern Australia (Cogger 2014). The species is present in the Study area with 1 record in 2018.

Fork-tailed Swift (*Apus pacificus*) – Mi, Ma

This species flies over inland plains but also occasionally foothills or coastal areas such as beaches and islands and well out to sea. They occur over dry or open habitats comprising of riparian woodland, low scrub, heathland or saltmarsh, also grasslands and sandplains with spinifex (Morcombe 2010). The species is present in the Study area with 1 record in 2019.

Oriental Cuckoo (*Cuculus optatus*) – Mi

This species is found throughout coastal regions of northern and eastern Australia, in monsoon forests and rainforest edges, river flats, roadsides and mangroves. This species is a regular non-breeding migrant in northern Australia from September to May but is uncommon. The species is present in the Study area with 1 record in 2018.

Common Sandpiper (*Actitis hypoleucos*) – Mi, Ma

This species is present in both saltwater and freshwater ecosystems, using a wide range of coastal wetlands and some inland wetlands. This bird is mostly found around muddy margins or rocky shores and rarely on mudflats.

The Common Sandpiper is often associated with mangroves, and sometimes found in areas of mud littered with rocks or snags (Higgins & Davies 1996). The species is present in the Study area with 116 records across 2016, 2018 and 2019.

Common Greenshank (*Tringa nebularia*) – Mi, Ma

This species inhabits estuaries, mudflats, saltmarshes, margins of lakes, claypans, commercial salt fields, sewage ponds, inland lakes and open swamps (Simpson 1993). The Common Greenshank is a regular and widespread summer migrant in Australia (Sept – April). The species is present in the Study area with 19 records across 2016, 2018 and 2019.

White-bellied Sea-Eagle (*Haliaeetus leucogaster*) – Ma

This species will occupy and forage within any habitats close to any type of water body including marine, estuarine and fresh water. The White-bellied Sea-eagle requires tall trees adjacent to a water body for nesting. The species is present in the Study area with 14 records across 2018 and 2019.

Rainbow Bee-eater (*Merops ornatus*) – Ma

The Rainbow Bee-eater occurs in a very diverse array of habitat from forests to samphire to sedgeland and is one of the most frequently observed species during biological surveys. It is readily noticed due to its highly conspicuous plumage. The Rainbow Bee-eater is highly mobile, widespread and relatively common throughout Australia. The species is present in the Study area with 45 records across 2017, 2018 and 2019.

Osprey (*Pandion haliaetus*) – Mi, Ma

The Osprey is found throughout much of the world in coastal areas, islands and rivers. This medium sized raptor has a white neck and underparts with a grey brown back. The species regularly nests in tall man-made structures such as TV and radio towers. The species is present in the Study area with 1 record in 2018.

Great Egret (*Ardea alba*) – Ma

This large egret occurs in shallow rivers, estuaries, tidal mudflats, freshwater wetlands and anthropogenic water bodies. The Great Egret builds a scanty platform of sticks to nest in, in treetops surrounding water and mangroves in March to May in northern Australia (Pizzey & Knight 2012). The species is present in the Study area with 13 records across 2018 and 2019.

Pacific Reef Heron (*Egretta sacra*) – Ma

This species prefers occupying islands and coastal areas, rocky shores, exposed coral reefs and mangroves. Breeding occurs on island woodlands, caves or ledges from September to February. Uncommon to rare in southern Australia, common on the Queensland coast and Great Barrier Reef, with occurrences around the Australian coastal region. The species is present in the Study area with 7 record across 2016, 2018 and 2019.

Little Tern (*Sternula albifrons*) – Mi, Ma

The Little Tern is found throughout much of northern Australia in coastal waters, bays, inlets and saline or brackish lakes. This species breeds from May to July in colonies on islands and sandspits (Pizzey & Knight 2012). The species is present in the Study area with 2 records in 2018.

Saltwater Crocodile (*Crocodylus porosus*) – Mi, Ma

The Saltwater Crocodile is the largest crocodilian on earth, sometimes reaching 7 m in length and weighing over 1000 kg, with females significantly smaller than males. Saltwater crocodiles live in coastal waterways throughout northern Australia and have grown in both abundance and distribution since the banning of unregulated hunting in 1971 (Fukuda et al. 2011). The species is present in the Study area with 1 record in 2016.

7.4.3.3 Fauna Habitat

Seven habitat types have been identified across the Study area (Figure 7-8) and are individually described below:

- Eucalyptus woodland;
- Monsoon Closed Forest;
- Native Grasslands;
- Melaleuca woodland;
- Temporary water bodies;
- Disturbed areas; and
- Mangroves.

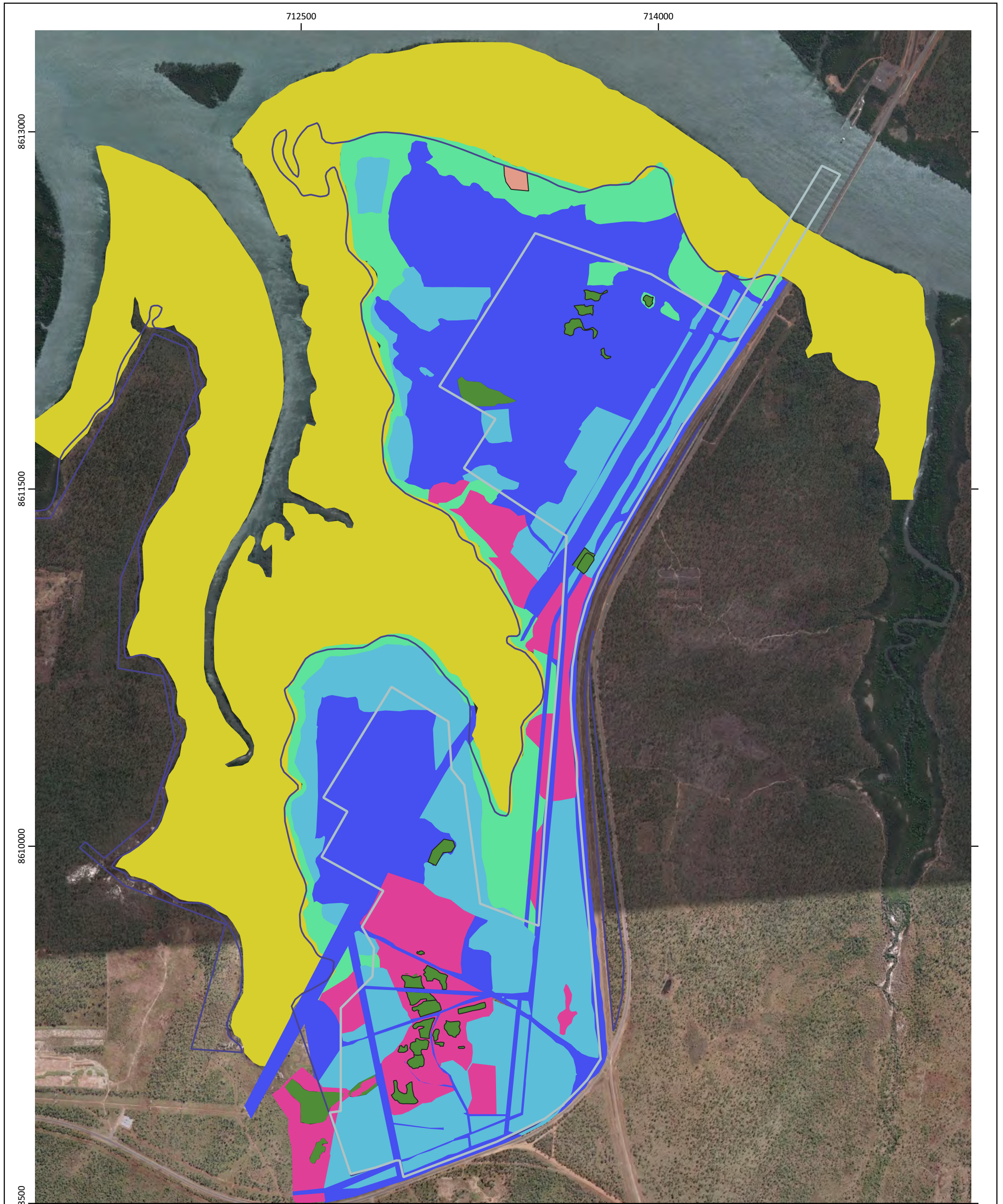


Figure 7-8: Fauna Habitats in the Study Area

Legend

- Darwin Processing Facility Development Envelope
- Lot 1817 Hundred of Ayres

Fauna Habitats

 Disturbed areas	 Mixed woodland
 Mangroves	 Monsoon Closed Forest
 Melaleuca woodland	 Native Grasslands
	 Temporary Water Bodies



0 400 800 m

1 centimeter = 150 m (when printed A3)
 Date: 13/10/2019
 Coordinate System: GDA 1994 / MGA
 Zone 52

Mixed Woodland

The Mixed woodland habitat corresponds with the vegetation associations VA1, and VA2 (Plate 7-5, Figure 7-8). This habitat type is typical of the northern Australian grassland savanna, with mixed *Eucalyptus*, *Corymbia* and *Erythrophleum* trees, over mixed shrubs, over grasses, herbs and vines. The fire age is highly variable across this habitat type, driven largely by the fragmentation of the site by clearing. Some areas are long unburnt and have abundant logs, litter and woody debris, and are likely to support a high level of species richness and diversity. In contrast some areas, particularly those most accessible to the public, are frequently burnt and as a result provide less refuge.

As the most widespread habitat type within the Study area, Mixed woodland supports a range of generalist species that require habitat connectivity and continuity, in contrast to specialised species that are restricted to isolated patches of a specific habitat.

A range of conservation significant fauna have been recorded in the mixed woodland habitat, including the Black-footed Tree Rat (*M. g. gouldii*), the Northern Brown Bandicoot (*Isodon macrourus*), the Rainbow Bee-eater (*Merops ornatus*), the Common Greenshank (*Tringa nebularia*), the Northern Brushtailed Possum (*Trichosurus vulpecula arnhemensis*) and the Orange Leaf-nosed Bat (*Rhinonictes aurantius*).



Plate 7-5: Mixed woodland habitat

Monsoon Closed Forest

The Monsoon Closed Forest habitat type corresponds to the vegetation association VA9 and occupies a small area between Melaleuca woodlands and Mangrove areas. This habitat type is characterised by dense vegetation, with *Corymbia*, figs, palms and vines with a dense shrubby understorey. This habitat type is generally long unburnt, resulting in abundant logs litter and woody debris. The large trees present in this habitat type provide hollows for both small and large species. Monsoon Closed Forest may provide habitat for a range of small species that can move freely through the dense vegetation, as well as those that seek refuge from the thermal extremes of more open habitat types.

Northern Brown Bandicoots (*I. macrourus*) have been frequently recorded within this habitat. The thick litter layer, and resulting abundant invertebrates and fungi are likely to make this habitat preferred by semi-fossorial animals such as Bandicoots. One conservation significant bird recorded was the Rainbow Bee-eater (*M. ornatus*). The Howard Springs Toadlet (*Uperoleia daviesae*) and Pale Field-rat (*Rattus tunneyi*) have also been recorded within the Monsoon Closed Forest and the Pale Field-rat is known only from this habitat.

Native Grasslands

Areas of open Native Grassland (vegetation associations VA10 and VA4) are present within the southern portion of the site, acting as an ecotone between Eucalypt Woodland and disturbed areas (Figure 7-8). This habitat type is dominated by tussock grasses, such as *Sorghum plumosum*, with scattered emergent trees, many of which provide suitable nesting and roosting habitat for birds.

Three conservation significant species have been recorded within this habitat type; the Rainbow Bee-eater (*M. ornatus*) the Northern Brushtail Possum (*Trichosurus vulpecula arnhemensis*), and Northern Brown Bandicoot (*I. macrourus*).

Melaleuca Woodland

The Melaleuca woodland corresponds with vegetation association VA3 and is characteristic of low lying seasonally inundated areas (Plate 7-6). This habitat type consists of an open woodland of Melaleucas over a dense tussock grassland, with little mid-storey. Some hollow bearing logs and leaf litter may be available, and the fire age of this habitat is variable. Much of the heterogeneity of this habitat type is associated with seasonal inundation and the provision of shallow water bodies.

Conservation significant species recorded in this habitat type are the Northern Brown Bandicoot (*I. macrourus*), the Black-footed Tree Rat (*M. g. gouldii*) and the Howard Springs Toadlet (*Uperoleia daviesae*, pending confirmation).



Plate 7-6: Melaleuca Woodland Habitat

Temporary Water Bodies

Seasonal water bodies form after rainfall, generally associated with previously disturbed areas, resulting from the site's previous use as a quarry. The 2017 survey reported no plants or fish being present and concluded that the wetlands were therefore seasonal. However ephemeral, these water bodies provide valuable habitat for waterbirds, such as the Straw-necked Ibis (*Threskiornis spinicollis*) and White-faced Heron (*Egretta novaehollandiae*), which were recorded in 2017. The introduced Cane Toad (*Rhinella marina*) may breed within these water bodies.

Disturbed Areas

Lot 1817 has been extensively disturbed by both its previous use as a quarry and is also frequent use by the public for a range of activities including motorbike riding and illegal dumping of rubbish (Plate 7-7). Some areas have been rehabilitated (vegetation association VA6) while others have not (VA7) or are periodically disturbed (VA11).

In addition, this habitat type includes an extensive network of tracks throughout the sites. Disturbed Areas provide little benefit to native species, however Northern Brown Bandicoots (*I. macrourus*) and the Black-footed Tree Rat (*M. g. gouldii*) have been trapped within this habitat type. These areas are also likely to favour generalist predators, such as the Dingo/Dog (*Canis familiaris*) and generalist introduced species such as the Cane Toad (*Rhinella marina*).



Plate 7-7: Disturbed habitat, showing illegal dumping of rubbish and vehicles

Mangroves

Mangroves occupy the areas fringing the Study area along the estuary side (west and north) and correspond with VA8 (Plate 7-8). This habitat type includes some vegetation heterogeneity, ranging from thick *Ceriops tagal* mangrove woodland to open Samphire/saltpan shrublands dominated by *Chenopods*. This dense vegetation provides good shelter for smaller bird species as well as small mammals and reptiles.

Conservation significant species recorded within this habitat type are the Rainbow Bee-eater (*M. ornatus*) and the Saltwater Crocodile (*Crocodylus porosus*). While no trapping (except camera traps) has been carried out within the mangrove habitat, it is likely to have a similar fauna assemblage to the Monsoon Closed Forest habitat type.



Plate 7-8: Mangrove Habitat

7.4.3.4 Introduced Fauna

Six introduced fauna species were recorded at the site. The most frequently recorded was the Cane Toad (*Rhinella marina*) which is found across all habitat types within the Study area. The Black Rat (*Rattus rattus*), Feral Cat (*Felis catus*), Dog/Dingo (*Canis familiaris*), Feral Pig (*Sus scrofa*) and the Asian House Gecko (*Hemidactylus frenatus*) were also recorded.

7.4.4 Potential impacts and risks

Development of the Darwin Processing Facility (including clearing of vegetation and future operations) has the potential to impact fauna. The source-pathway-receptor model was used to identify potential impacts (Table 7-19). Individual pathways are discussed in the chapters below.

Table 7-19: Potential impact pathways for fauna

Source	Pathway	Receptor
Construction activities	Vegetation clearing	Fauna of Conservation significance
	Habitat fragmentation	
	Uncontrolled fire	
	Potential vehicle strike	
Operation activities	Increase in abundance of introduced species	Fauna habitat
	Impact to fauna through the use of lighting, noise, vibration, or human movement	
	Fauna entrapment in infrastructure	
	Vehicle strike	

7.4.4.1 Loss of conservation significant fauna and fauna habitat

The conservation significant fauna species listed in Table 7-20 are known to inhabit the site or have been assessed as likely to inhabit the site based upon local presence and suitable habitat availability. Table 7-20 details the amount of suitable habitat that occurs within the Development Envelope. The species listed in Table 7-20 will be impacted by the project due to a direct loss of habitat availability.

Due to the small amount of habitat in the Development Envelope compared to the regional extent, loss of habitat is unlikely to materially impact any individual species at the population level. Measures to reduce the potential impacts on individual animals are appropriate and are detailed in the Biodiversity Management Plan (BMP) (Appendix L).

The BMP outlines the pre-clearance trapping and translocation of fauna that will occur prior to the clearing of habitat. The objective of pre-clearance trapping is to minimise the risk of loss of all fauna, including conservation significant fauna, as much as possible.

Table 7-20: Loss of habitat for conservation significant fauna

Species	Conservation Code		Habitat Type	Area in Development Envelope (ha)	% of regional extent
	EPBC Act	TPWC Act			
Eastern Curlew	CR/Mi/Ma	VU	Mangroves	2	<0.001
Whimbrel	Mi/Ma	NT			
Common Sandpiper	Mi, Ma				
Oriental Cuckoo	Mi				
Great Egret	Ma				
Pacific Reef Heron	Ma				
Grey-tailed Tattler		NT	Mixed Woodland	79	0.01
Northern Quoll	EN	CR			
Black-footed Tree-rat	EN	VU			
Osprey	Mi, Ma				
White-bellied Sea-Eagle	Ma				
Western Chestnut Mouse		NT			
Orange Leaf nosed Bat		NT	All habitat types	264	<0.001
Arnhem Sheath-tailed Bat		NT			
Northern Brushtail Possum		NT			
Fork-tailed Swift	Mi, Ma				
Howard River Toadlet		VU			
Northern Brushtail Possum		NT			
Bush Stone-curlew		NT	All habitat types	264	<0.001
Rainbow Bee-eater	Ma				
Northern Brown Bandicoot		NT			
Mulga Snake		NT			

7.4.4.2 Potential loss of habitat quality

The conservation significant fauna species listed in Table 7-21 are known to inhabit the site or considered likely to inhabit the site. The species listed in Table 7-21 may be impacted by the project due to a loss of habitat quality.

The most common avenues for the construction and operation of the Project to reduce habitat quality is by water emissions, dust emissions and reduced patch size, which may make marine and terrestrial areas less habitable to some species. In addition, lighting, noise, vibration and human movement may impact habitat quality, but are dealt with in detail in the following sections.

Table 7-21: Conservation significant fauna at risk from loss of habitat quality

Species	Conservation Code		Habitat Type
	EPBC Act	TPWC Act	
Great Knot	CR/Mi/Ma	VU	Tidal Mudflats
Eastern Curlew	CR/Mi/Ma	VU	
Red Knot	EN/Mi/Ma	VU	
Lesser Sand Plover	EN/Mi/Ma	VU	
Greater Sand Plover	VU/Mi/Ma	VU	
Whimbrel	Mi/Ma	NT	
Grey-tailed Tattler		NT	
Common Greenshank	Mi, Ma		
Little Tern	Mi, Ma		
Salt-water Crocodile	Mi, Ma		
Common Sandpiper	Mi, Ma		
Great Egret	Ma		
Black-footed Tree-rat	EN	VU	Monsoon Closed Forest
Howard River Toadlet		VU	
Pale Field-rat		VU	
Northern Brushtail Possum		NT	
Oriental Cuckoo	Mi		

7.4.4.3 Habitat fragmentation

Reduced habitat quality is possible as a consequence of fragmentation of the remaining habitat in Lot 1817. There is existing fragmentation due to:

- Channel Island Road;
 - Adelaide- Darwin Railway corridor;
 - Infrastructure corridor bisecting the site; and
 - Patches of disturbance associated with historic land use at the site.

Under the current proposal, the degree of fragmentation will increase. Fragmentation can lead to degradation of habitat and an increase in predation as fauna cross from one fragment to another. While there will clearly be localised impacts, the loss of habitat and increase in fragmentation is unlikely to materially impact any individual species at a population level. TNG notes that there is a substantial area, virtually uninterrupted and undisturbed, from the east side of Channel Island road towards the east.

Following the development, a corridor ranging in width from 50 to 470 m exists along the western boundary between the Mangroves and the Project, allowing migration of animals to the south and west. Control of grassy weeds and controlled access to the site will likely reduce the risk of fire in the remnant vegetation.

7.4.4.4 Uncontrolled fire

As discussed in chapter 7.3.4.5, fire is a natural occurrence within northern Australia; however, an increase in fire frequency or intensity can reduce the quality of fauna habitat within an area.

The site currently experiences significant pressure from fire, predominantly due to human activities such as dumping and burning of vehicles. Although the establishment of industry can result in introduction of additional ignition sources, control measures and fire response protocols are expected to result in a reduction in fire frequency within the Project area.

7.4.4.5 Impact to fauna through the use of incessant lighting, noise, vibration, or human movement

A reduction in fauna habitat quality in the immediate vicinity of the Processing Facility will occur due to noise emissions from machinery and equipment, the use of lighting, vibration and human movement 24 hours per day during construction and operations. This has partially been taken into account by the calculation of impacts from the Development Envelope, which provides a buffer around the actual development.

For marine birds inhabiting the mangroves and tidal mudflats, displacement of fauna would be into surrounding habitats of similar quality. The quality of marine habitat in the area of the Processing Facility outside of the Disturbance Envelope is not expected to be significantly impacted by lighting, noise, vibration, or human movement as the vegetation fringing the marine area will substantially reduce exposure and across most of the boundary there is in excess of 200 m between the Development Envelope and the mangroves.

Noise and light emissions may have an impact on terrestrial fauna. The Facility will be fitted out with external lighting for security purposes. It is known that artificial lighting has the potential to impact fauna behaviour, resulting in impacts to foraging patterns.

TNG will implement noise controls to minimise potential impacts.

7.4.4.6 Fauna entrapment in infrastructure (ponds or fences)

Death of wildlife resulting from interactions with settling ponds and water storage dams is considered unlikely given raised embankments will be constructed around dam and pond edges and fencing installed for safety. In the event of early closure, TNG is committed to ensuring the settling ponds are made safe and stable, which will include minimising risks to fauna.

The Facility will be located within a security-fenced compound. It is possible that bats can become entangled in fences – particularly barbed wire fences suitable for security purposes (van der Ree 1999). This may result in loss of individuals, however, is not expected to significantly affect local population size.

7.4.4.7 Vehicle strike causing injury or death of native fauna

During construction, machinery movements are likely to deter fauna from the area.

Materials will be delivered and removed from site via train, as well as trucks, minimising the volume of vehicle movements and the potential for vehicle strike causing injury or death of native fauna. The use of buses for employee transport will also reduce vehicle movements associated with the Project.

Train movements will be limited to 1-2 trips per day, which is not a significant increase in existing traffic. As the potential impacts are very limited, no specific management measures are deemed necessary.

7.4.4.8 Increase in abundance of introduced species

Increased predation/competition with native wildlife by pest species such as rats, cats and dogs attracted to the Project area through access to domestic waste, is unlikely to occur at levels that would cause a significant impact to fauna.

Due to the location close to Darwin, an on-site landfill will not be required. All putrescible waste from the Project will be stored in covered bins and removed from site regularly by a licenced waste contractor. Further, machinery movements onsite are likely to deter pest animals from the area during operations. It is unlikely there will be an increase upon the level of introduced predators already accessing the site. The frequency of pest animal predators such as dogs and cats will be monitored, as outlined in the BMP, and if numbers increase remedial action can be taken.

7.4.5 Mitigation and Management

The mitigation measures outlined in Table 7-22 will be implemented to reduce the risk of impacts on fauna and fauna habitats. More detail is provided in the management plans and procedures developed through the BMP (Appendix L) and EMP (Appendix D).

Table 7-22: Fauna – potential impacts and mitigation measures

Pathway	Mitigation hierarchy	Mitigation measure
Vegetation clearing resulting in loss of fauna	Avoid/Minimise	- Implement the Ground Disturbance and Vegetation Clearing Procedures (EP-05) within the EMP and BMP, including: - Pre-clearance fauna trapping and translocation.
Vegetation clearing resulting in loss of fauna habitat	Avoid/minimise	- Ensure habitat to be cleared is well represented elsewhere on the Middle Arm Peninsula, and in the region. - Implement the Ground Disturbance and Vegetation Clearing Procedures (EP-05) within the EMP and BMP, including: - Development and implementation of an internal Ground Disturbance Permit system, whereby no land clearing is undertaken without completing a series of checks to ensure: - The proposed clearing has been approved; - Conditions in relation to fauna clearing and other requirements have been assigned. - Approved permits are assessed for compliance with permit conditions.
Habitat fragmentation	Avoid/minimise	Site layout design to be compact and reduce areas of habitat fragmentation where possible.
Uncontrolled fire causing loss of individuals and habitat destruction	Avoid	- Implementation of the FMP (Appendix K) including: - Site personnel will be trained in fire protection; - The site will be equipped with fire extinguishers and other fire prevention measures; and - A hot work permit system will be implemented; - Grassy weeds will be controlled.
Vehicle strike	Avoid/minimise	- Maintain suitable speed limits. - Erect warning signs in any locations where fauna are regularly sighted. - Ensure employee and local contractor awareness of local fauna and encourage reporting of sightings and any incidents of vehicle strike.

Pathway	Mitigation hierarchy	Mitigation measure
Increase in the abundance of introduced fauna	Minimise	• Ensure all putrescible waste is securely stored until removed from site • Monitor sightings of feral fauna and undertake control measures in consultation with stakeholders.
Lighting, noise and vibrations altering natural behaviour	Minimise	• All light sources will be aimed towards work areas and away from surrounding habitat, using light shields as necessary to minimise light spill.
Fauna entrapment in infrastructure	Avoid, minimise	• Fence settling ponds ○ Install fauna egress points in water storage dams and / or sumps • Ensure vegetation around barbed wire fences is kept to a minimum • Avoid the use of barbed wire in fences where possible. • Barbed wire fences will be regularly inspected for trapped animals (particularly bats), and mitigation measures explore, including: ○ Covering top strand of barbed wire with a PVC pipe shroud; and ○ Tying flag tape to barbed wire.

7.4.6 Monitoring and Reporting

The BMP, EMP and associated sub-plans detail objectives, monitoring procedures and performance indicators, as well as corrective actions and reporting requirements. The sub-plans and procedures are reported through the EMP. The monitoring measures are outlined in Table 7-23, and other inspection and reporting activities are outlined in Table 7-23 below.

Table 7-23: Monitoring actions for terrestrial fauna and habitat

Action	Timing	Methods used	Criteria
Mammal monitoring	Annually during construction, and for the first year of production (Jan – April)	Elliot and Cage Traps, Camera Traps, Acoustic Bat Detectors	As per Biodiversity Management Plan (Appendix L).
Avifauna monitoring	Annual (Dec – Mar) during construction, and for the first year of production	Terrestrial and boat surveys.	As per Biodiversity Management Plan (Appendix L).
Habitat quality monitoring	Prior to Ground Disturbance activities. Biannual throughout Project life.	Establish permanent photographic monitoring points across various vegetation associations within the site.	Comparative assessment against previous monitoring results.

Table 7-24: Other inspection and reporting for terrestrial fauna and habitat

Relevant Plan	Procedure (if relevant)	Monitoring/Inspection	Reporting
Environmental Management Plan	NA	Daily inspection of high-risk locations, including to identify any new risks / unmanaged risks.	
	Ground Disturbance and Vegetation Clearing Procedure	Daily inspection (using GPS) during vegetation clearing to confirm clearing is within the approved envelope.	Monthly Environmental Performance Report
	Water Management Procedure	Weekly inspection of swales and sediment traps.	Half Year Report
	Air and Dust Management Procedure	Review complaints and grievance register to identify if excessive dust have been noted.	Annual Report and Performance Review
	Weeds Management Procedure	Monthly weed surveys and follow-up control.	
Biodiversity Management Plan		Ongoing fauna sighting and fatality reporting.	Annual Report and Performance Review
Erosion and Sediment Control Plan		Weekly inspection of erosion and sediment controls during the wet season.	Monthly Environmental Performance Report
FMP		Weekly inspections of fire response equipment.	Annual Review

7.4.7 Statement of Residual Impact

In consideration of the outcomes of the EIA and proposed management measures, TNG considers that the EPA's objective for terrestrial fauna can be achieved. The following outcomes are predicted:

- No loss of important populations of conservation significant fauna; and
- Loss of fauna habitat is negligible at the regional scale;

By implementing management measures detailed above, the residual impact is not considered significant and no offsets are considered to be required.

TNG LIMITED

DRAFT ENVIRONMENTAL IMPACT
STATEMENT

DARWIN PROCESSING FACILITY

**ENVIRONMENTAL
FACTOR:
HYDROLOGICAL
PROCESSES**

7.5 ENVIRONMENTAL FACTOR: HYDROLOGICAL PROCESSES

7.5.1 NT EPA Objective

Hydrological processes refer to the occurrence, distribution, connectivity, movement and quantity of surface water and groundwater. The NT EPA's objective for the environmental factor Hydrological Processes is to:

Maintain the hydrological regimes of ground water and surface water so that environmental values are protected.

The Hydrological Processes objective recognises the fundamental link between hydrological regimes and the environmental values they support such as water-dependent ecosystems, amenity, cultural values, recreational, public drinking water, agricultural and industrial use of water.

This chapter describes the existing hydrological processes of the Project area and the groundwater aquifers that lie beneath. The potential impacts to surface water and groundwater resulting from the implementation of the Project are discussed and mitigation measures proposed by TNG to avoid and/or reduce impacts are summarised. A statement of residual impact is also included, detailing the extent to which the proposed mitigation and management measures will address potential impacts to ensure the NT EPA's objectives for this environmental factor are met.

The content of this chapter has been developed specifically to address section 3.1 and section 4.3 of the EIS TOR (Appendix A).

7.5.2 Technical Studies

Technical studies undertaken to inform assessment of potential impacts of the Project on Hydrological Processes are listed in Table 7-25.

Table 7-25: Hydrological/ hydrogeological studies undertaken for the Project

Date	Study Title	Consultant	Description	Report
October 2019	TNG Darwin Processing Facility Hydrology and Coastal Assessment	Advisian	Baseline hydrologic assessment of site characteristics and behaviour.	Appendix N
13 September 2019b	Hydrogeological Study TNG Darwin Process Facility	Golder Associates Pty Ltd	Baseline assessment of the existing hydrogeological environment including water quality.	Appendix M

7.5.3 Existing Environment

This chapter has been informed by baseline assessment and modelling of the existing hydrological and hydrogeological environment.

7.5.3.1 Surface Water

The following hydrological features have been identified at or around the site:

- The Elizabeth River;
- Two intertidal tributaries associated with the Elizabeth River Estuary to the west of the site;

- Three surface water features located on the northern peninsula:
 - standing water in open quarry (SW1);
 - water dam (SW2);
 - surface water in low point of quarry (SW3).
- Four surface water features located on the southern peninsula:
 - water dam;
 - wetland; and
 - two swamps.

In addition to the above hydrological features, localised pooling of surface water occurs in other areas of the site during periods of prolonged rainfall (particularly during the wet season), when the soil surface layer becomes saturated.

Surface water features are presented in Figure 7-9.

Waterway classification

Using the Strahler hierarchical classification system, the waterways surrounding the site include the 4th order Elizabeth River, and 1st and 2nd order unnamed estuaries to the west of the site.

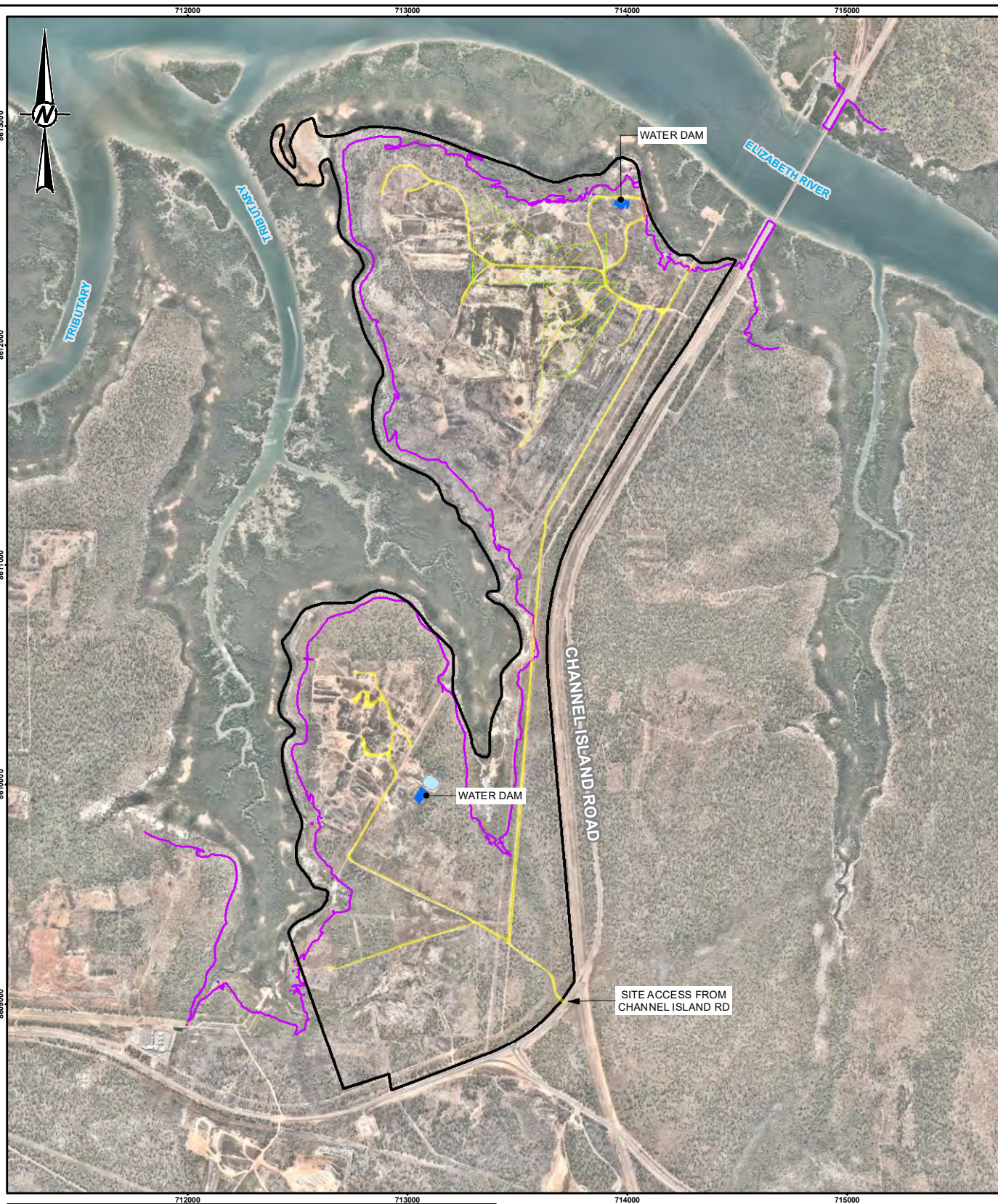
Tidal statistics

The site is subject to a calculated tidal range of 8.43 m; tide levels appear in Table 7-26 below.

Table 7-26: Tidal submergence statistics

Description	Elevation (mAHD)
Highest Astronomical Tide (HAT)	4.17
Mean High Water Springs	3.12
Mean High Water Neaps	1.01
Mean Sea Level	0.03
Mean Low Water Neaps	-0.96
Mean Low Water Springs	-3.06
Lowest Astronomical Tide (LAT)	-4.26

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- LEGEND**
- 100 YEAR SURGE LEVEL
 - SURFACE WATER FEATURE OBSERVED TO BE WET DURING BOTH SITE VISITS IN 2019
 - SURFACE WATER FEATURE OBSERVED TO BE WET ONLY DURING SITE VISIT IN MAY 2019
 - ACCESS ROAD
 - MINING LEASE
 - LOT 1817 BOUNDARY (464 ha)

0 200 400 600 800 1,000
1:25,000 METRES

NOTE:
1. COORDINATE SYSTEM: GDA 1994 MGA ZONE 52

REFERENCES:
1. LOT 1817 PROVIDED BY CLIENT (2019-10-07)
2. AERIAL IMAGE SOURCED FROM NEARMAP (2019-06-13)

CLIENT
ANIMAL PLANT MINERAL PTY LTD
(ON BEHALF OF TNG PTY LTD)

PROJECT
PROPOSED TNG DARWIN PLANT
LOT 1817 HUNDRED OF AYERS, DARWIN, NT

CONSULTANT	YYYY-MM-DD	2019-11-19
	DESIGNED	DAK
	PREPARED	MS
	REVIEWED	PVB
	APPROVED	PVB



TITLE
SITE HYDROLOGY

Figure 7-9: Hydrological Features of the Project Area

PROJECT NO.	CONTROL	REV.	FIGURE
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28mm IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM 150 A4

Storm tide

Storm tide information is collated by Advisian (2019) (Appendix N) and presented below within Table 7-27 with regard to the elevation of the storm tide for various Annual Exceedance Probabilities (AEP). This information provides the basis for storm tide inundation mapping that is presented in Figure 7-10.

Table 7-27: Storm tide statistics

Description	Elevation (mAHD)
1 in 10,000 AEP	8.1
1 in 1,000 AEP	6.4
1 in 100 AEP	5.1

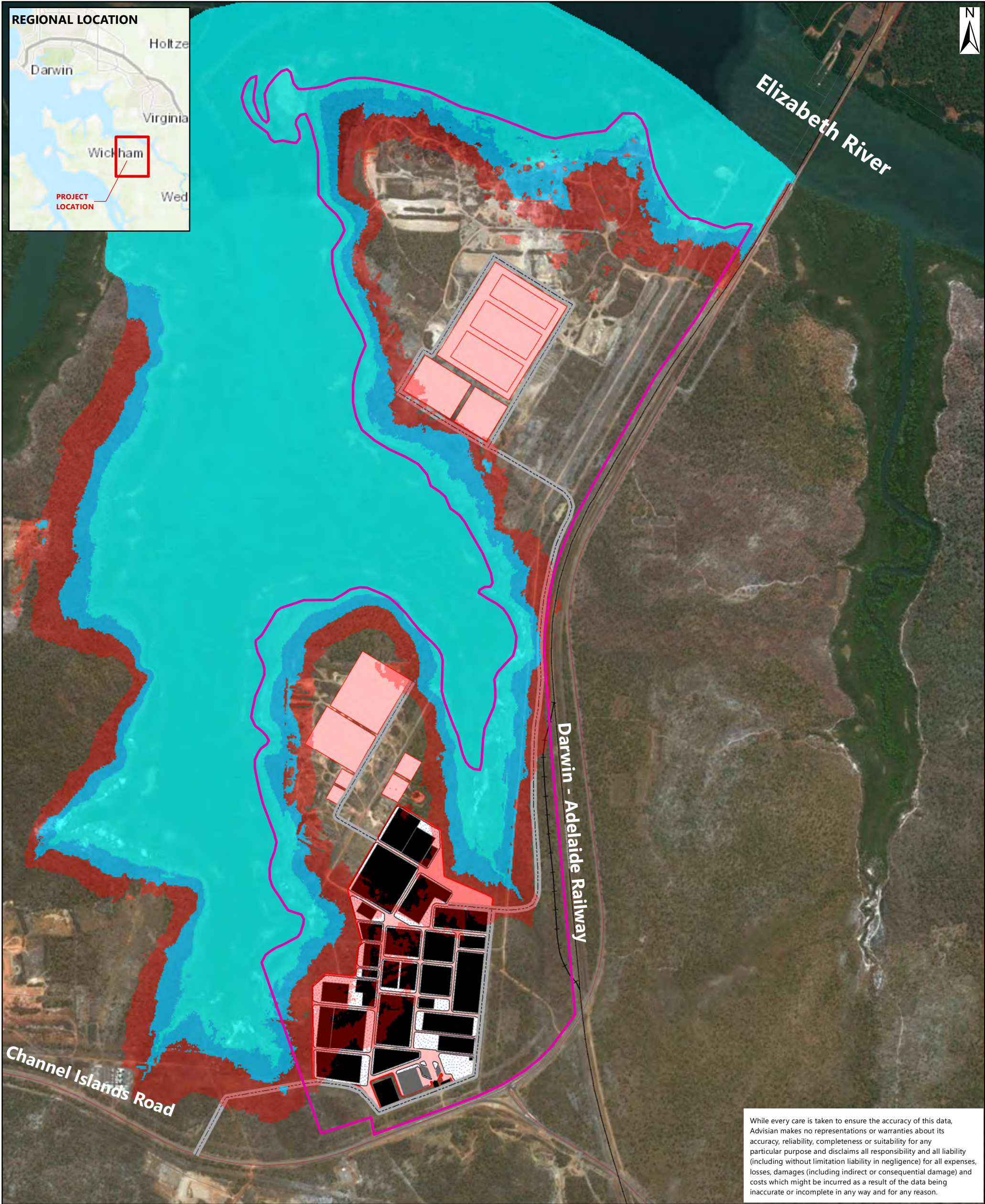
Flooding

The location of the site adjacent to the mouth of the Elizabeth River and the transition into East Arm of the Darwin Harbour results in inundation of the site being dominated by either tidal influence, storm tide or local catchment runoff.

Regional flooding associated with the Elizabeth River has been previously assessed in the *Elizabeth and Blackmore River Catchments – Flood Study* (Cardno 2014) and summarised in Appendix N. Advisian (2019) concluded that peak flood levels associated with the Elizabeth River adjacent to the site are dominated by the adopted tailwater condition. This means that flood water levels are heavily influenced by the prevailing tide. Peak flood levels for the site are presented in Table 7-28.

Table 7-28: Elizabeth River peak flood level predictions (Cardno, 2014)

Description	Peak Flood Elevation at Project Site (mAHD)	Adopted Tailwater Elevation (mAHD)
1 in 100 AEP – Mean Sea Level Tailwater	0.09	0.075
1 in 100 AEP – Highest Astronomical Tide Tailwater	3.65	3.65



TNG Darwin Processing Facility

Figure 7-10: Storm tidal inundation mapping scenarios

Legend

- Site Boundary
- Primary Storm Surge (PSS) Inundation Extent
- Secondary Storm Surge (SSS) Inundation Extent
- Extreme Storm Surge (ESS) Inundation Extent
- Railspur
- Proposed Access Road
- Conceptual Site Plot
- Carparks
- Buildings

0 0.125 0.25 0.5 0.75 1
Kilometers
Scale at A3 - 1:15,000
Coordinate System: GDA 1994 MGA Zone 52
Projection: Transverse Mercator
Datum: GDA 1994
False Easting: 500,000.0000

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Advisian
Worley Group

At the site level, Advisian (2019) (Appendix N) undertook a site flood assessment by developing a model considering the following:

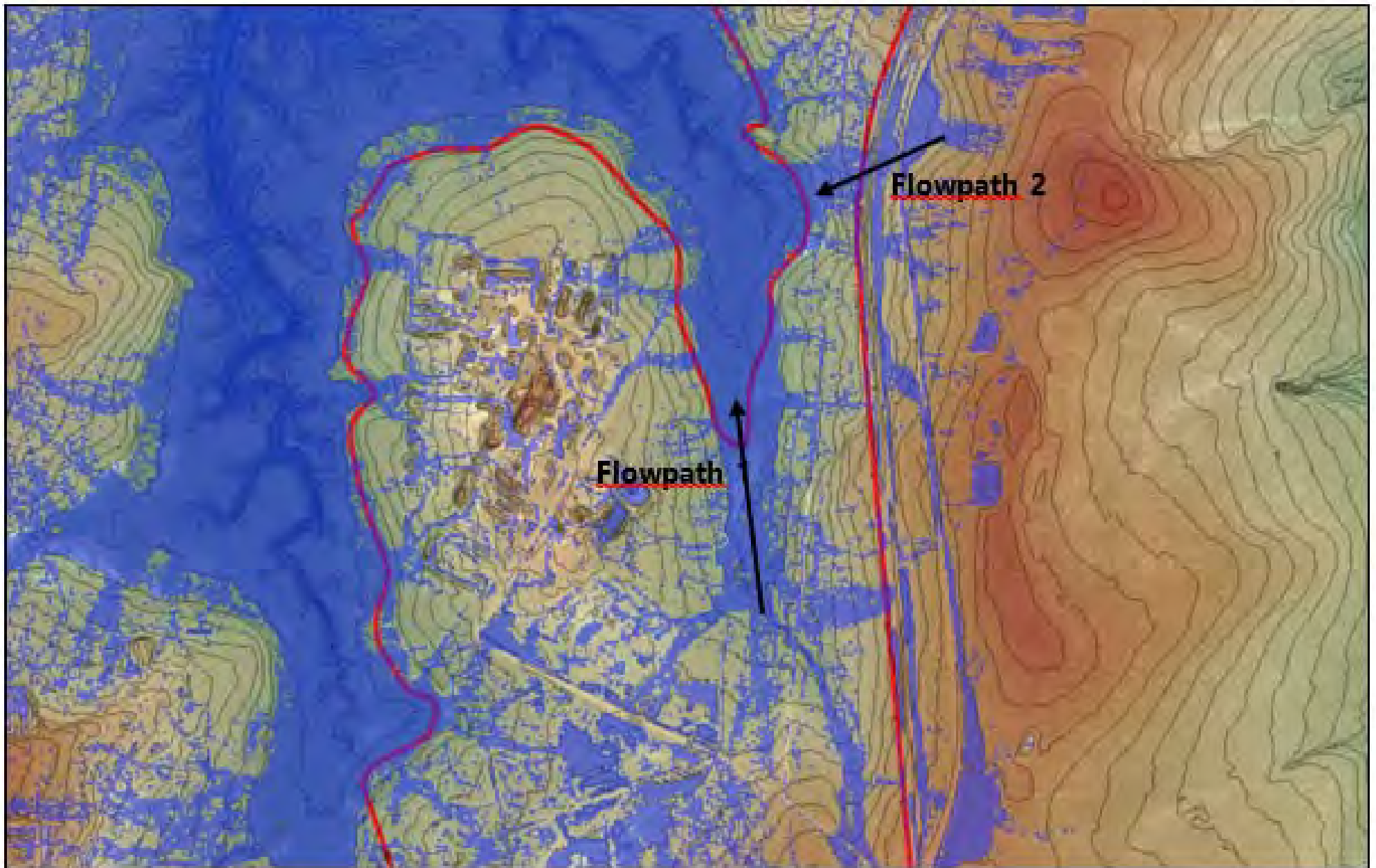
- Site characteristics (raised peninsular with limited influence from external catchment runoff);
- Intensity Frequency Duration rainfall data from Bureau of Meteorology;
- Temporal patterns for the site 'Monsoonal North' leading to the use of the 'Ensemble Approach' for flood estimation;
- Estimated rainfall losses for the site;
- Tailwater conditions (a static tailwater elevation of Mean High Water Springs) was adopted for assessment of local flood behaviour;
- Topography (utilising 5 m Digital Elevation Modelling for use in the TUFLOW model, and 1 m bathymetric Digital Elevation Model of Darwin Harbour for the areas west and north of the site);
- Floodplain roughness values based on site notes, photographic record and available aerial imagery;
- Cross drainage structures that exist at the site;
- Conceptual design elements from the Project; and
- Sensitivity analysis related to climate change scenarios.

Site flooding characteristics – no development

For the existing site without development, the modelling results indicate that flooding depth will be typically limited to sheet flow style flood (< 100 mm in depth) associated with low flow velocities. Detailed mapping for 39, 10, 1 and 0.1 percent AEP appears in Appendix C of the Advisian (2019) report (Appendix N). Some areas of deeper ponding are evident and associated with existing disturbance activities on the site.

There are two concentrated flowpaths through the site, as depicted in Figure 7-11. A description of the flowpaths is as follows:

- **Flowpath 1:** To the east of the proposed main processing facility area (southern peninsula) flowing in a northerly direction parallel to the Adelaide-Darwin Railway. This streamline conveys external catchment runoff and its hydrologic response to rainfall is affected by the existing hydraulic controls of the Adelaide-Darwin Railway and Channel Island Road.
- **Flowpath 2:** Where the Adelaide-Darwin Railway and Channel Islands Road veer to the north east, a series of existing culvert structures under these features concentrate external catchment runoff for a small distance before flowing into the estuary of East Arm. Peak flows from this catchment are heavily influenced by the hydraulic controls associated with the linear infrastructure embankments and culvert structures of the railway and roads previously mentioned.



Site flooding characteristics – conceptual design case

Given the proposed location of the facility on the top of the two peninsulas that make up the site, only minor localised changes in runoff are predicted to occur as a result of the proposed facility.

The proposed access road and rail siding will require incorporation of appropriate cross-drainage features to accommodate external catchment runoff and prevent impacts on upslope drainage features associated with the Adelaide-Darwin Railway and Channel Islands Road.

7.5.3.2 Groundwater

The aquifer/s that occur beneath the Site have been investigated through installation of monitoring bores and development of a hydrogeological model for the project area (Golder 2019b), attached as Appendix M. The preliminary groundwater investigation undertaken in May 2019 by Golder Associates Pty Ltd (**Golder**) involved the drilling and construction of 12 monitoring bores, installation of groundwater level transducers in four of the bores, hydraulic testing (recovery tests) and water quality sampling. Detailed information on bores including location and logs are provided in full in Appendix M.

Aquifers

The substrate and underlying geology of the Site consists mainly of a thin lateritic sand and gravel overlying a weathered basement rock. These lateritic soils are underlain by silt and clay, inferred to be weathered and fractured Burrell Creek Formation (**BCF**). The weathered BCF was encountered from the shallowest depth of 0.5 mbgl to the end of the investigation depth at 21.5 mbgl. The Bynoe, Northern Territory, Australia, 1:100,000 Geological Series (Pietsch 1986) indicates that fresh, unweathered BCF lies below the weathered BCF profile, however this was not encountered during the study.

The most prominent aquifer at the Site is the weathered and fractured rock aquifer of the BCF. The shallow, lateritic soils that overly the weathered BCF also have potential for minor, unconfined aquifers where the laterite profile is more extensive, however this was not observed as the lateritic soils were unsaturated at the drilling locations during the study. The lateritic soils have the potential to become saturated during the wet season (or after significant rainfall events) where water could “perch” on top of the less permeable weathered BCF. As a result, the lateritic soils have been identified as potential aquifers.

The Hydrogeology of Darwin 1:250,000 map indicates that the typical yield from the aquifer at the Site is <0.5 litres per second (**L/s**) and groundwater salinity being fresh inland (<1000 Total Dissolved Solids [**TDS**]) and becoming brackish/saline toward the coastal areas, tributaries and rivers. This mapped category has the lowest groundwater resource potential in the Greater Darwin region.

Depth to water tables

The groundwater level generally follows the topography of the Site. The groundwater levels measured during the May 2019 monitoring event ranged between 1.5 mbgl and 4.61 mbgl in the northern peninsula and between 1.65 mbgl and 3.10 mbgl in the southern peninsula and is located in the inferred weathered BCF. The lateritic sand and gravel were found to be unsaturated at all monitoring well locations during the time of investigation.

The groundwater levels measured during the May 2019 monitoring event are presented in Table 7-29. Groundwater levels are expected to fluctuate seasonally based on trends in rainfall, with higher groundwater levels to be observed during the wet season.

Table 7-29: Groundwater levels – May 2019

Monitoring Well	Location of Bore	Ground Surface ¹	Groundwater Level	
		RL m AHD	mbgl ²	RL m AHD
BH01	Northern Peninsula	10.89	1.95	8.34
BH02	Southern Peninsula	8.84	2.95	5.89
BH03	Northern Peninsula	7.07	1.50	5.53
BH04	Northern Peninsula	11.36	4.61	6.75
BH05	Southern Peninsula	9.06	2.59	6.47
BH06	Northern Peninsula	7.16	2.64	4.53
BH07S	Southern Peninsula	10.62	2.05	8.56
BH07D	Southern Peninsula	10.64	2.11	8.53
BH08S	Southern Peninsula	8.62	1.65	6.98
BH08D	Southern Peninsula	8.67	1.68	7.00
BH09	Southern Peninsula	7.50	2.5	4.98
BH10	Southern Peninsula	9.66	3.10	6.56

Notes:

¹Surveyed by Land Surveys Pty Ltd.

²Groundwater Levels are measured from metres below Top of Casing (**mbTOC**)

m AHD – metres Australia Height Datum

RL – Relative Level

Hydraulic gradient

Based on the groundwater level measurements from the May 2019, the hydraulic gradient is estimated to be around 0.003 metres per metre (**m/m**) in the northern peninsula and 0.005 m/m in the southern peninsula, indicating that the groundwater table across the site is relatively flat. Steeper gradients are expected closer to the coastal discharge, where the hydraulic gradient was approximately 0.008 m/m. The groundwater flow is expected to be predominantly towards the tributaries rather than a deeper aquifer.

Groundwater flow directions and rates

The regional groundwater flow is in a north-westerly direction towards the Darwin Harbour and Elizabeth River. Groundwater at the site generally flows radially from the central areas of the peninsula towards the coastline. Groundwater levels measured within the southern peninsula indicate that the groundwater discharges into the two tributaries (associated with the Elizabeth River), bordering the southern peninsula of the site to the north-east and south-west, and into the Darwin Harbour. Groundwater levels measured within the northern peninsula

indicate that groundwater discharges into the tributary bordering the peninsula to the south-west, the Elizabeth River (that borders the peninsula to the north and the north-east) and the Darwin Harbour.

Groundwater velocity depends on the hydraulic conductivity and porosity of the aquifer and the hydraulic gradient. Hydraulic conductivity is the ease with which groundwater can move through the geological formation which hosts the aquifer. Where hydraulic conductivity is high, water will flow through the aquifer easily, and the converse when hydraulic conductivity is low. Table 7-30 displays the hydraulic conductivity recorded in the Project site study.

Estimations and field testing of hydraulic conductivity of the aquifers identified in the Project area observed that the:

- Thin surface laterite (potential) aquifer was estimated to have a moderate to high flow velocity of 36 metres per day (**m/d**) when saturated.
- Weathered BCF aquifer was calculated to have a relatively low groundwater flow velocity, ranging between 0.05 metres per year (**m/yr**) to 0.15 m/yr, but could be as high as 5 m/d when in areas where hydraulic conductivity is greater.

Table 7-30: Summary of hydraulic test analysis

Test Location	Monitoring Well	Screen Target Unit	Hydraulic Conductivity (m/d)
Northern Peninsula	BH01	Inferred Weathered BCF	0.005
	BH03	Inferred Weathered BCF	0.01
	BH04	Inferred Weathered BCF	0.4
	BH06	Sandy Gravel Layer within BCF	20
Southern Peninsula	BH02	Inferred Weathered BCF	0.01
	BH05	Inferred Weathered BCF	0.002
	BH07S	Inferred Weathered BCF	0.15
	BH07D	Inferred Weathered BCF	0.05
	BH08S	Inferred Weathered BCF	0.01
	BH08D	Inferred Weathered BCF	0.12
	BH09	Inferred Weathered BCF	0.05
	BH10	Inferred Weathered BCF	0.01

Interconnectivity between aquifers

The aquifers beneath the site are likely unconfined and therefore receive direct rainfall recharge. The rainfall infiltrates first into the laterite soils and then into the weathered and unweathered BCF below. The groundwater level in the paired shallow and deep monitoring wells were measured to be similar, indicating limited vertical flow gradient. The groundwater flow is therefore expected to be predominantly towards the tributaries rather than a deeper aquifer.

Local springs

No local springs were identified in the Project area however, localised pooling at surface was evident at site after significant rainfall events. The surface water pooling observed is due to the surface soil layer, which are clayey in nature, becoming saturated.

Conceptual Hydrogeological Site Model

A conceptual site hydrogeological site model is presented in (Figure 7-12; dry season) and (Figure 7-13; wet season).

The hydrogeological conceptual model shows that the hydrogeological cycle consists of rainfall recharge during the wet season, which creates a groundwater mound below the northern and southern peninsulas with radial groundwater flow toward Elizabeth River and the intertidal tributaries.

Figure 7-12 shows that during the dry season (the site conditions encountered during the field work) the groundwater table is located in the weathered BCF, meaning that the above laterite is mainly unsaturated across the site. The groundwater flow would therefore, during the dry season, mainly occur in the low permeability weathered BCF.

Figure 7-13 illustrates the potential hydrogeological conditions following average or above average rainfall at site, where it is expected that the groundwater level would rise due to rainfall recharge, resulting in the laterite becoming partially saturated (i.e. the groundwater table rises into the laterite). The rainfall recharge could result in groundwater inundation in areas where the laterite is thin. At the beginning of the wet season it is possible that groundwater could be perching in the laterite on top of the low permeability BCF until the BCF becomes fully saturated and the groundwater table rises up into the laterite.

The hydraulic conductivity of the BCF Creek Formation is estimated to be low (median of 0.01 m/d), indicating a general low bulk aquifer permeability and thereby groundwater flow in this unit. The gravel layer encountered at depth in BH06 indicates that some localised more transmissive layers may be present, which could be connected to the river system. The lateritic soils are likely to have a hydraulic conductivity that could be several orders of magnitude higher than the weathered basement rock. The majority of the groundwater flow could be occurring within the lateritic soils if they become saturated following significant rainfall events and the laterite therefore could act as a preferential flow path for potential contaminants on site.

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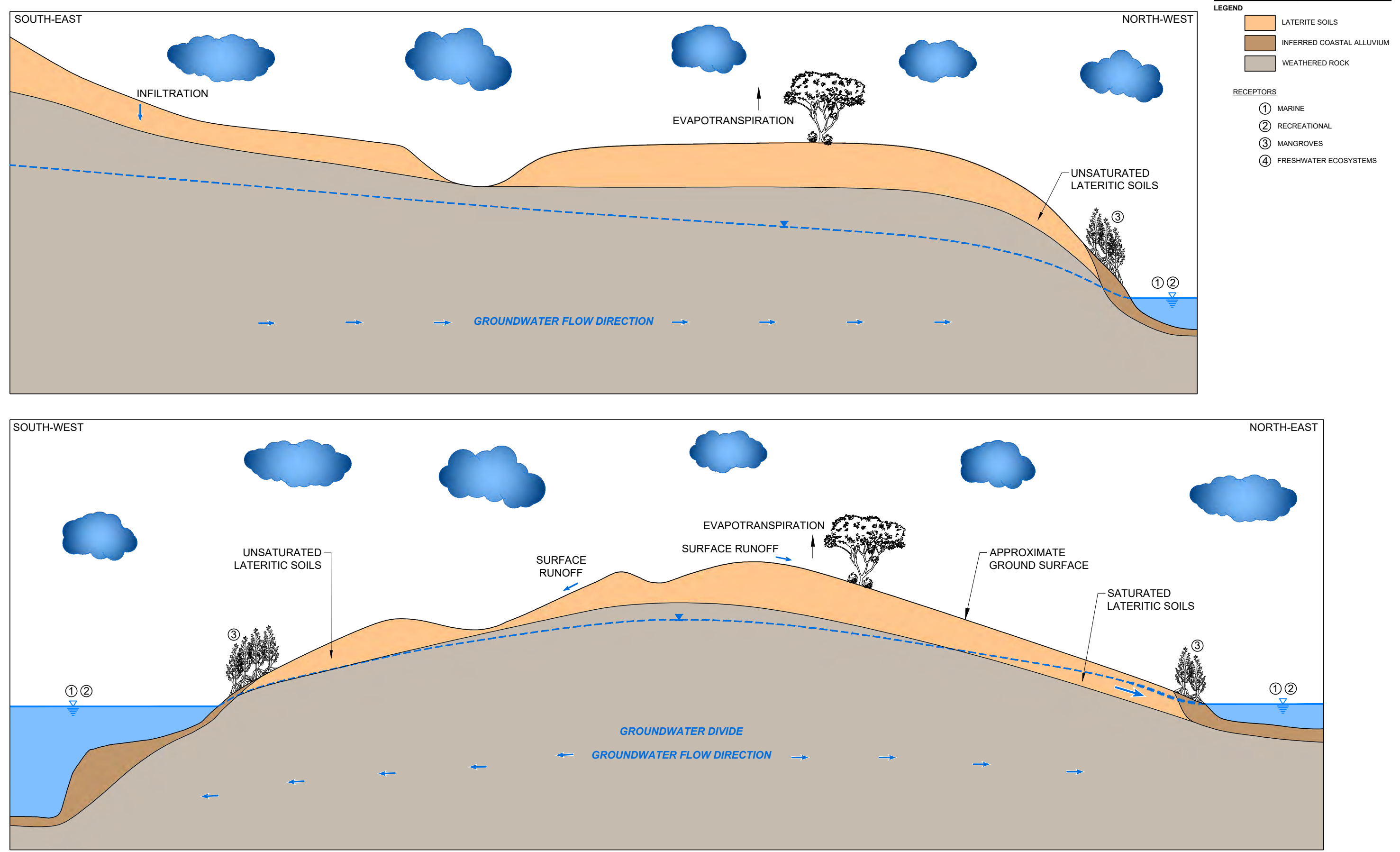


Figure 7-12: Dry season conceptual hydrogeological site model

CLIENT ANIMAL PLANT MINERAL PTY LTD (ON BEHALF OF TNG PTY LTD)			PROJECT PROPOSED TNG DARWIN PLANT LOT 1817 HUNDRED OF AYERS, DARWIN, NT		
CONSULTANT					
	YYYY-MM-DD	2019-11-21			
	DESIGNED	KM			
	PREPARED	JRP			
	REVIEWED	PVB			
	APPROVED	PVB			
GOLDER			PROJECT NO. 19115223	CONTROL 002 R	REV. 2
					FIGURE 8

25 mm IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A3

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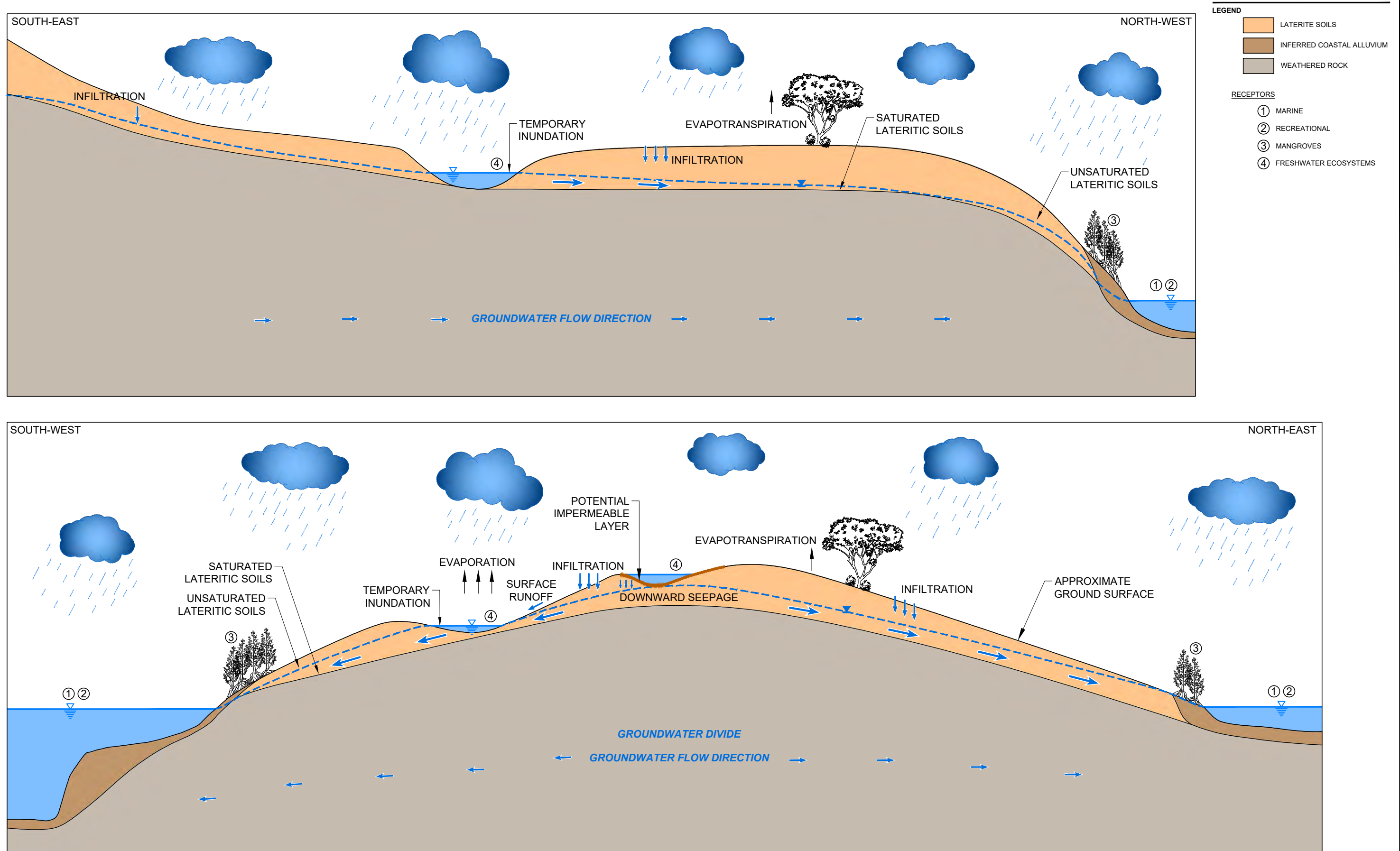


Figure 7-13: Wet season conceptual hydrogeological site model

CLIENT
ANIMAL PLANT MINERAL PTY LTD
(ON BEHALF OF TNG PTY LTD)

PROJECT
PROPOSED TNG DARWIN PLANT
LOT 1817 HUNDRED OF AYERS, DARWIN, NT

CONSULTANT

YYYY-MM-DD 2019-11-21



DESIGNED	DAK
PREPARED	JRP
REVIEWED	PVB
APPROVED	PVB

PROJECT NO.
19115223

CONTROL
002 R

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2

FIGURE
7

7.5.4 Potential impacts and risks

Development of the Project has the potential to impact surface and groundwater aspects of the Site. The source-pathway-receptor model was used to identify potential impacts (Table 7-31). Individual pathways are discussed in the chapters below.

Table 7-31: Potential impact pathways for hydrological processes

Source	Pathway	Receptor
Construction activities	Alteration of surface hydrology – stormwater management, sedimentation, contaminants, flooding.	Onsite and off site surface water and water users.
Operations activities	Inundation during storm surges.	Groundwater, habitats and users of waters where groundwater discharges – tributaries, Elizabeth River and Darwin Harbour
	Reduced aquifer recharge from impermeable surfaces.	
Decommissioning activities	Altered aquifer characteristics – altered groundwater flow velocity.	

7.5.4.1 Alteration of surface hydrology

The surface hydrology of the Project site will necessarily be altered by the addition of infrastructure. It is expected that there will be minor increases in runoff volume due to the establishment of impervious surfaces when the site is developed. Potential impacts from increases in surface runoff are scour from runoff velocity, terrestrial erosion, smothering of aquatic flora and fauna and loss of aquatic habitat. Given the location of the Site adjacent to East Arm of Darwin Harbour, the potential impacts on downstream receiving waterways resulting from stormwater quantity changes are a medium level risk and will require appropriate design and mitigation strategies.

Some infrastructure (site roads, railway siding, outfall pipeline) will intercept existing surface water flow paths (as seen in Figure 7-14). The environmental impacts of the interception are of a low risk given appropriate design of infrastructure, installation of suitable drainage pipes and culverts and appropriate management.

Sediment ponds, bunding and armoured outfalls will form aspects of the stormwater management system at the Project. Stormwater within the Development Envelope will be contained and directed to the wastewater treatment plant prior to discharge from the site.

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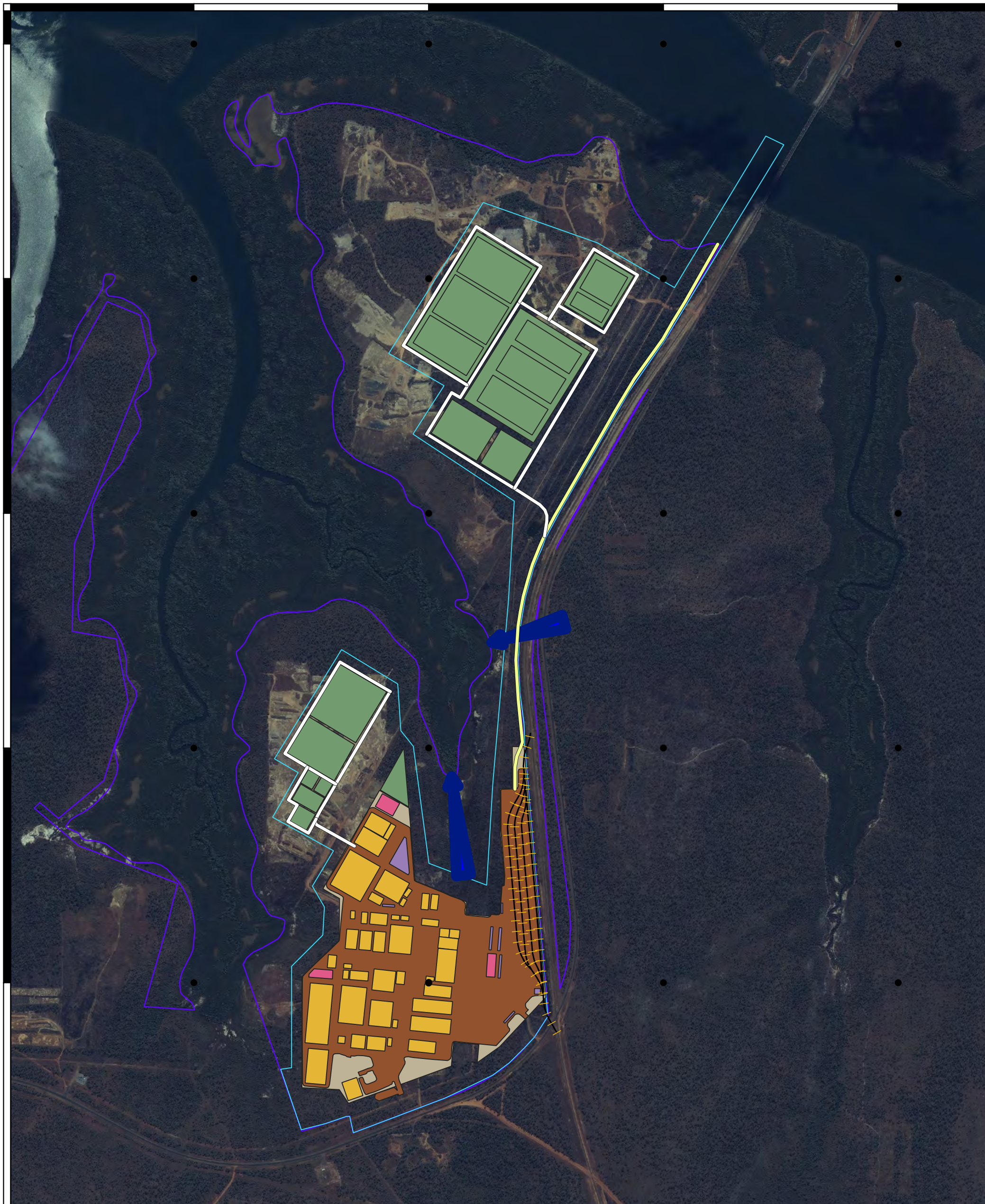


Figure 7-14: Flow paths in relation to proposed infrastructure

Legend

Processing Facility Buildings (SMS Sept 2019)	Easement (Road Waste Pipeline TNG Sept 2019)
Proposed Access Road (SMS Sept 2019)	Flowpaths
Ponds (SMS Sept 2019)	Additional Plant Infrastructure (TNG Sept 2019)
Rail Spurs (SMS Sept 2019)	Darwin Processing Facility EIS Envelope (TNG Oct 2019)
Storage Areas (SMS Sept 2019)	Lot 1817 Hundred of Ayers

Date: 22/11/2019



0

1 km

GDA 94 MGA Zone 52

Scale 1:15,000

Drawn by ems@animalplantmineral.com.au

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7.5.4.2 Inundation during storm surges

A storm surge at HAT is likely to be low risk at the site due to the location of infrastructure outside the primary (1 in 100 AEP) and secondary (1 in 1,000 AEP) storm surge inundation extents.

The site is likely to be exposed to impact from a tertiary storm surge inundation (1 in 10,000 AEP) event (see Figure 7-10). Given appropriate design of infrastructure and bunding at the Site, inundation and associated impacts to receptors is likely to be reduced. Alteration of hydrological processes through such a storm surge event would be temporary and are not anticipated to result in long term impacts.

7.5.4.3 Reduced aquifer recharge and groundwater accessibility

Development of the Project will require vegetation clearing throughout the Project area and the development of impervious or sealed surfaces. The groundwater beneath the site is believed to be predominantly recharged by infiltration of rainfall (see 7.5.3.2) and as such, construction of sealed areas within the Project area could limit recharge into the underlying aquifers.

Limiting recharge to the aquifer is likely to have little impact to groundwater and will have no direct impact on site, as there are no groundwater users. Discharge to tributaries and the Elizabeth River may be minimally reduced but this is an impact of low order and therefore a low environmental risk.

Restricted groundwater accessibility for current and future use is not considered a risk of the Project as TNG will not be abstracting groundwater.

Because groundwater is not being abstracted and the magnitude of the impact is very low, no specific mitigation measures have been proposed to address this impact.

7.5.4.4 Altered aquifer characteristics

The development of the Processing Facility and associated infrastructure may cause compaction of the underlying unconfined shallow aquifers, thereby potentially altering the hydrogeological characteristics (i.e. porosity, permeability, structure). This may affect the groundwater flow, levels and gradients. Compaction is likely to be limited, and because the extent of the area affected is small in comparison to the aquifer, the magnitude of the impact is considered to be low and therefore of low risk.

The chemical qualities of the aquifer have potential to be impacted by leaks or spills of chemicals, reagents, concentrates or fuel during construction and processing activities and are addressed in chapter 7.6.

7.5.5 Mitigation and management

The mitigation measures outlined in Table 7-32 will be implemented to reduce the risk of impacts on hydrological processes. More detail is provided in the management plans and procedures developed through the EMP (Appendix D).

Table 7-32: Mitigation measures for hydrological processes

Pathway	Mitigation hierarchy	Mitigation measure
Alteration of surface hydrology	Avoid, minimise	- Implementation of the ESCP (Appendix N) and Water Management Procedure (EP-10), within the EMP (Appendix D), to avoid erosion. - Vegetation clearing to be undertaken in stages and in dry season conditions wherever possible. - Erosion protection measures (bundings, spoon drains, silt fencing and sediment ponds) will be installed to contain any erosion. - Utilise appropriate drainage infrastructure (drains, culverts) to maintain existing surface water flowpaths where possible.
Site flooding or inundation from storm surge	Avoid, minimise	- In general, locate primary infrastructure in areas above the 1 % AEP flood levels. - Model 0.1% AEP inundation and flood levels and locate Processing Facility infrastructure above these levels. - ESCP (Appendix N) recommendation for a diversion bund around site infrastructure to be implemented.
Reduction in aquifer recharge	Minimise	Retain as much of Lot 1817 in a condition that will assist recharge of aquifer. This includes retaining (and/or enhancing through site rehabilitation activities) existing vegetation and soils.
Alteration of the physical aquifer characteristics	Minimise	- Retain as much of the existing laterite substrate (potential aquifer) as possible within the Project area to avoid significant interference with the structure of the aquifer. - Rehabilitate sites at the completion of construction where they are not required for operations, including replacement of subsoils and topsoils as appropriate and undertake ripping and seeding with local provenance native taxa to enhance potential infiltration.

7.5.6 Monitoring and reporting

The EMP and associated sub-plans detail objectives, monitoring procedures and performance indicators, as well as corrective actions and reporting requirements. There are no specific monitoring regimes for hydrological processes, however other inspection activities are outlined below in Table 7-33.

Table 7-33: Monitoring and reporting for hydrological processes

Relevant Plan	Procedure (if relevant)	Monitoring	Reporting
Environmental Management Plan	NA	Daily inspection of high-risk locations, including to identify any new risks / unmanaged risks.	
	Water Management Procedure (EP-10), within the EMP (Appendix D).	Weekly inspection of swales and sediment traps. Inspection of culverts and drainage infrastructure prior to commencement of wet season, particularly for sedimentation and blockages, to ensure uninhibited flow can occur as designed.	Monthly Environmental Performance Report Half Year Report Annual Report and Performance Review
Erosion and Sediment Control Plan		Weekly inspection of erosion and sediment controls during the wet season.	Monthly Environmental Performance Report

7.5.7 Statement of residual impact

In consideration of the outcomes of the EIA and proposed management measures, TNG considers that the EPA's objective for hydrological processes can be achieved. The following outcomes are predicted:

- The surface water hydrological regime can be maintained given appropriate consideration of modelling and studies being integrated into the design of Project infrastructure;
- Groundwater hydrological regime will be maintained to the extent that environmental values associated with groundwater are not likely to be significantly impacted.

By implementing management measures detailed above, the residual impact to hydrological processes is not considered significant.

TNG LIMITED

DRAFT ENVIRONMENTAL IMPACT
STATEMENT

DARWIN PROCESSING FACILITY

**ENVIRONMENTAL
FACTOR: INLAND
WATER
ENVIRONMENTAL
QUALITY**

7.6 ENVIRONMENTAL FACTOR: INLAND WATER ENVIRONMENTAL QUALITY

7.6.1 NT EPA Objective

The NT EPA's objective for the environmental factor Inland Water Environmental Quality is to:

Maintain the quality of groundwater and surface water so that environmental values including ecological health, land uses, and the welfare and amenity of people are protected.

The Inland Water Environmental Quality objective recognises the fundamental link between water quality and the environmental values they support such as water-dependent ecosystems, amenity, cultural values, recreational, public drinking water, agricultural and industrial use of water.

This chapter describes the existing surface water quality of the Project area and the groundwater aquifers that lie beneath. The potential impacts to surface water and groundwater quality resulting from the implementation of the Project are discussed and mitigation measures proposed by TNG to avoid and/or reduce impacts are summarised. A statement of residual impact is also included, detailing the extent to which the proposed mitigation and management measures will address potential impacts to ensure the NT EPA's objectives for this environmental factor are met.

The content of this chapter has been developed specifically to address section 3.1, 4.2.2 and section 4.3.2 of the EIS TOR (Appendix A).

7.6.2 Technical Studies

Technical studies undertaken to support the assessment of Inland Environmental Water Quality appear listed in Table 7-34.

Table 7-34: Inland environmental water quality studies undertaken for the Project

Date	Study Title	Consultant	Description	Report
April, May and September 2019a	Preliminary Site Investigation and Shallow Soil Baseline Assessment – Proposed TNG Plan Lot 1817 Hundred of Ayers, Darwin, NT	Golder Associates Pty Ltd	Baseline assessment of the terrestrial environment including soils and surface water quality.	Appendix H
13 Sept 2019b	Hydrogeological Study TNG Darwin Process Facility	Golder Associates Pty Ltd	Baseline assessment of the existing hydrogeological environment including water quality	Appendix M

7.6.3 Existing Environment

This chapter has been informed by baseline assessment of the existing surface water and groundwater quality.

7.6.3.1 Water quality sampling locations

Surface water at the site is ephemeral and therefore the sampling locations were selected based on availability of water. Twelve groundwater bores were established for the hydrogeological site investigation, with groundwater sampled at all borehole locations. The sampling locations are presented in Figure 7-15.

7.6.3.2 Water quality assessment criteria

Surface water assessment criteria

Based on the ecological setting of the site and the surrounding area, and with consideration given to the uses of Elizabeth River and Darwin Harbour, the surface water analytical results have been assessed against groundwater criteria for the purposes of the Site investigation.

Criteria in *Department of Health 2014b Non-potable Groundwater Use (NPUG) Guidelines* were selected for the assessment of water quality with respect to human health.

With respect to recreational water guidelines, the *Department of Water and Environment Regulation 2014 Assessment and Management of Contaminated Sites; Contaminated Site Guidelines 2014*, is considered to present best practice guidance. It states:

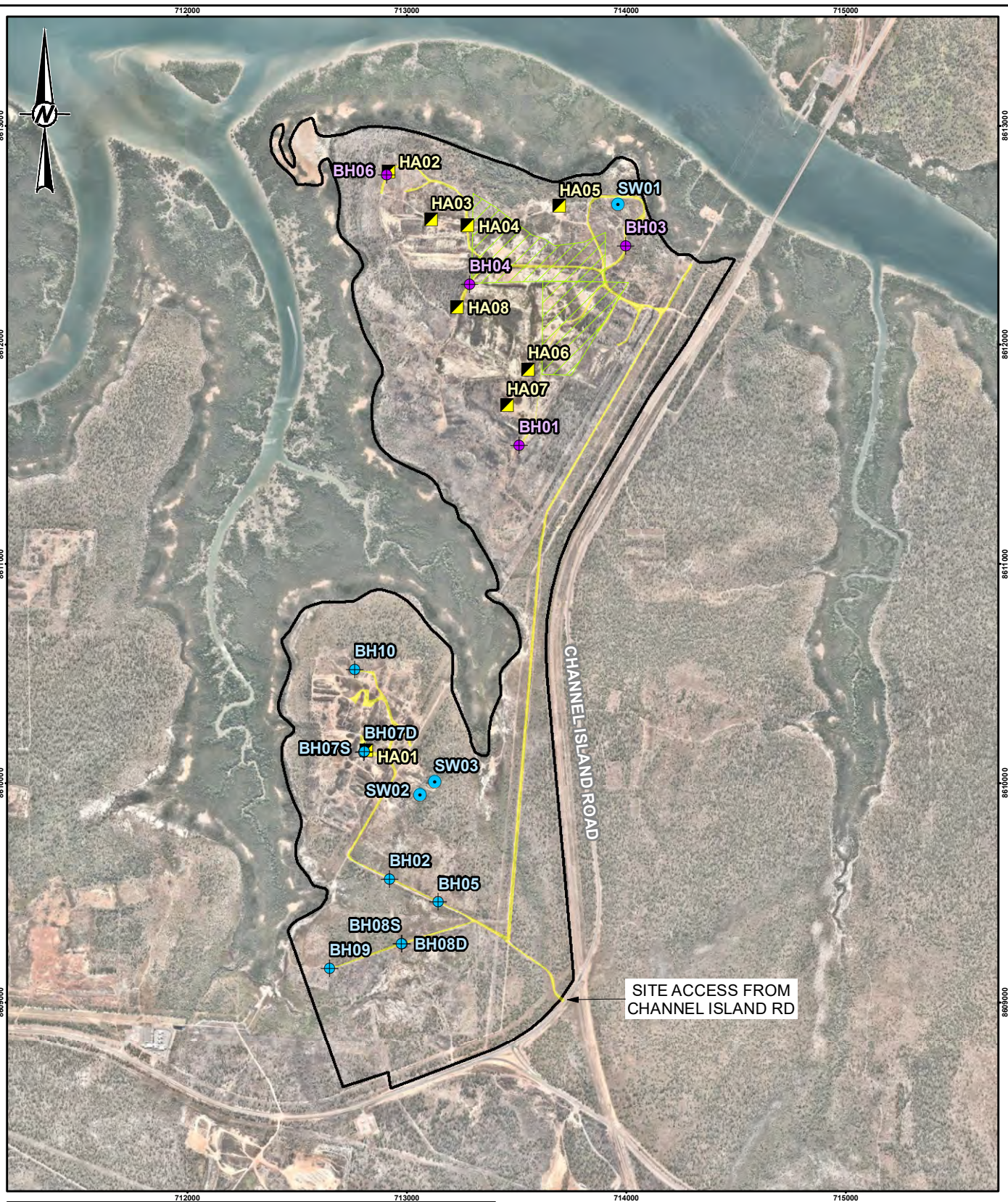
‘Consistent with NEPM, where the Conceptual Site Model indicated that there may be public exposure to contaminants in surface water (or in groundwater where there are discharges to a river, lake, or estuary), via recreational activities such as water sports and swimming, the Guidelines for Managing Risk in Recreational Water (National Health and Medical Research Council (NHMRC 2008) apply. Consistent with the NHMRC (2008), the Department of Health (DoH 2014b) has specified that the NPUG should be applied for the assessment of chemical substances in recreational waters, or groundwater that discharges to recreational waters’.

Whilst this document is based upon Western Australian guidance, it is considered to be suitable guidance in the context of the Darwin Site.

The NHMRC 2008 guidance predominantly focuses upon the risk of algal and bacterial growth and associated health risks; however, water analyte concentrations have been compared to NPUG guideline values as an initial means of comparison with NHMRC 2008.

NEPM 2013 Groundwater Investigation Levels – ‘Fresh Waters’ guidelines were selected for the assessment of the surface water quality with respect to potential ecological receptors. The investigation levels apply to typical slightly-moderately disturbed systems deriving from the ANZG (2000) guidance document.

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LEGEND

INVESTIGATION LOCATIONS

- NORTHERN PENINSULA
GROUNDWATER MONITORING WELL
BOREHOLE
- SOUTHERN PENINSULA
GROUNDWATER MONITORING WELL
BOREHOLE
- SURFACE WATER
- HAND AUGER

- ACCESS ROAD
- MINING LEASE
- LOT 1817 BOUNDARY

CLIENT
ANIMAL PLANT MINERAL PTY LTD
(ON BEHALF OF TNG PTY LTD)

CONSULTANT

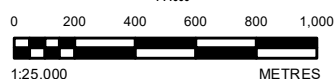
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DESIGNED AR

PREPARED MS

REVIEWED PVB

APPROVED PVB



NOTE:

1. COORDINATE SYSTEM: GDA 1994 MGA ZONE 52

REFERENCES:

- LOT 1817 GEOREFERENCED FROM PLAN 1 (17-03-02_DARWIN PROCESS PLANT_EXISTING_PROPOSED_A3) PROVIDED BY CLIENT
- AERIAL IMAGE SOURCED FROM NEARMAP (2019-06-13)

PROJECT
PROPOSED TNG DARWIN PLANT
LOT 1817 HUNDRED OF AYERS, DARWIN, NT

TITLE

Figure 7-15: Surface water and ground water sampling locations

PROJECT NO.
19115223

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3

FIGURE
7

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM 150 A4

Groundwater assessment criteria

As above, with consideration given to the recreational uses of the Darwin Harbour area (adjacent to the site and immediately down-hydraulic-gradient of the site), the NPUG guidelines have been selected to assessment risks to human health.

The following assessment criteria has been selected for the assessment of groundwater quality with respect to potential ecological receptors:

- Australian and New Zealand Guidelines (**ANZG**) for Fresh and Marine Water Quality (2018), Marine Species 95% species protection value. It should be noted that the ANZG (2018) are still in draft form and therefore criteria are subject to potential change. These guidelines have been used as their endorsement is anticipated to occur shortly and future investigations at site will be required to adopt them;
- Darwin Harbour Water Quality Protection Plan (**WQPP**) 'Developing Water Quality Objectives for the Darwin Harbour Region' (Aquatic Health Unit 2010) 'Water Quality Objectives for the Darwin Harbour Region' ('Upper-Estuary'). The wider Darwin Port estuary is considered as 'Upper-Estuary', and therefore the 'Upper-Estuary' assessment criteria have been selected.

7.6.3.3 Surface water quality baseline

Field measured parameters

A summary of field measured water quality parameters appear below.

- The temperature of the surface water ranged from 24.2°C to 31.5 °C;
- The Electrical Conductivity (**EC**) of the surface water ranged from 70.3 (SW02) to 447 micro Siemens per centimetre (**µS/cm**) (SW01), suggesting that the surface water is generally fresh. These results correspond to calculated TDS concentrations of 47 mg/L and 300 mg/L respectively;
- pH ranged between 5.44 (SW01) and 5.48 (SW02), indicating that the surface water is slightly acidic;
- The Dissolved Oxygen (**DO**) of the surface water ranged between 4.3 mg/L (SW01) and 6.88 mg/L (SW02), suggesting that redox conditions are toxic.
- The measured redox potential ranged between 69 millivolts (**mV**) (SW01) and 109 mV (SW02), indicating oxidising conditions.

Laboratory parameters

Surface water quality baseline results are presented in Table 7-35. The surface water quality at the locations sampled indicate that rainwater is the source of water for the ponds and that the surface water ponds are generally fresh and oxidising. Full surface water quality results appear in Table C of Appendix H.

Table 7-35: Surface water quality baseline results

Parameter	Average (mg/L)
Laboratory reported Electrical Conductivity (EC – $\mu\text{S}/\text{cm}$)	250
Laboratory reported pH (no units)	6.25
Total Dissolved Solids (TDS)	149
Sodium (Na)	32.5
Potassium (K)	2.15
Calcium (Ca)	6.15
Magnesium (Mg)	5.5
Chloride (Cl)	75
Sulfate (SO_4)	6.5
Total Acidity (as CaCO_3)	<5
Total Alkalinity (as CaCO_3)	<5
Hardness (as CaCO_3)	9
Nitrate (as N)	0.025
Nitrite (as N)	0.01
Total Nitrogen (as N)	1.1
Total Phosphorus (as P)	0.065
Aluminium (Al)	0.275
Arsenic (As)	0.00075*
Cadmium (Cd)	0.00075*
Chromium (Cr)	<0.001
Copper (Cu)	0.002
Iron (Fe)	0.68
Lead (Pb)	<0.001
Manganese (Mn)	0.05
Mercury (Hg)	<0.0001
Nickel (Ni)	<0.001
Selenium (Se)	<0.001
Titanium (Ti)	<0.01
Vanadium (V)	<0.01

Note:* Where the values are reported as below LOR, a conservative value of half the LOR is used in the calculation.

7.6.3.4 Groundwater quality baseline

Baseline sampling of water quality was conducted at 12 monitoring wells within the Project area during 2019. Complete details and analysis of baseline water quality data are included in the Hydrogeological Study provided at Appendix M.

Field measured parameters

A summary of field measured parameters appears in Table 7-36 below.

Table 7-36: Summary of groundwater field parameters

Parameter	Unit	Southern Peninsula		Northern Peninsula	
		Minimum	Maximum	Minimum	Maximum
pH	pH units	3.69	6.08	4.66	5.62
Electrical Conductivity	uS/cm	25.1	2200	34	11095
Dissolved Oxygen	mg/L	0.29	6.41	0.49	4.19
Reduction Potential	mV	-37	284.3	-1.8	119.1
Temperature	°C	29.7	35.1	31.7	35.3

Laboratory parameters

The groundwater quality at the site is acidic and generally fresh with one monitoring well (BH03) having brackish groundwater. Some metals (aluminium, copper, lead, nickel and iron) and nutrients (total nitrogen and phosphorus) exceeded the adopted ANZG 2018 95% Marine Water in some of the wells. All the tested potential groundwater contaminants (e.g. hydrocarbons, Monocyclic Aromatic Hydrocarbons (**MAH**), Polynuclear Aromatic Hydrocarbons (**PAH**), pesticides, halogenated benzenes or volatile organic compounds) were below detection level in the sampled monitoring wells. Baseline water quality conditions in the BCF aquifer are summarised in Table 7-37 and appear in full in Appendix M.

Table 7-37: Summary of groundwater quality parameters

Parameter	Weathered BCF aquifer – baseline water quality summary
pH	- The pH results measured in May 2019 ranged from 3.69 to 5.86 in the southern peninsula and from 4.66 to 5.62 in the northern peninsula. The results indicate that the groundwater is acidic. All 12 monitoring wells are below the recommended range presented in the Darwin Water Quality Guidelines. - The pH and total alkalinity indicate that the groundwater can be classified as having very low to low alkalinity, indicating that there is insufficient buffering capacity in the groundwater to maintain stable and acceptable pH levels. The groundwater could therefore be prone to acidification.
Total metals	- Aluminium exceeded the ANZG 2018 95% Marine Water criterion in the 12 monitoring wells and the NPUG criterion in six (6) monitoring wells (BH02, BH04, BH07D, BH07S, BH08D and BH09). - Copper exceeded the ANZG 2018 95% Marine Water criterion in two (2) monitoring wells (BH02 and BH04). - Lead exceeded the ANZG 2018 95% Marine Water criterion in one monitoring well (BH04). - Nickel exceeded the ANZG 2018 95% Marine Water criterion in one (1) monitoring well (BH03). - Iron exceeded the NPUG criterion in five (5) monitoring (BH04, BH07, BH07D, BH07S and BH09). - Vanadium was below detection level in all the monitoring wells. - Titanium was detected slightly above the laboratory limit of reporting (LOR) in two monitoring wells (BH04 and BH08D).

Parameter	Weathered BCF aquifer – baseline water quality summary
Dissolved metals	- Aluminium exceeded the ANZG 2018 95% Marine Water criterion in three monitoring wells (BH02, BH08s and BH09). - Copper exceeded the ANZG 2018 95% Marine Water criterion in two monitoring wells (BH02 and BH09). - Nickel exceeded the ANZG 2018 95% Marine Water criterion and NPUG criterion in one monitoring well (BH03). - There was no detections of titanium and vanadium in any of the monitoring wells.
Nutrients	- Nitrogen (total oxidised) exceeded the Darwin Water Quality Guidelines Mid Estuary criterion in the 12 monitoring wells. - Total nitrogen exceeded the Darwin Water Quality Guidelines Mid Estuary criterion in six (6) monitoring wells (BH01, BH02, BH03, BH05, BH06 and BH09). - Phosphorus exceeded the Darwin Water Quality Guidelines Mid Estuary criterion in three (3) monitoring wells (BH04, BH07D, BH08D). - Ammonia (as N) exceeded the ANZG 2018 95% Marine Water criterion, NPUG criterion, and the Darwin Water Quality Guidelines Mid Estuary in one monitoring well (BH02) and only the ANZG 2018 95% Marine Water in one monitoring well (BH05).
Chloride	Chloride exceeded the NPUG criteria in two (2) monitoring wells (BH03 and BH05). These two locations also have the highest TDS, which is indicative of elevated salinity.
Groundwater contaminants	All the tested potential groundwater contaminants (e.g. hydrocarbons, MAH, PAH, pesticides, halogenated benzenes or volatile organic compounds) were below detection level in the sampled monitoring wells.
Electrical Conductivity	The electrical conductivity results measured in May 2019 ranged from 11 uS/cm to 2700 uS/cm in the southern peninsula and from 34 uS/cm to 7490 uS/cm in the northern peninsula.
Dissolved Oxygen	The DO results measured in May 2019 ranged from 0.87 mg/L to 6.41 mg/L in the southern peninsula and from 0.96 mg/L to 7.00 mg/L in the northern peninsula.
Reduction Potential	The reduction potential results measured in May 2019 ranged from 98.7 mv to 284.3 mV in the southern peninsula and from 107.7 mV to 119.7 mV in the northern peninsula.
Temperature	The groundwater temperature results measured in May 2019 ranged from 29.7 degrees Celsius (°C) to 33.4 °C in the southern peninsula and from 31.7 °C to 33.6 °C in the northern peninsula.

7.6.4 Potential impacts and risks

Project related activities, if unmanaged, have the potential to impact on inland water environmental quality. The source-pathway-receptor model has been used to identify potential impacts and risks to this Factor (Table 7-38), with further detail provided in the chapters below.

Table 7-38: Potential pathways for impact on inland water environmental quality

Source	Pathway	Receptor
Construction activities	Contamination resulting from disturbance of AASS during construction.	
	Use of hazardous materials, concrete batching plant contaminating surface water and groundwater.	Degradation of inland surface water quality.
	Sedimentation of surface water as a result of clearing activities during construction.	Degradation of inland groundwater quality.
Operation activities	Uncontrolled terrestrial based chemical spills impacting receptors via surface water and groundwater pathways.	

7.6.4.1 Degradation of surface and groundwater quality through disturbance of acid sulfate soils

The baseline soil assessment identified the presence of actual and potential ASS within certain areas of the Site, however there is a high potential for ASS to be encountered more broadly across the site during the proposed construction works for the project.

As a result, in certain areas construction of Project infrastructure may generate acid from oxidation of sulfide minerals in the potential and actual ASS. This may cause the acidification and degradation of shallow groundwater quality. In addition, the reduction in pH promotes an increase in the solubility of some metals in groundwater. This can cause acidic discharge with elevated metal concentrations. Metal concentrations may increase to the point where it could pose a risk to groundwater receptors, and potential off-site impacts may potentially eventuate.

Potential ASS disturbing activities resulting from the construction of project infrastructure include excavation, dewatering and other surface disturbances. The most common form of disturbance to ASS is the excavation of large areas by machinery during construction activities that have the potential to expose underlying ASS to oxygen, which will then form sulfuric acid if water is also introduced. Dewatering requirements for this Project are expected to be negligible.

Other surface disturbances associated with construction activities include clearing, traffic movement and placement or pick up of materials. Where ASS occur at the surface, these disturbances can allow soils to come into direct contact with the air. All the aforementioned construction activities have the potential to expose ASS to oxygen.

Where ASS exist within the soil profile at similar depths to the groundwater level, water can be easily introduced to the exposed ASS and the groundwater is at risk of acidifying. Furthermore, during the Wet Season, large amounts of rainfall have the potential to fall on exposed ASS and consequently create sulfuric acid. This acidic water may then runoff or infiltrate the underlying aquifers and increase the acidity of the groundwater. Metal contaminants may also be mobilised with this acidification because most metals are more soluble under acidic conditions.

There is a medium to high risk of contamination to surface or groundwater if there is no active management of exposed actual ASS.

7.6.4.2 Contamination of surface and groundwater – spills and leaks

There is potential that the chemical qualities of the surface and groundwater could be impacted by leaks or spills of chemicals, reagents, concentrates, hydrocarbons or cement residue during construction and processing activities. There is a high level of inherent risk (pre-mitigation) associated with alteration of the chemical characteristics of the surface water and groundwater considering it is likely to discharge to the Elizabeth River, tributaries and ultimately, Darwin Harbour.

It is also recognised that a 1 in 10,000 year event has the capacity to result in a significant release of hazardous materials. It is considered, however, that the likelihood of such an event occurring is extremely low and impacts from substance release may be reduced through amplified dilution rates associated with increased water volumes from the storm surge.

7.6.4.3 Contamination of surface and groundwater – erosion and sedimentation

Erosion and sedimentation risks are expected to be highest during the construction phase of the Project. Clearing of vegetation, excavation and site levelling activities have the potential to facilitate migration of sediments into inland surface water bodies or site runoff. This is predominantly anticipated during the wet season.

Given the short timeframe for construction (2 years), the seasonality of the risk, the relatively flat topography of the site and the availability of proven management strategies, it is not considered that sedimentation and erosion will present a long term significant impact for the Project.

7.6.5 Mitigation and management

The mitigation measures outlined in Table 7-39 will be implemented to reduce the risk of impacts on inland water environmental quality. More detail is provided in the management plans and procedures developed through the ESCP (Appendix N) and EMP (Appendix D).

Table 7-39: Mitigation measures for inland water environmental quality

Pathway	Mitigation hierarchy	Mitigation measure
Disturbance of ASS during clearing and earthworks	Avoid, minimise, rehabilitate	ASS management is explored in depth in chapter 7.2 ASS is to be managed in accordance with the ASS Management Plan.
Water pooling, sedimentation and contamination during Project operations phase	Avoid, minimise	Implement the Hazardous Material Management Procedure (EP-13) , within the EMP, including the following: - Ensure stockpiles of bulk materials are located well clear of any waterway or drainage systems; - Train personnel in implementation of safe work practices to minimise risks and impacts of spillage of fuels, chemicals and other contaminants; - Train personnel in incident reporting and emergency management procedures and encourage the reporting of issues and near misses; - Construct bunds around fuel and chemical storage areas according to <i>Australian Standards 1940:2017</i> (unless quantity of the liquid stored is within that allowable as minor storage).
Contamination of surface and groundwater systems through leaks or spills	Avoid, minimise	Implement the Hazardous Material Management Procedure (EP-13) , within the EMP (Appendix D), including the following:

Pathway	Mitigation hierarchy	Mitigation measure
		- o Record and report all POL, chemical and hazardous substance spills - o Ensure personnel have access to spill kits that contain an absorbent material, clearly marked oily waste disposal drum and a shovel. - o In the event of a POL spill less than 20L on soil, remove the soil and dispose of in oily waste disposal drum. - o In the event of a POL spill of between 20 and 80L, soak up as much as possible using absorbent, and turn/aerate the soil to allow natural processes (i.e. aeration and microbial systems) to breakdown the organic compounds (i.e. hydrocarbons). Remove contaminated soil if the spill occurs in the vicinity of drainage lines and waterways. If on a hard surface such as road or concrete, use absorbent and dispose in the oily waste disposal drum. - o In the event of a POL spill greater than 80L, all contaminated soil is to be removed, and disposed of in a clearly marked oily waste disposal drum. - o Undertake validation sampling of soil if the spill, or combined record of spills, is greater than 80L to confirm all contaminated soil has been removed - o All contaminated soil and absorbent in the oily waste disposal drum should be disposed of at a designated oily waste disposal site approved by Darwin authorities. - o If pooled water becomes contaminated, e.g. through a diesel spill, ensure it is contained and removed (and not discharged to sewerage system or natural water courses) - o In the event of a chemical or hazardous substance spill ensure all requirements of the Material Safety Data Sheet (MSDS) are complied with - o MSDSs are to be located within storage areas, as well as centrally located and readily available to staff for use in case of an emergency. MSDSs are to remain current at all times. - o Any spillage of wastes, contaminants or other materials shall be cleaned up as quickly as practicable using procedures that prevent contaminants or material being transferred to the stormwater drainage system; - o The stormwater system for the site shall be inspected regularly to identify any failures and, if necessary, repairs shall be undertaken; • Chemical storage and handling areas shall be bunded and shall have drainage lines separate from the stormwater drainage, to reduce the likelihood of chemical contamination of stormwater.
Erosion and sedimentation impacting on water quality	Avoid, minimise	• Implementation of the ESCP (contained within Appendix O) and Implementation of the Water Management Procedure (EP-10) contained within the EMP (Appendix D) including: - o Use of swales and sediment basins where required; and - o Use of minor diversions where required. • Ensure stockpiles of bulk materials are located well clear of any waterway or drainage systems; • The stormwater system for the site shall be inspected regularly to identify any failures and, if necessary, repairs shall be undertaken • Utilise appropriate drainage infrastructure (drains, culverts) to maintain existing surface water flowpaths where possible. • Stormwater within the development envelope will be contained and directed to the wastewater treatment plant during operations prior to discharge. • Clearing will be scheduled during the dry season, wherever possible.

7.6.6 Monitoring and reporting

The EMP and associated sub-plans detail objectives, monitoring procedures and performance indicators, as well as corrective actions and reporting requirements. These are outlined below in Table 7-40. Other inspections and activities associated with inland water environmental quality appear in hydrological processes appear in Table 7-41.

Table 7-40: Monitoring and reporting for inland water environmental quality

Action	Timing	Methods used	Criteria
Surface water quality monitoring	Biannual	Laboratory methods for parameters outlined in Appendix H. Field based methods for temperature, EC, pH, DO, mV.	<i>Department of Health 2014b Non-potable Groundwater Use (NPUG) Guidelines</i> NHMRC 2008 NEPM 2013 Groundwater Investigation Levels – ‘Fresh Waters’
Groundwater monitoring	Quarterly	Laboratory methods for parameters outline in Appendix M. Field based methods for temperature, EC, pH, DO, mV.	<i>Department of Health 2014b Non-potable Groundwater Use (NPUG) Guidelines</i> ANZG) for Fresh and Marine Water Quality (2018), Marine Species 95% species protection value <i>Water Quality Objectives for the Darwin Harbour Region</i> (‘Upper-Estuary’).

Table 7-41: Other inspection and reporting for inland water environment environmental quality

Relevant Plan	Procedure (if relevant)	Monitoring	Reporting
Environmental Management Plan	NA	Daily inspection of high-risk locations, including to identify any new risks / unmanaged risks.	Annual Report and Performance Review Monthly Environmental Performance Report Half Year Report
	Hazardous Material Management Procedure (EP-13)	Daily inspection to ensure water is not unintentionally pooling on site (see Daily Inspection Checklist)	Reporting for the Annual Report will include the volume of controlled wastes moved off site;

Relevant Plan	Procedure (if relevant)	Monitoring	Reporting
		Daily monitoring to ensure site is cleared of waste, all POL/chemicals have been stored and disposed of correctly, and all spills have been identified and dealt with (see Daily Inspection Checklist) Regular inspection of any bunds to check integrity and to detect leaks and spills (see Weekly Inspection Checklist) Regular inspection of stormwater drains for any sediment capture (see Weekly Inspection Checklist)	All incidents will be reported in the Annual Report. Any activities/incidents that require notification or reporting to the NT EPA under the <i>Waste Management and Pollution Control Act 1998</i>.
ASS Management Plan		Monitoring of lime-treated soil for successful neutralisation before being moved or covered. Existing water bores will be utilised for the purpose of groundwater monitoring including pH and groundwater level. Groundwater level monitoring will be conducted on a monthly basis, with groundwater quality assessed quarterly. Monitoring of pH and total acidity of any pools of water collected within bunds and treatment of water to keep the pH within the range of baseline data levels.	Monthly Environmental Performance Report Half Year Report Annual Report and Performance Review Regulatory Incident Report, as required.
Erosion and Sediment Control Plan		Weekly inspection of erosion and sediment controls during the wet season.	Monthly Environmental Performance Report

7.6.7 Statement of residual impact

In consideration of the outcomes of the EIA and proposed management measures, TNG expects that the EPA's objective for inland water environmental quality can be achieved. The following outcomes are predicted:

- Inland surface water quality can be maintained given appropriate design of facilities and management of surface water infrastructure is integrated into the construction and operation of the Project;
- Groundwater quality can be maintained so that environmental values associated with groundwater are not likely to be significantly impacted.

By implementing management measures detailed above, the residual impact to inland water environmental quality is not considered significant.

TNG LIMITED

DRAFT ENVIRONMENTAL IMPACT
STATEMENT

DARWIN PROCESSING FACILITY

**ENVIRONMENTAL
FACTOR: MARINE
ENVIRONMENTAL
QUALITY**

7.7 ENVIRONMENTAL FACTOR: MARINE ENVIRONMENTAL QUALITY

7.7.1 NT EPA Objective

The NT EPA's objective for the factor Marine Environmental Quality is to:

Maintain the quality and productivity of water, sediment and biota so that environmental values are protected.

Marine environmental quality refers to level of contaminants in water, sediments or biota, or to changes in the physical or chemical properties of waters and sediments relative to a natural state. It does not include noise pollution, which is dealt with separately under the factor – *Marine Fauna and Flora*.

The marine environmental quality objective recognises that the quality of the marine environment is important for protecting ecosystem health and supporting the declared beneficial uses for Darwin Harbour, including environmental, aquaculture and cultural uses and values.

This chapter describes the existing marine environmental quality of the Project area, including Elizabeth River and East Arm, identifies potential Project related risks to marine environmental quality and details the mitigation and management required to ensure these risks do not result in unacceptable impacts to marine environmental quality. This chapter also presents the proposed monitoring and reporting requirements to determine if mitigation and management methods are adequate.

The content of this chapter has been developed specifically to address section 3.1 of the EIS TOR (Appendix A).

7.7.2 Technical Studies

Technical studies undertaken to support the assessment of Marine Environmental Quality appear listed in Table 7-42.

Table 7-42: Marine environmental quality studies undertaken for the Project

Date	Study Title	Consultant	Description	Report
September 2019a	TNG Darwin Outfall: Hydrodynamic Modelling Report	Baird Australia	Hydrodynamic modelling of discharge	Appendix O
September 2019b	TNG Darwin Processing Facility Outfall: Pollutant Outfall Modelling Report	Baird Australia	High-resolution three-dimensional numerical modelling system to assess the mixing and dispersion of the wastewater from the proposed outfall locations.	Appendix P
2019a	Darwin Processing Facility: Marine Environmental Quality Site Investigation	O2 Marine	Baseline assessment of water, sediment and biota quality in proposed outfall location	Appendix Q
2019b	Darwin Processing Facility: Marine Environmental Quality Monitoring and Management Plan	O2 Marine	Monitoring and management plan for water, sediment and biota quality at the outfall location.	Appendix R

7.7.3 Marine Environmental Quality Standards

The process for setting marine and freshwater quality objectives is based on the national framework outlined in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (**ANZG 2018**). The guidelines provide a framework that allows the user to move beyond a single-number conservative value, to guidelines and objectives that can be refined according to local environmental conditions. It is within this context that the Darwin Harbour region guidelines and objectives have been initiated and will be progressively enhanced.

The National Water Quality Management Strategy (**NWQMS**) was introduced in 1992 in response to growing community concern surrounding the condition of the nation's water resources and the need to manage them in an environmentally sustainable way.

Locally derived guidelines and objectives are the preferred ambient quality benchmarks, as envisaged by the NWQMS. The Australian and New Zealand Guidelines for Fresh and Marine Water provide default values for a range of water quality parameters in the absence of locally or regionally derived reference values.

7.7.3.1 Relevant Northern Territory Guidelines

Water Quality Objectives

The NT Department of Natural Resources, Environment, The Arts and Sport (**NRETAS**) (now DENR) developed the Water Quality Objectives (**WQOs**) for the Darwin Harbour Region (NRETAS 2010) to commence the implementation of the NWQMS. The key aim of this document was to identify a *'suite of Water Quality Objectives that relate to the beneficial uses and environmental values of the waterways has been developed to provide some preliminary benchmarks against which various attributes of the health and condition of these waterways can be measured and reported'* (NRETAS 2010).

These WQOs, along with the key Beneficial Uses (**BUs**), were declared by the NT Parliament in NT Government Gazette: no. G27, 7 July 2010.

Darwin Harbour Water Quality Protection Plan

This supported the development of the Darwin Harbour Water Quality Protection Plan (**WQPP**) (DLRM 2014), which sought to further implement the national strategy and, in particular, the national Framework for Marine and Estuarine Water Quality Protection through identification of specific actions relevant to the protection of the water quality within Darwin Harbour.

The WQPP *'aims to support good management and sustainable development through its focus on protecting Darwin Harbour waterways from excessive sediment and nutrient inputs'*.

Whilst the WQPP and the declared WQOs primarily focus on water quality and key identified threats such as nutrients and suspended sediment inputs to Darwin Harbour, they are applicable to the Project as primary guidelines for interpretation of water quality criteria relevant to the Darwin Processing Facility.

Beneficial Uses

Environmental Values are defined in the Australian and New Zealand Water Quality Guidelines (**ANZG**) (2018) as:

"Particular values or uses of the environment that are important for a healthy ecosystem or for public benefit, welfare, safety or health and which require protection from the effects of pollution, waste discharges and deposits".

The NT *Water Act* has defined and declared each of the NT's environmental values or uses, classifying them as BUs. BU status for Darwin Harbour were declared in the NT Government Gazette: no. G27, 7 July 2010.

Environmental Quality Objectives

NREATAS (2010) defines Environmental Quality Objectives (**EQOs**) for water quality as high level management objectives; described as *'the water quality needed to protect and sustain each of the environmental values and beneficial uses identified'* and *'intended for the community, local councils and government agencies to use in catchment management and land use planning activities'*.

While this description is primarily focused on water quality, rather than marine environmental quality, for the purposes of this document substitution of *'marine environmental quality'* in place of *'water quality'* is in keeping with the philosophy of WQOs in their application for this section. EQOs for Darwin Harbour are defined in NRETAS (2010).

Three BUs and four corresponding EQOs apply to the Darwin Harbour area and are presented in Table 7-43.

Table 7-43: Beneficial uses and environmental quality objectives applicable to the Darwin Harbour region

Beneficial Uses	Environmental Quality Objectives
Environment	EQO1: To maintain and protect the ecological condition of marine, estuarine and freshwater ecosystems of the Darwin Harbour Region. EQO1 is split into four sub- objectives, being: High Conservation Value, Slightly to Moderately Disturbed and Highly Disturbed (Refer chapter 2.3 below).
Aquaculture	EQO2: To maintain water quality for the production and consumption of aquatic foods derived from aquaculture.
Cultural	EQO3: To maintain marine, estuarine and fresh water quality so that it is suitable for activities such as swimming and other direct water contact sports. EQO4: To maintain water quality for the production and consumption of aquatic foods derived from recreational, commercial or indigenous food gathering.

Levels of Ecological Protection

ANZG (2018) identifies three tiers for the protection of aquatic ecosystems;

- Highly Disturbed (**HD**);
- Slightly to Moderately Disturbed (**SMD**); and
- High Ecological Value (**HEV**).

These levels have been adopted and applied within the wider Darwin Harbour region, with HEV allocated to specific areas identified as requiring the highest protection (cultural sites of significance, marine reserves), HD allocated within small pockets specific to operational activities as approved by the NT Government, and SMD applied to all other areas.

Currently the sites adjacent to the Project and surrounding the outfall location are defined as SMD ecosystems and are awarded the level of ecological protection commensurate with that zone. Within the wider local area an approved mixing zone (Environmental Protection Licence 228) has been established surrounding the INPEX jetty outfall located at Bladin Point (Figure 7-14).

The levels of ecological protection, as defined within NRETAS (2010), are presented within Table 7-44.

Table 7-44: Limits of acceptable change allocated to levels of ecological protection as defined by NRETAS (2010) and adapted from ANZG (2000)

Indicator Class	Effect Size of Departure from Reference		
	HEV Systems	SMD Systems	HD Systems
Toxicants and Nutrients in Water	No change to natural values	95% SPL*	80-90% SPL
Toxicants in Sediments	No change to natural values	>90% SPL	
Physico-chemical	No change to natural values	Median lies within 20th/80th percentile of reference range	Locally determined (10th/90th percentile of range)
Biological	No change to natural values	Median lies within 20th/80th percentile of reference range	Locally determined (10th/90th percentile of range)

* SPL = Species Protection Level

The Project will be required to meet the level of ecological protection afforded to a HD system within the mixing zone and, for all other waters including directly adjacent to the Project within Elizabeth River, the protection commensurate with a SMD system.

The levels of ecological protection applicable to this Project are displayed in Figure 7-16.

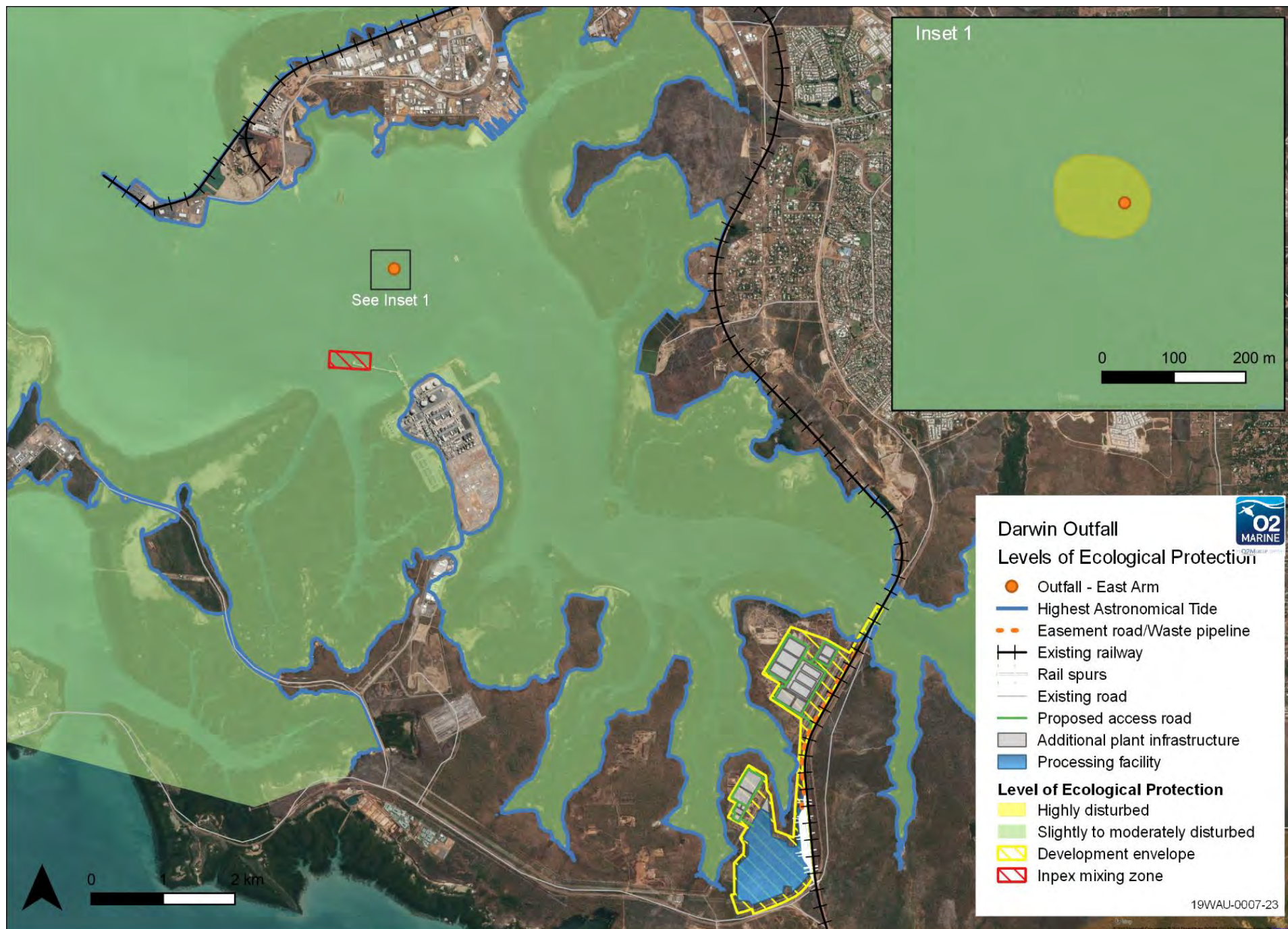


Figure 7-16: Levels of Ecological Protection associated with the Project

7.7.4 Existing Environment

The existing marine environment has been extensively described in Baird (2019a) and O2 Marine (2019a). The following chapters provide a summary of the hydrodynamics, water and sediment quality within Darwin Harbour.

The marine water and sediment quality in Darwin Harbour and Elizabeth River (up to Elizabeth River Bridge) is broadly regarded as good to excellent, especially in comparison to waterways surrounding other major Australian cities. Darwin Harbour is one of the least-disturbed working harbours around the Australian coastline (DLRM, 2014)

The area is a valued tropical coastal environment that is home to most of the NT residents and the country of the Larrakia people. There is no evidence of widespread water or sediment pollution in the Harbour, although there is some localised pollution around the industrial estates (Padovan 2003).

Darwin Harbour is macro-tidal; however, the upper estuary reaches are not well-flushed and are most vulnerable to pollution.

Darwin Harbour has naturally high levels of suspended sediments due to it being a tide dominated estuary, with large tidal movements, strong currents and large volume of mangrove sediments. However, due to urban development across the Darwin metropolitan area there has been an increase in sediments and also nutrients entering the Harbour waterways above natural background levels. An increased proportion of modified, sealed surfaces associated with development typically result in double the volume of stormwater runoff in the wet season compared to an undisturbed landscape (Skinner et al. 2009). This increased volume, combined with urban land uses, has resulted in greater pollutant loads entering the Harbour waterways; typically resulting in nutrients and higher levels of suspended sediment.

The Elizabeth River estuary is a major tributary of Darwin Harbour and the area surrounding the estuary is subject to these pressures of urban and industrial development. The catchments of several suburbs drain into Mitchell Creek and Brooking Creek, which are both tributaries of the Elizabeth River estuary (URS 2011a).

7.7.4.1 Metocean Conditions

The meteorological and oceanographic conditions of the Project area, as described in Baird (2019a), typically include:

- A dry season (generally May to October), characterised by hot temperatures, easterly to south-easterly winds and clear and stable conditions derived from the subtropical high-pressure ridge. Whilst in the wet season months (generally November to April), the wind climate is more active and dominated by westerly and north-westerly winds.
- The Darwin regional climate is classed by the Bureau of Meteorology (BoM) as 'Equatorial Savanna' characterised by year-round hot weather, with emphasis on a hot humid summer. Two distinct seasons occur being the 'Wet' and 'Dry' seasons:
 - During the wet season, rains are delivered in by the northwest monsoonal system bringing warm moist air over the Darwin region. These systems can bring both tropical storms (lows) and tropical cyclones to the Darwin region, consistently bringing considerable rainfall and associated large volumes of fresh water to Darwin Harbour (BoM 2019).
 - During the dry season, conditions are more stable due to the sub-tropical high-pressure ridge that sits over the region during these months. There is little cloud cover or rainfall during the

dry season, with associated high rates of evaporation from water bodies during this season (BoM 2019).

- The Darwin Processing Facility Outfall project location experiences a semi-diurnal tide (two highs and two lows a day), with an overall tidal range of 8m, a spring tidal range of about 6m, and a neap tidal range of around 3m (Cardno 2014);
- The measured currents within Darwin Inner Harbour (East Arm) show the following characteristics during the dry season period over which it was deployed:
 - Depth averaged peak current speed of 0.6m/sec - 0.7m/sec in springs and 0.2m/sec – 0.25m/sec in neaps;
 - Current direction (direction to) consistent in Ebb 240° - 270° and Flood 40° - 70°; and
 - The ebb current speeds are also generally stronger than the flood current speeds.

7.7.4.2 Water Quality

Water quality within Darwin Harbour has been subject to numerous studies and monitoring programs, with a validation survey undertaken in the vicinity of the Project area to provide context for the historic information.

Typical water quality characteristics of the Project area include:

- Water temperatures typically range from 23.5 – 32.7°C with an average of 30.6°C and 24.5°C in the wet and dry seasons, respectively. Values observed during the O2M site investigation were consistent with historical temperatures, with results between 28.9°C and 29.9°C during the March survey;
- Dissolved oxygen typically ranges between 54-103%, averaging 84%. The O2M March 2019 survey observed dissolved oxygen values within this range (i.e. between 66-84%). Dissolved oxygen has been observed to decrease with respect to distance upstream, an observation conclusive within the O2M March 2019 survey results;
- Salinity levels in Darwin Harbour are reported to range between 8.74 to 39 ppt, with a median of 35.4 ppt. Salinity varies considerably over the year and respect to distance upstream. Salinity averages 35 ppt, although salt wedges are typical of the mid to upper estuary areas, with salinities identifies up to 12 ppt higher within bottom waters compared with surface waters during wet season. Salt wedge effects were observed during outgoing tides by O2 Marine, with greater mixing identified during incoming tides;
- Turbidity and suspended sediments are naturally high, associated with the large tidal movements and strong currents. Turbidity is highest during spring tides, typically around the midpoint between high and low water when current velocity is greatest, and vice versa lowest during neap tides. Average turbidity increases during the wet season as a result of increased sediment loading due to high rainfall resulting in suspended sediments entering the system. Turbidity has been observed to range between 6.9 Nephelometric Turbidity Units (**NTU**) and 73.6 NTU; the O2M March 2019 survey observed turbidity within the range of 4 - 11 NTU;
- pH typically ranges between 7.8 - 9.2 with an average of 8.4. The results of the O2M March 2019 survey reported pH range at the low end of the typical range (i.e. 7.75 - 8.12). Little to no seasonal variation has previously been observed; however, greater variability and higher pH has been observed in the upper reaches attributed to acidification processes occurring within from mangrove communities;
- The result of the O2M March 2019 sampling confirmed that with the exception of total nitrogen, nutrient enrichment (i.e. elevated phosphorus and ammonia) is present in the vicinity of the Project

area. In the past this finding has been most prevalent in the wet season and attributed to excess surface water runoff.

- Limited information is available for heavy metal levels within Darwin Harbour waters. However, the March O2M survey confirmed that there is no heavy metal contamination in the vicinity of the Project area, with all metals reported below the Default Guideline Value (**DGV**) for SMD waters.
- The waters surrounding the project are considered to have no known hydrocarbon or pesticide water quality issues, an observation consistent with the O2M March 2019 sampling results, which recorded these parameters generally below the Limit of Reporting.

Overall the marine and estuarine waters of Darwin Harbour and the Project area are considered to be in good to excellent quality with limited evidence of anthropogenic impacts.

7.7.4.3 Sediment Quality

The sediment quality characteristics of the Project Area include:

- Sediments within Elizabeth River sample locations comprised predominately of sand with some gravel;
- Concentrations of metals sampled from surficial sediments within Darwin Harbour and the Project area are generally low, with arsenic being the only contaminant that is consistently reported to be elevated across multiple locations in the Harbour.
- Elevated arsenic levels in sediments are thought to be attributed to local geology, not contamination from anthropogenic sources;
- With the exception of arsenic, the O2 Marine (2019a) sediment survey found all metals to be below the ANZG (2018) DGV. However, historic surveys have found occasional samples to contain elevated levels of chromium, lead and copper in isolated areas of Darwin Harbour.
- Concentrations of elevated metal contaminants (i.e. arsenic) are not thought to be bioavailable to any significant extent that would result in toxic effects to marine biota;
- Low levels of Total Petroleum Hydrocarbons (**TPH**) (11-16 mg/kg) have been detected in East Arm surrounding the wharf, although Benzene, Toluene, Ethylbenzene and Xylene and Polynuclear Aromatic Hydrocarbons (**PAHs**) were below the detection levels. Similarly, O2 Marine found that TPH and Total Recoverable Hydrocarbons (**TRH**) within the lower reaches of Elizabeth River were below detection levels;
- ASSS are known to exist in sediments, both sub- and inter- tidal, surrounding the Project Area and appropriate sampling and management would be required if disturbance of marine sediments is Proposed.

Overall, sediment quality in Darwin Harbour and in the vicinity of the Project area is of good quality with limited evidence of anthropogenic impacts.

7.7.5 Potential impacts and risks

Project related activities, if unmanaged, have the potential to impact on marine environmental quality. The source-pathway-receptor model has been used to identify potential impacts and risks to this Factor (Table 7-45), with further detail provided in the chapters below.

Table 7-45: Potential pathways for impact on marine environmental quality

Source	Pathway	Receptor
Construction activities	Sedimentation of marine environment as a result of terrestrial based land clearing.	
	Uncontrolled terrestrial based chemical spills entering marine environment through soil and groundwater pathways.	Degradation of marine water quality within the Darwin Harbour system.
	Contamination resulting from disturbance of AASS during pipeline construction.	Contamination of marine sediments within the Darwin Harbour system.
Operation activities	Non-process waste entering waterways.	
	Discharge of treated wastewater to the marine environment.	

7.7.5.1 Discharge of wastewater

Outfall Locations

TNG are proposing to discharge wastewater generated from the Processing Facility into the adjacent waterway, within East Arm. Two locations for the wastewater outfall in Darwin Harbour were examined:

- Outfall Case 1: Darwin Harbour in the branch of the Elizabeth River near the Processing Facility site
- Outfall Case 2: Darwin Harbour in East Arm.

The wastewater will be directed through a seabed pipeline to an outfall at the seabed in both cases. The outfall locations are shown in Figure 7-17.

Discharge Water Quality

Treated wastewater discharge will contain water quality constituents that differ from natural conditions. Wastewater design specifications compared with the Environmental Quality Criteria are presented in Table 7-46 and Table 7-47, identifying requirements within the HD Level of Ecological Protection (LEP) at the discharge point, at the boundary of the HD/SMD LEP and an estimate of concentration calculated at the HD/SMD boundary.

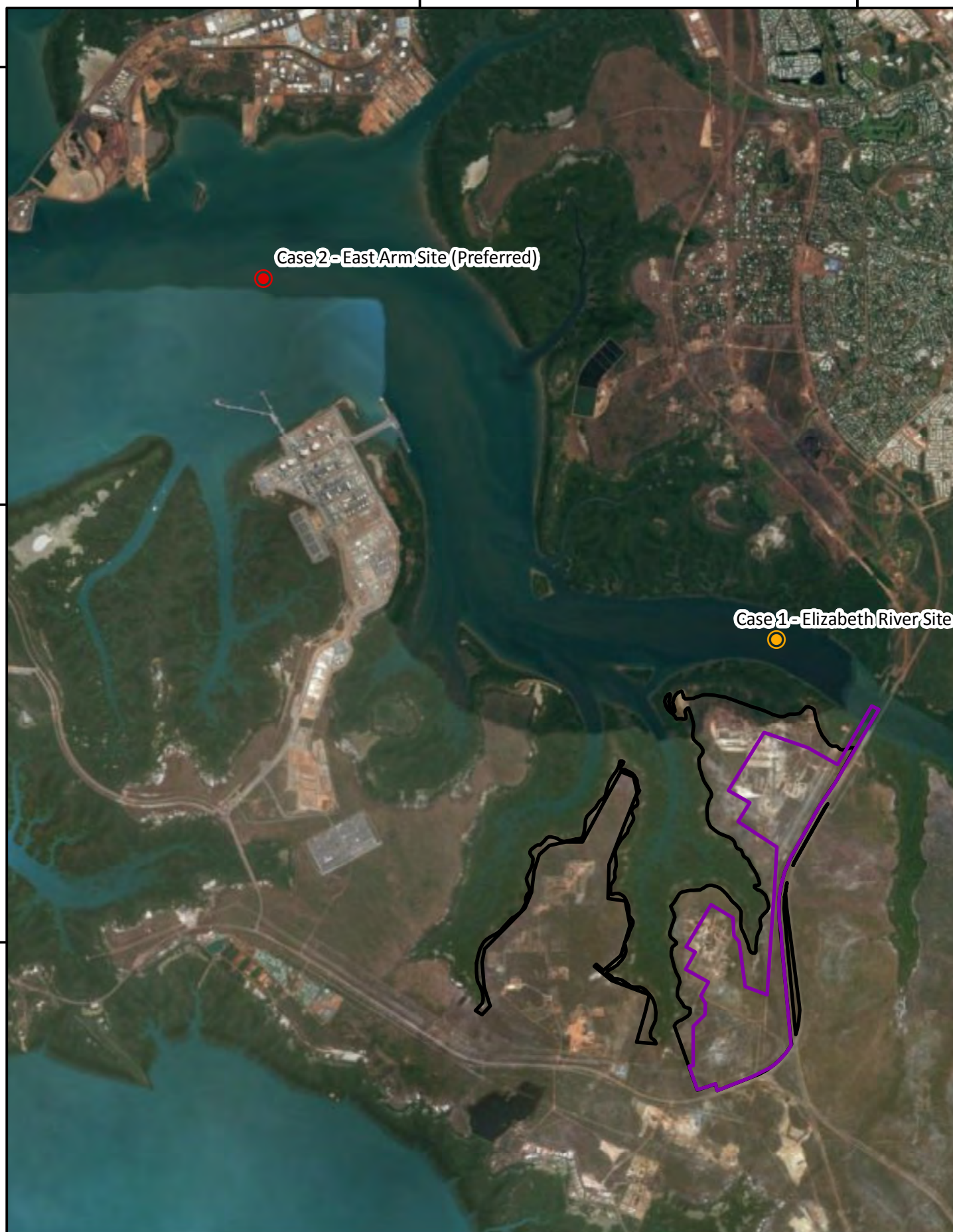


Figure 7-17: Wastewater outfall locations assessed for the Darwin Processing Facility

Legend

Modelled outfall locations points

- Case 1 - Elizabeth River Site
- Case 2 - East Arm Site (Preferred)

Darwin Processing Facility Envelope

Lot 1817, Hundred of Ayers



1:57,313 GDA 94 MGA Zone 52
Date: 22/11/2019



Table 7-46: Wastewater design specification compared with the environmental quality criteria for contaminants

Wastewater Constituent	Wastewater Design Specification	Point of Discharge Criteria (HD LEP) ¹	Mixing Zone Boundary Criteria (SMD/HD LEP boundary) ²	Estimated concentration at mixing zone boundary ³
Wastewater Contaminants - µg/L				
Ammonia	20	20	20	0.2
Chromium (CrIII)	5	91	27	0.05
Chromium (CrVI)	0.14	85	4.4	0.0014
Cobalt	0.005	150	1.0	0.00005
Copper	0.3	8	1.3	0.003
Cyanide	2	14	7	0.02
Manganese	5	NG*	NG	0.05
Nickel	5	560	70	0.05
Phenol	270	720	400	2.7
Silver	0.8	2.6	1.4	0.008
Thallium	17	NG	17	0.17
Vanadium	50	NG	100	0.5
Zinc	7	43	15	0.07
Arsenic (III)	2.3	NG	NG	0.023
Arsenic (V)	13	NG	NG	0.13
Tin	35	NG	35	0.35
Boron	5100	NG	NG	51
Iron	300	NG	NG	3
Aluminium	0.5	NG	NG	0.005
Barium	10	NG	NG	0.1
Fluoride	10	NG	NG	0.1
Sulfide	1	NG	1	0.01
Sulfate	20	NG	NG	0.2

Wastewater Constituent	Wastewater Design Specification	Point of Discharge Criteria (HD LEP) ¹	Mixing Zone Boundary Criteria (SMD/HD LEP boundary) ²	Estimated concentration at mixing zone boundary ³
Free Chlorine	3	NG	3	0.03
Sodium	10	NG	NG	0.1
Magnesium	10	NG	NG	0.1
Titanium	10	NG	NG	0.1

Notes:

1: Values derived from NRETAS (2010) for physico-chemical and nutrient and toxicants from ANZG (2018) 80% species protection levels as presented within (O2 Marine 2019b). Values with NG are proposed to be developed in accordance with ANZG (2018) using site specific data as detailed within O2 Marine (2019b).

2: Values derived from NRETAS (2010) for physico-chemical and nutrient and toxicants from ANZG (2018) 95% species protection levels as presented within (O2 Marine 2019b). Values with NG are proposed to be developed in accordance with ANZG (2018) using site specific data as detailed within O2 Marine (2019b).

3: Based upon 50th percentile of 100 dilutions at ~50m (Baird 2019a) to provide a conservative estimate of the expected concentration for boundary zone set at 60m.

* NG = No Guideline

Table 7-47: Wastewater design specification compared with the environmental quality criteria for temperature and salinity

Wastewater Constituent	Wastewater Design Specification	Point of Discharge Criteria (HD LEP) ¹	Mixing Zone Boundary Criteria (SMD/HD LEP boundary) ¹	Predicted distance from discharge point SMD criteria met ²
Temperature - °C	50	Wet - 32.0 Dry - 30.2	Wet - 31.6 Dry - 29.7	Wet - ~100m Dry - ~90m
Salinity – ppt	12	Wet - 29.1 Dry - 34.0	Wet - 29.7 Dry - 34.3	Wet - <10m Dry - ~30m

Notes:

1: Values for wet and dry season defined from Baird (2019a) as the 80th or 20th percentile of the median for SMD/HD boundary and the 90th or 10th percentile of the median for HD LEP.

2: Based upon estimated distances from discharge point using modelled contours presented in Baird (2019b).

Predictive Dispersion Modelling

To assess the potential impact of wastewater discharge on marine environmental quality, TNG initiated predictive numerical dispersion modelling of water quality associated with the outfall locations. Predictive dispersion modelling of the ocean outfall was undertaken by Baird (2019b) based on a discharge rate of 34.6 ML/day. The purpose of this outfall modelling was to identify:

- Dilution contours for specific wastewater constituents;
- Define the appropriate spatial area of the outfall Mixing Zone; and

- Predict associated physico-chemical and toxicant concentrations likely to arise in the surrounding water body associated with the outfall.

The outcomes of the dispersion modelling were used to assist with assessing the levels of impact likely to occur through implementation of the Project.

Continuous and intermittent release scenarios were initially considered; however, early modelling indicated that release of wastewater on a continual basis would not meet the objectives for marine environmental quality. As such TNG, along with the specialist consultants, have focused on release of wastewater on the ebb (outgoing) tide only.

Baird (2019b) identified Elizabeth River, Outfall Case 1, as being unacceptable due to the hydrodynamics within this system. Dispersion modelling indicated that within the system adequate dilutions were not occurring and the SMD LEP would not be achieved. Within the Elizabeth River system the dispersion modelling indicated initial dilution with the outgoing tide as the plume mobilised downstream, however the incoming tide effectively re-mobilised the plume upstream to the discharge area, resulting in a concentration of wastewater constituents over time (Figure 7-18).

Consequently, this discharge location was discarded and a secondary discharge location (Outfall Case 2) was identified within East Arm. Dispersion modelling undertaken at this secondary location identified a far more suitable level of temporal and spatial dilution of the wastewater plume, with constituents returning to background levels within 100 m of the immediate discharge area (Figure 7-19). Dispersion modelling was run for both wet and dry season scenarios with acceptable results.

The mixing zone, as defined by the boundary where temperature returns to the 80th percentile of background levels¹ (commensurate with SMD LEP) will require a licenced HD LEP, or mixing zone whereby the 10th and 90th percentiles will be applied to facilitate initial dilution. The 80th percentile (SMD LEP) and 90th percentile (HD LEP) are spatially displayed for wet season temperature in Figure 7-20.

Modelling by Baird (2019b) indicated that for contaminants identified within the HD LEP, at approximately 60m from the outfall, prior to the established SMD/HD boundary, the dilutions predicted for the 50th percentile case to be approximately double (59 dilutions) and for the 95th percentile case approximately five times as high (128 dilutions).

The comparison of the shape and extent of the dry season and wet season dilution contours confirms:

- the wet season cases have a larger extent compared to the dry season. This is a result of the winds that steer the surface layer further to the east; and
- the surface layer dilution contours extend across a larger area than those at the seabed. This outcome is due to the density difference that causes the plume to rise and concentrate more in the surface layers in the immediate vicinity of the outfall.

¹ Temperature contours for the 80th percentile as presented by Baird (2019b) for the wet season define the mixing zone based upon the most conservative modelled estimate of extent.

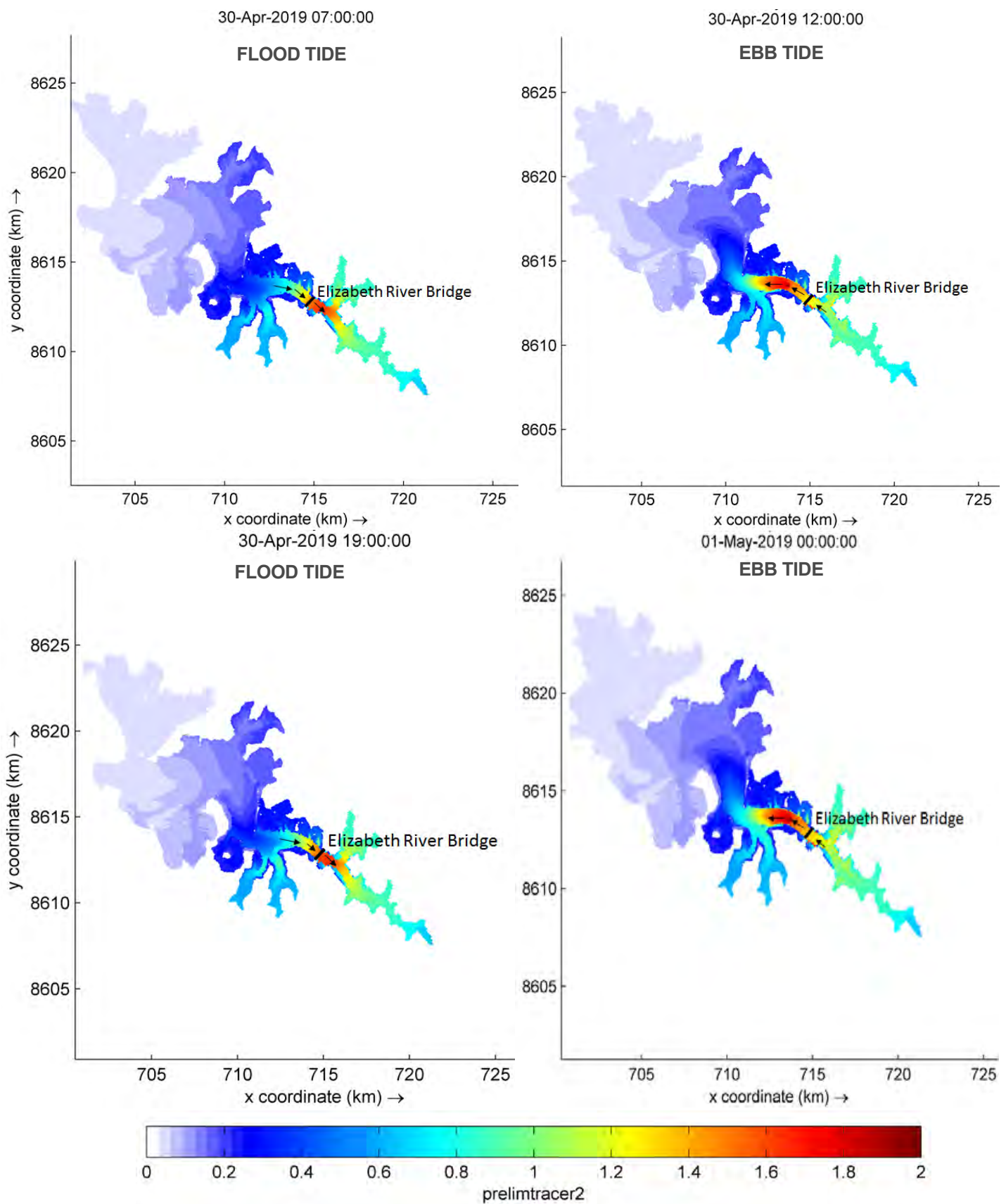


**Figure 7-18: Elizabeth River outfall plots showing plume oscillation
(Source: Baird 2019b)**

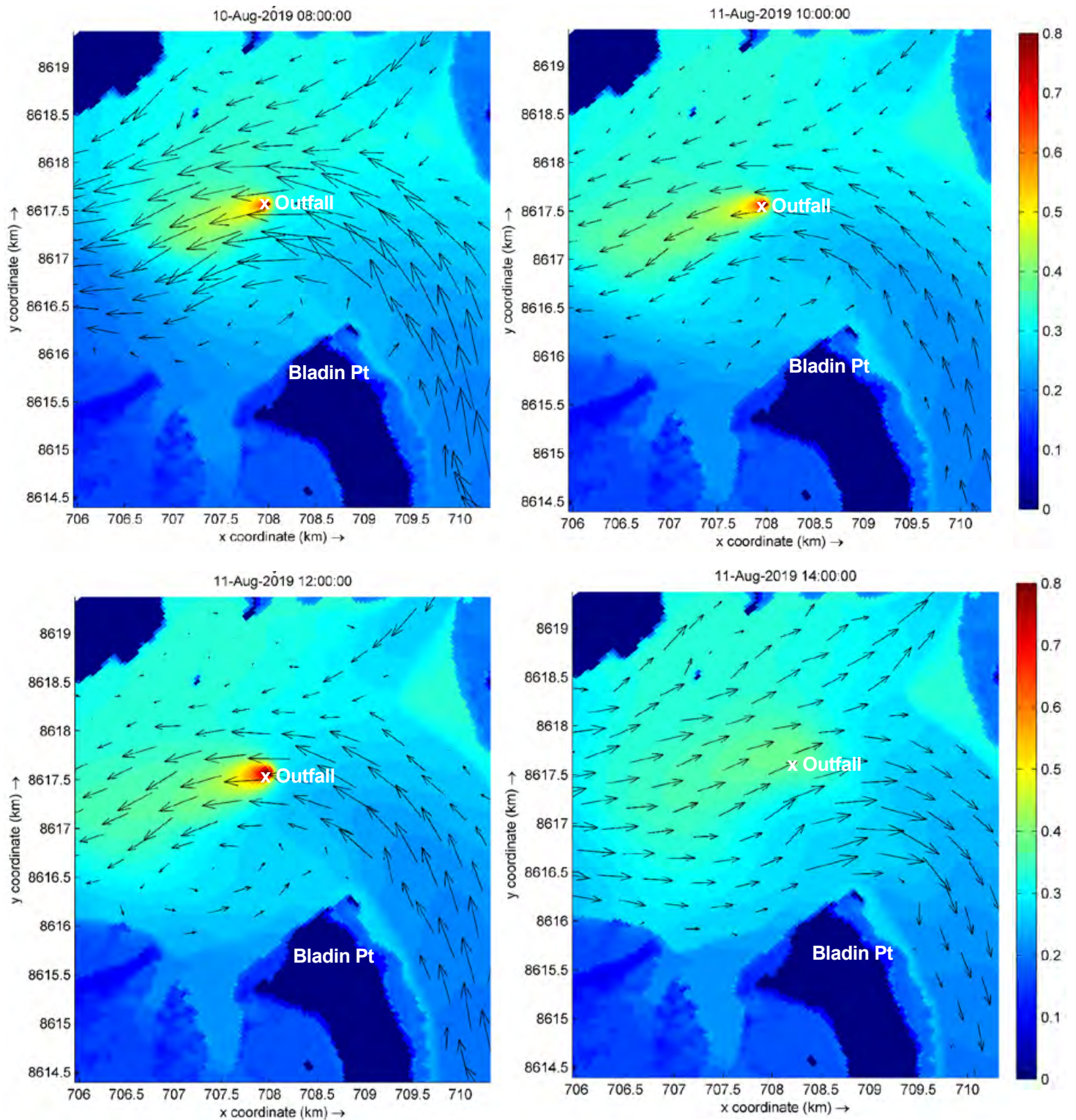


Figure 7-19: East Arm outfall plots showing dilution of discharged wastewater (Source: Baird 2019b)



Figure 7-20: 80th and 90th percentiles for temperature during the wet season

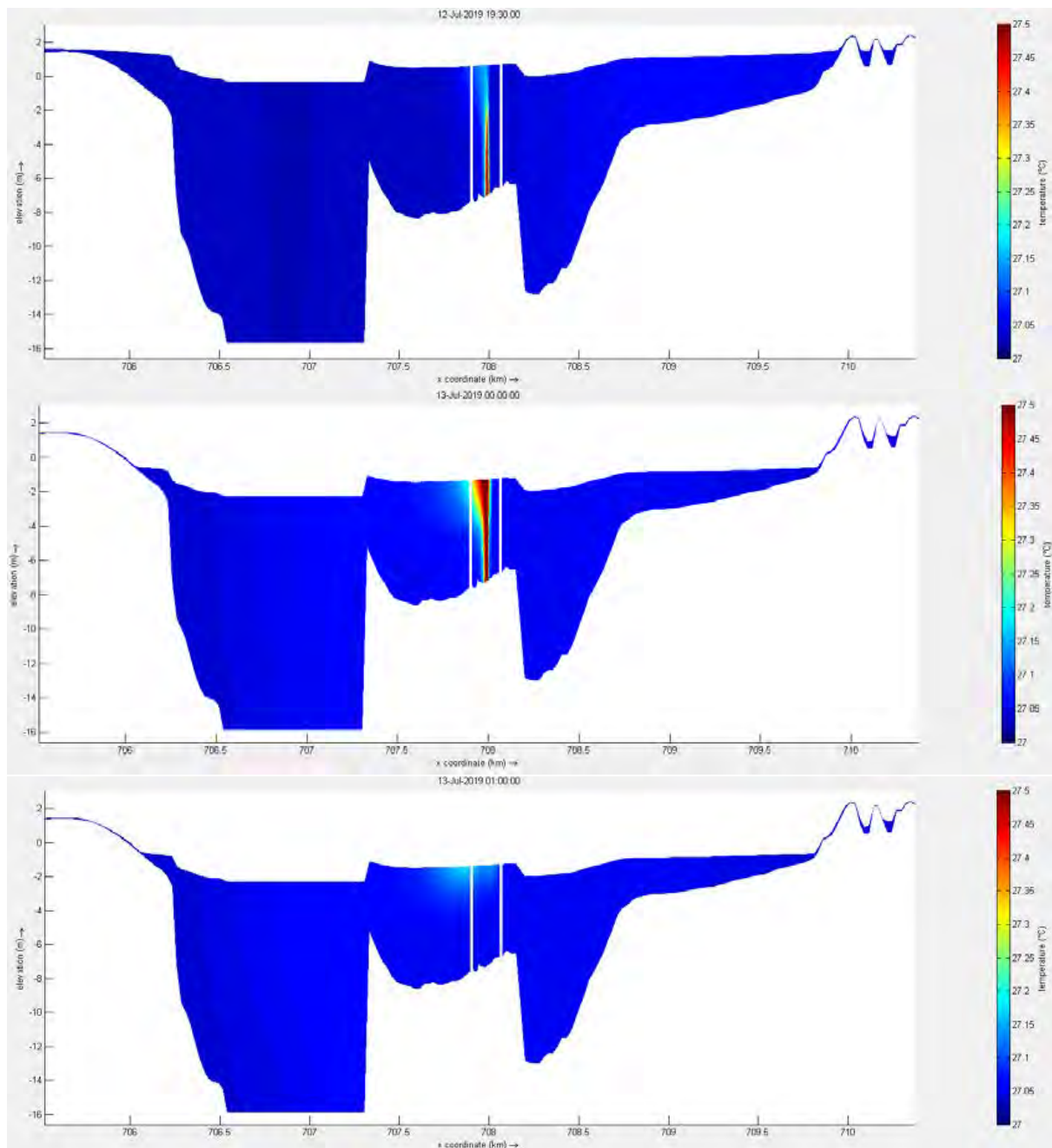


Figure 7-21: Temperature profile of cross sectional area during discharge

Stratification of the two key physico-chemical constituents within the wastewater discharge were modelled over a cross section of East Arm (Baird 2019b). Modelling indicates that stratification effects around the outfall are typically localised to the immediate area of the outfall (i.e. within the HD LEP), after which the temperature and salinity become quite well mixed through the water column (Baird 2019b).

Figure 7-21 displays the warmer water being discharged over a cycle that occurs for approximately five hours (as indicated by the first two plots, which represent commencement and just prior to completion of the cycle). The final plot represents the system approximately one hour after the discharge by which the plume has become so mixed it is almost indiscernible amongst the natural background levels within East Arm.

Analysis of the modelled tracer concentrations were completed to determine the shape and extent of the dilution contours around the outfall across the two seasonal scenarios, with the wet season showing marginally larger extents compared with the dry season. Dilution at the surface from the 3D model shows larger spatial extents compared with the bed level, due to the salinity difference of the wastewater compared to the receiving waters.

The farfield model results were analysed for the two seasonal scenarios to determine the shape and extent of the temperature and salinity plumes. The 3D model outcomes demonstrate that there is good mixing of the plume through East Arm - at the discharge location there is stratification around the immediate vicinity of the outfall, but the water column is vertically well mixed a short distance away. For both temperature and salinity, the modelled changes caused by the wastewater are within the natural temperature variance experienced within the harbour over the wet and dry season periods.

A 6-month simulation case was analysed to investigate the tracer concentration for locations upstream and downstream of the outfall in East Arm, upstream Elizabeth River and sites through Darwin Harbour. The tracer modelling showed that at locations upstream and downstream of the outfall the tracer concentration increased over time and then reached equilibrium within approximately six months. Based on the model outcomes, it is concluded that the East Arm outfall would result in an increase in the background concentration in the Harbour of the respective chemicals in the waste stream, with dilution reaching an equilibrium within approximately 6-months.

Outfall Design

CORMIX, a specialised nearfield dilution model was utilised to determine the diffuser design best suited to producing the maximum amount of mixing within the nearfield mixing zone for the outfall regime.

A range of diffuser types were examined within CORMIX including single port diffusers, multi-port diffusers and surface diffusers. A thorough modelling assessment was completed to test the range of diffuser types across a variety of design hydrodynamic cases to examine which performed best in terms of delivering the highest rate of dilution around the outfall. This determined that a single-port diffuser produced the optimal dilution rate for the site under the environmental conditions and discharge regime.

Due to the lower relative density of the wastewater plume compared to the receiving environment, as well as the sensitivity cases being run based on a 'worst-case scenario' of the lowest expected combination of water level and current velocity, the greatest plume stability was achieved with a single port diffuser, located at the bottom of the water column (i.e. seabed) discharging at 90° to the prevailing current direction and angled to discharge level with the seabed.

Detailed results of the predictive modelling undertaken by Baird (2019b) are attached as Appendix O.

Summary of Potential Impacts.

Outcomes of technical studies indicate the following:

- Quality of discharge water is good, with all Darwin Water Quality Objectives for contaminants being met at the point of discharge;
- Modelling predicts that after initial mixing within the HD LEP, background conditions are achieved prior to reaching the boundary of the SMD LEP.
- Discharge of wastewater will result in short term temperature increases and salinity decreases within close proximity to the outfall location.
- Dispersion modelling indicates that stratification will only occur within close proximity of the outfall location (~60m) and be very short in duration post discharge cycle (i.e. <60 minutes for temperature).
- Any impacts associated with stratification are expected to be minimal as the discharge is not continuous and between discharges stratification will return to normal state.

In summary, discharge of good quality treated wastewater is unlikely to impact the marine environment beyond the HD LEP, assuming mitigating measures detailed in chapter 7.7.5 are implemented.

7.7.5.2 Non-Process Waste Impacts

Impacts from non-process waste (e.g. Litter) are present in all urban and industrial areas. Waste, particularly plastics, can reduce visual amenity and water quality, thus affecting the marine environmental quality of the area.

Implementation of effective controls, such as good housekeeping and waste handling practices, are anticipated to result in negligible risk to the environmental quality of the marine environment from Project operations.

7.7.5.3 Degradation of Marine Environmental Quality through Chemical Spills

Unmanaged, poorly handled, poorly stored or spilled chemicals, such as fuel, oil, lubricants, concrete batching wastewater and process chemicals, have the ability to enter the marine environment through stormwater and groundwater pathways. Chemicals can have a wide range of effects based upon type, concentration and extent of exposure. These effects can be species specific or effect an ecosystem.

Entrainment of chemicals into the marine environment can lead to water and sediment quality issues which may result in ecological changes, including marine fauna, outside of the acceptable limits assigned to the specific area impacted.

Given the management strategies discussed in chapters 7-2 and 7-5, the proposed design of the Facility, incorporating significant hardstand and bunded areas, stormwater containment infrastructure and designated chemical storage and handling facilities, as well as an ability to detect and address spills promptly within the terrestrial environment, it is considered that the likelihood of chemicals entering groundwater or stormwater pathways and directing to the marine environment is low. The risk, however remains as a medium risk warranting ongoing management to ensure impacts do not occur.

7.7.5.4 Sedimentation of Waterways as a result of Land Based Clearing

Clearing of terrestrial vegetation and exposing underlying soils has the potential to result in increased sediment loads entering the marine environment via windblown or stormwater transportation mechanisms.

Clearing adjacent to the marine environment however is limited to a small (2 ha) area for the outfall pipeline shore crossing. Any impacts to increased sedimentation are therefore likely to be short in duration, limited to a small spatial extent and able to be effectively mitigated through appropriate site drainage and construction environmental management controls specified in the EMP (Appendix D), refer to Ground Disturbance and Vegetation Clearing (EP-05).

7.7.5.5 Disturbance of Acid Sulfate Soils

Unmanaged ASS that become exposed to the atmosphere have the potential to oxidise and become acidic. Acidification of soils can lead to contamination of soil, groundwater or stormwater which may ultimately mobilise into the marine environment. ASS have been identified in select areas within the site; it is anticipated that existence of ASS may be higher within the mangrove belt due to the tidal nature of the soil profile.

The risk of exposure of ASS as a result of outfall pipeline construction is, however, expected to be negligible as TNG propose to install the pipeline overland, negating requirements for excavation.

No dredging or excavation of the seabed floor is proposed for this Project.

7.7.6 Mitigation and management

The mitigation measures outlined in Table 7-48 will be implemented to reduce the risk of impacts on marine environmental quality as a result of Project activities.

Table 7-48: Mitigation measures for marine environmental quality impacts

Pathway	Mitigation hierarchy	Mitigation measure
Discharge of wastewater through ocean outfall	Minimise	• Outfall location to be selected based upon dispersion modelling to ensure dilutions are adequate to reduce concentrations within small mixing zone; • Implementation of Marine Environmental Quality Monitoring and Management Plan (MMEQMMP); • Develop wastewater treatment plans and quality control processes to support operation of the Processing Facility • Obtain and comply with Mixing Zone Licence Conditions • Obtain and comply with Waste Discharge Licence Conditions
Non-process waste management	Avoid	Appropriate Domestic and Industrial Waste Management Procedure (EP-14), within the EMP (Appendix D), to be implemented for the Site. • Recyclable materials, including cardboard, paper, glass, batteries, waste hydrocarbon drums and scrap metal, will be recycled wherever possible; • Housekeeping inspections of all work areas will be undertaken weekly; • Littering on site is prohibited and work and office sites are to be kept clean and tidy; • Rubbish containers are to be carried in all vehicles and provided at all work area; • Waste management will be addressed in the site induction.
Chemical Spills	Avoid	Chemical management is detailed in Terrestrial Environmental Quality (chapter 7-2).

Pathway	Mitigation hierarchy	Mitigation measure
		- Implement management procedures detailed in the EMP (refer to Hazardous Material Management Procedure (EP-13), Appendix D). - Implementation of the MEQMMP.
Sedimentation impacts from clearing	Avoid, minimise	- Limit clearing of mangrove areas to the minimal requirements. - Implement management procedures detailed in EMP (refer to Ground Disturbance and Vegetation Clearing Procedure (EP-05) Appendix D).
ASS risk from pipeline construction	Avoid	- Avoid excavation of ASS as part of the installation of the outfall pipeline. - Implement management procedures detailed in ASS Management Plan. - Should ASS be inadvertently liberated, implement protocols of the ASS Management Plan.

7.7.6.1 Marine Environmental Quality Monitoring and Management Plan

More detail on proposed mitigation measures is provided in the MEQMMP (Appendix S). The MEQMMP has been developed with consideration for outcomes of the proposed outfall location and predictive dispersion results. This comprehensive plan is designed to ensure that Project related impacts are managed within the defined spatial LEPs.

The MEQMMP has been developed specifically for this Project with the following targeted objectives:

- Define BUs and EQOs relevant to the project area;
- Spatially define LEP relevant to the Project area;
- Establish Environmental Quality Criteria (**EQC**) through determining scientifically derived limits of acceptable change to measurable Environmental Quality Indicators (**EQIs**) for each of the BUs;
- Establish protocols and procedures associated with the monitoring, management and reporting on achievement of EQOs and protection of BUs;
- Develop a risk-based monitoring framework to assess Project related impacts;
- Develop a framework to guide management response and required actions in the event established EQC are exceeded during routine facility operation; and
- Ensure collection, analysis and reporting of marine environmental quality data in a consistent and robust manner.

The MEQMMP applies the Environmental Quality Management Framework designed to achieve the objectives of the National Water Quality Management Strategy Guidelines, as described within ANZG (2018).

An overview of the framework and its application to ongoing assessment of the impacts of the Project is presented in Figure 7-22.

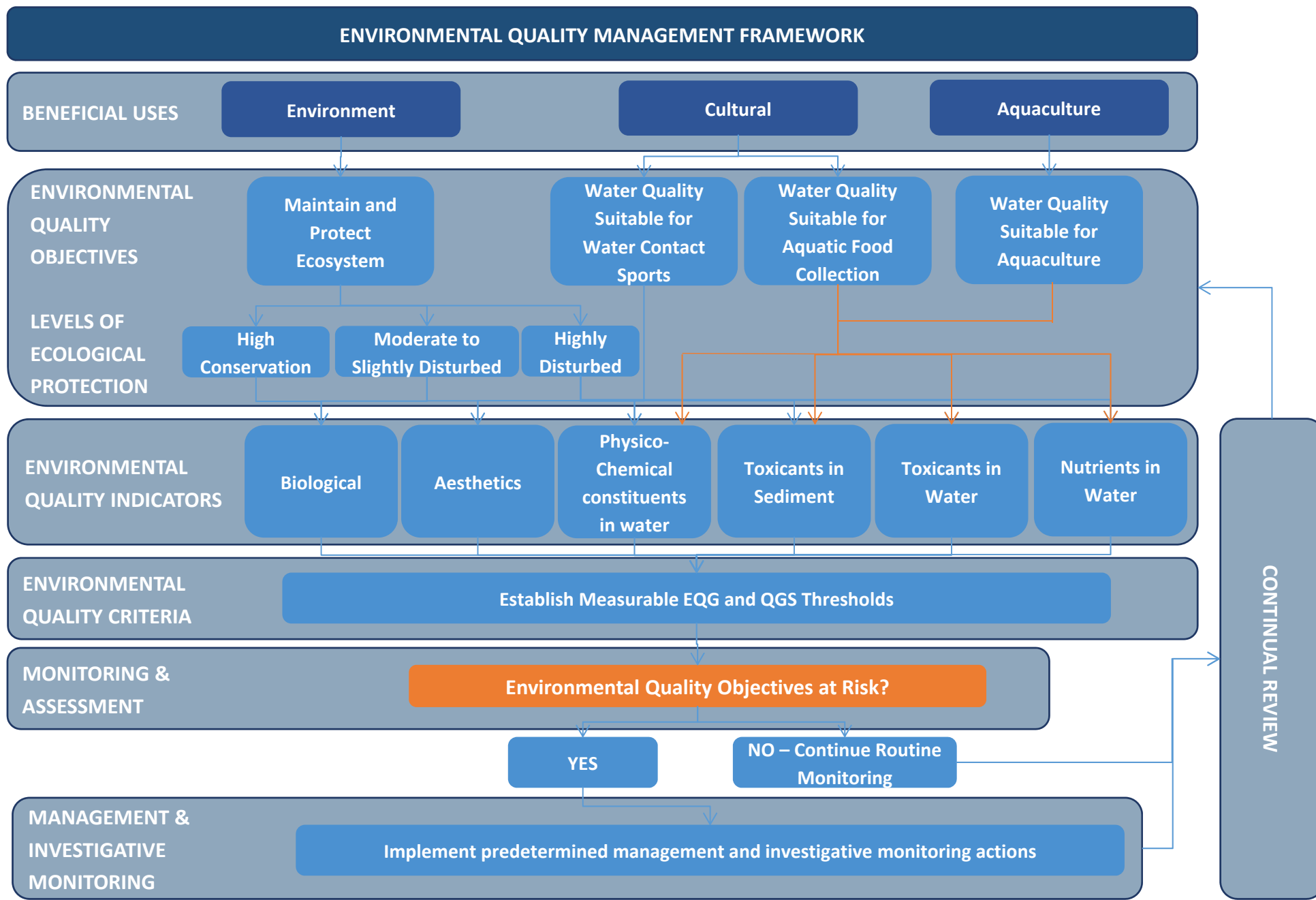


Figure 7-22: Environmental Quality Framework as applied to the Darwin Processing Facility

Risk Based Monitoring and Management Program

A risk-based monitoring and management program has been established as part of the MEQMMP. The monitoring and management program has been developed to target each specific life stage of the Project and their associated risk profiles. This process of tailoring monitoring and management provides an early detection of potential impacts and therefore allows management intervention to occur in the shortest possible timeframe, thus reducing any associated impacts.

The framework ensures the associated levels of risk for each life stage of the Project are continually monitored, reviewed and revised to confirm that implementation of the Project does not compromise the BUs and EQOs for Darwin Harbour. The monitoring and management process has been divided into four specific programs:

1. Pre-project baseline monitoring;
2. Wastewater Treatment Plant Commissioning;
3. Marine Environmental Quality Validation; and
4. Routine Operational Performance Assessment.

The processes through which risk to marine environmental quality are mitigated and managed for these four programs are described below.

Pre-Project Baseline Monitoring

This program has been developed to reduce data gaps around the uncertainty of baseline environmental quality within the defined Project area. Through the collection of baseline marine environmental quality data collection, site specific EQC can be derived in accordance with ANZG (2018) for assessment of impacts against identified EQIs. Site specific EQC are required to be developed where generic screening guidelines have been applied, such as the ANZG (2018) water quality protection levels and sediment default guideline values, within the MEQMMP.

To ensure that Project related marine environmental quality impacts are measured accurately, a sound scientific understanding of the marine environmental quality within the Project area and the establishment of site-specific EQC are a critical step.

Wastewater Treatment Plant Commissioning

The commissioning of any new plant or infrastructure is inadvertently associated with an increased risk profile due to the potential for failure, the requirement to alter initial engineering designs during application and the level of activities co-occurring. Treatment plants, due to the complex chemical, physical and often biological processes involved, take time to reach the design specifications for treated wastewater constituents.

Typically, a staggered approach is undertaken as the treatment process commences with smaller volumes and, as targets are reached, volumes increase until commissioning is complete and the design parameters are reached for typical operational water volumes.

Monitoring and management during this phase is targeted specifically on wastewater quality being discharged to ensure it meets the specifications used for the predictive dispersion modelling. This requires flow rates and wastewater discharge quality to be monitored throughout the commissioning phase, with management triggers set as the maximum instantaneous flow rate and 100% of the design specifications for wastewater constituents.

If at any time during commissioning monitoring identifies an elevation above the assigned management triggers the processes summarised in Figure 7-23 are to be implemented, reducing the likelihood of re-occurrence. Through this process of identifying faults and implementing corrective and preventative actions the risk profile from treated wastewater discharge post-commissioning is minimised.

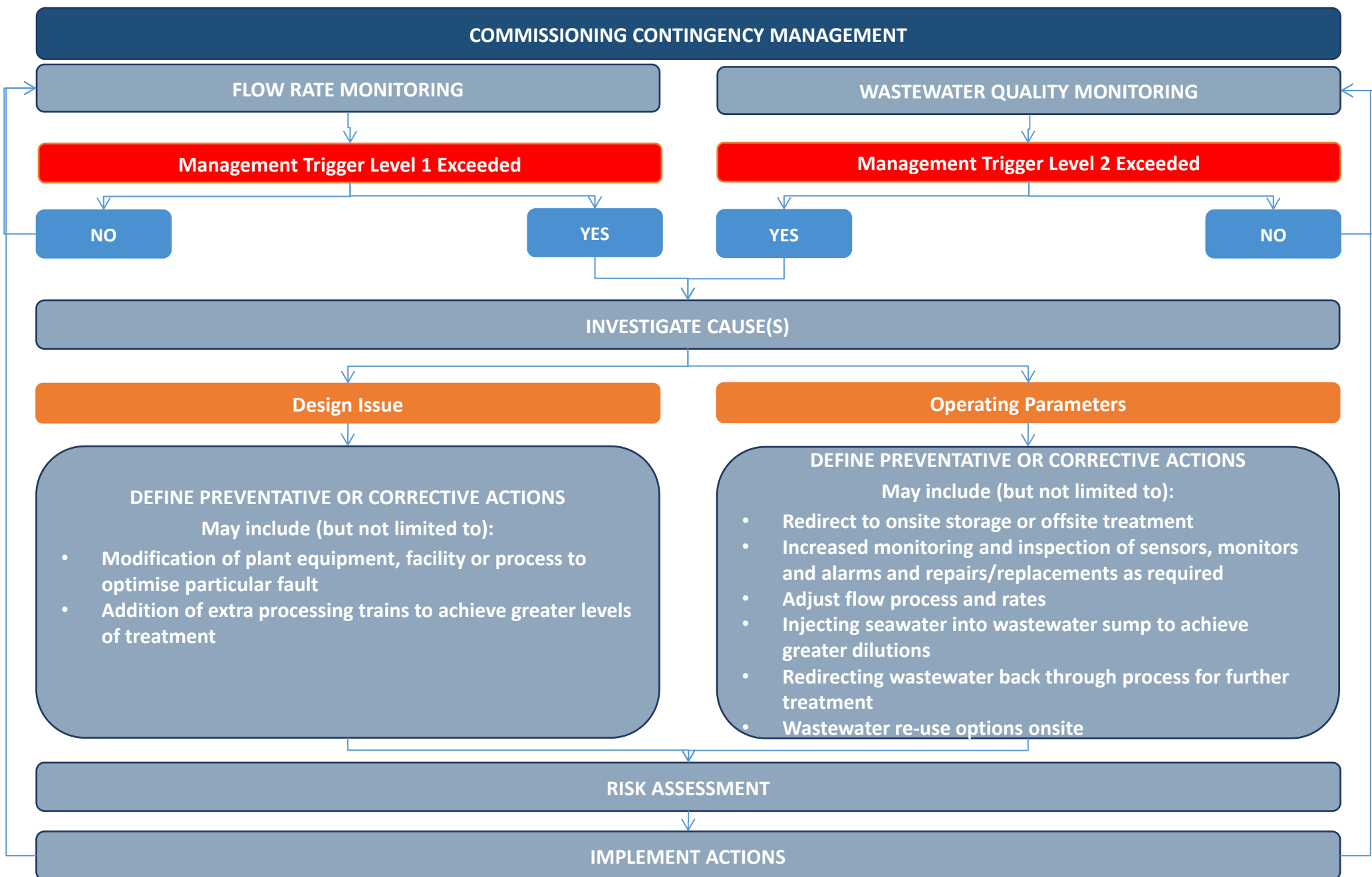


Figure 7-23: Contingency management action for the commissioning phase

Marine Environmental Quality Validation

Validation of the marine environmental quality is considered an extremely important step in the overall process of ensuring the risk profile of wastewater discharges remain within the level of acceptable change assigned to each LEP. The primary aim of the validation monitoring program is to ensure that predicted impacts are within the levels assessed for post-commissioning operations.

Prior to this stage, all assessment has been based upon the current level of understanding of the Project risk profile and the receiving environment through modelling or application of previous learning from similar Projects. Through the implementation of this program the actual risk profile will be determined, and predictive assessment and modelling validated. To ensure marine environmental quality is accurately validated, the following monitoring programs have been defined:

- Whole Effluent Toxicity testing to determine actual discharge toxicity;
- Effluent validation monitoring to characterise the wastewater discharge against design; and
- EQC and modelling validation monitoring within each LEP and at the boundary between the HD and SMD, where the designated mixing zone ends.

For specific information regarding each of these testing programs refer the appended MEQMMP.

Validation Monitoring Performance Assessment

Three levels of management triggers have been developed for assessment of environmental performance results; prompting appropriate management actions to ensure any elevated result is investigated and mitigating strategies implemented. The first two management triggers are as per the commissioning phase, with the third based upon assessment against the defined EQGs.

Figure 7-24 displays a summary of the contingency management framework for the Marine Environmental Quality Validation monitoring and management process.

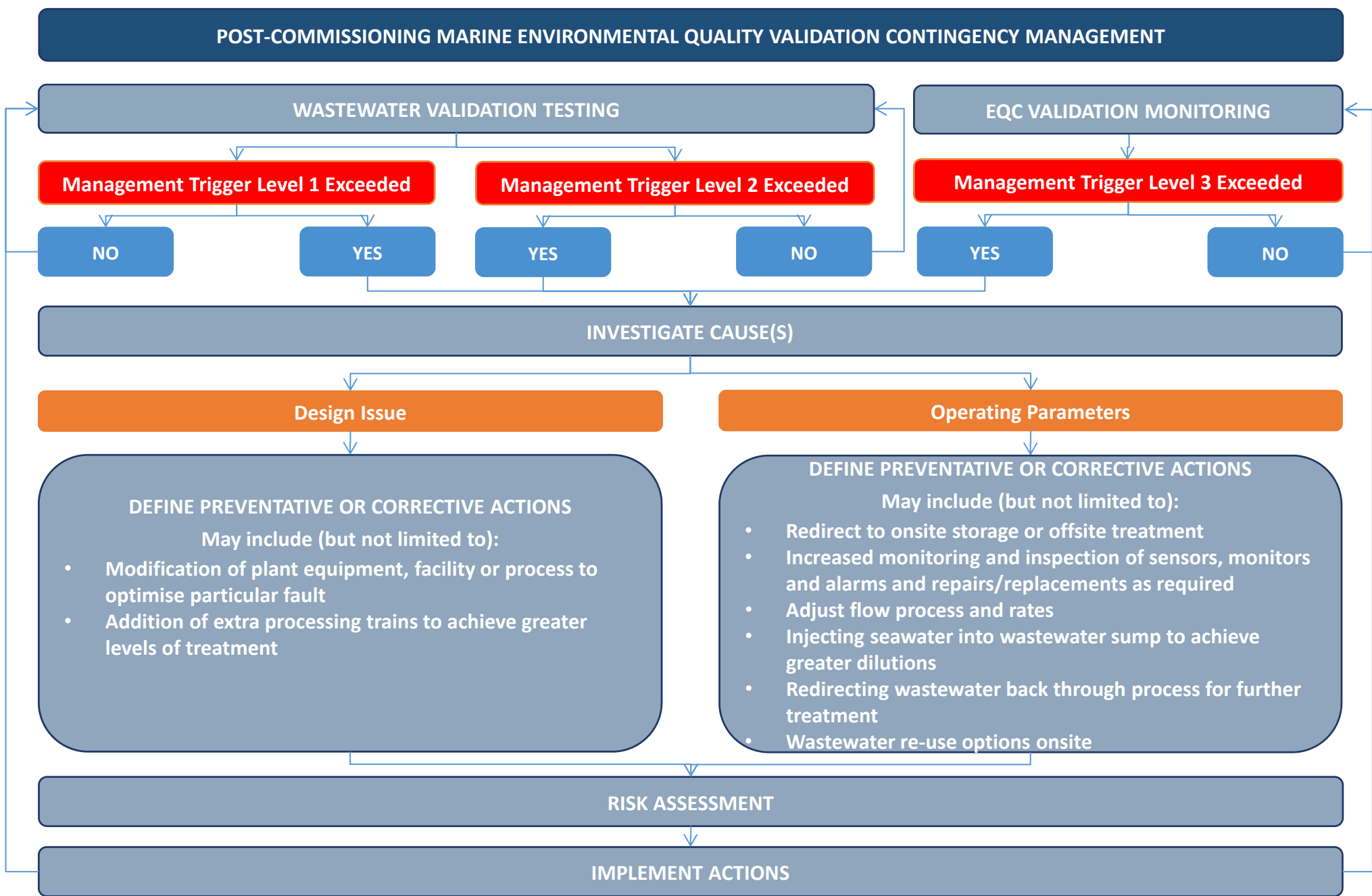


Figure 7-24: Post commissioning wastewater quality validation contingency management

Routine Operational Performance Assessment

The final monitoring and management program is designed to monitor and mitigate impacts from the wastewater outfall over the lifecycle of the Project. To assess if marine environmental quality impacts are within the defined EQC assigned to each LEP, two ongoing monitoring and management programs have been established:

1. Routine assessment of discharge wastewater quality against WWTP design specifications; and
2. Ongoing marine environmental quality monitoring to ensure that potential impacts from operational activities are occurring within the limits of acceptable change allocated within each spatial LEP.

The first program aims to ensure that the treated wastewater parameters continue to be within the design specifications of the treatment plant. As this was validated against the EQC in the previous phase, if there is no deviation from discharge water quality or volume then the probability of impacts above the LEP is highly unlikely.

Whilst it has been determined as unlikely to result in an elevation above EQC if the discharge water quality is maintained, the ongoing marine environmental quality monitoring has been designed to address the possibility over the lifecycle of the Project. The contingency management for the ongoing phase is summarised in Figure 7-25 and Figure 7-26.

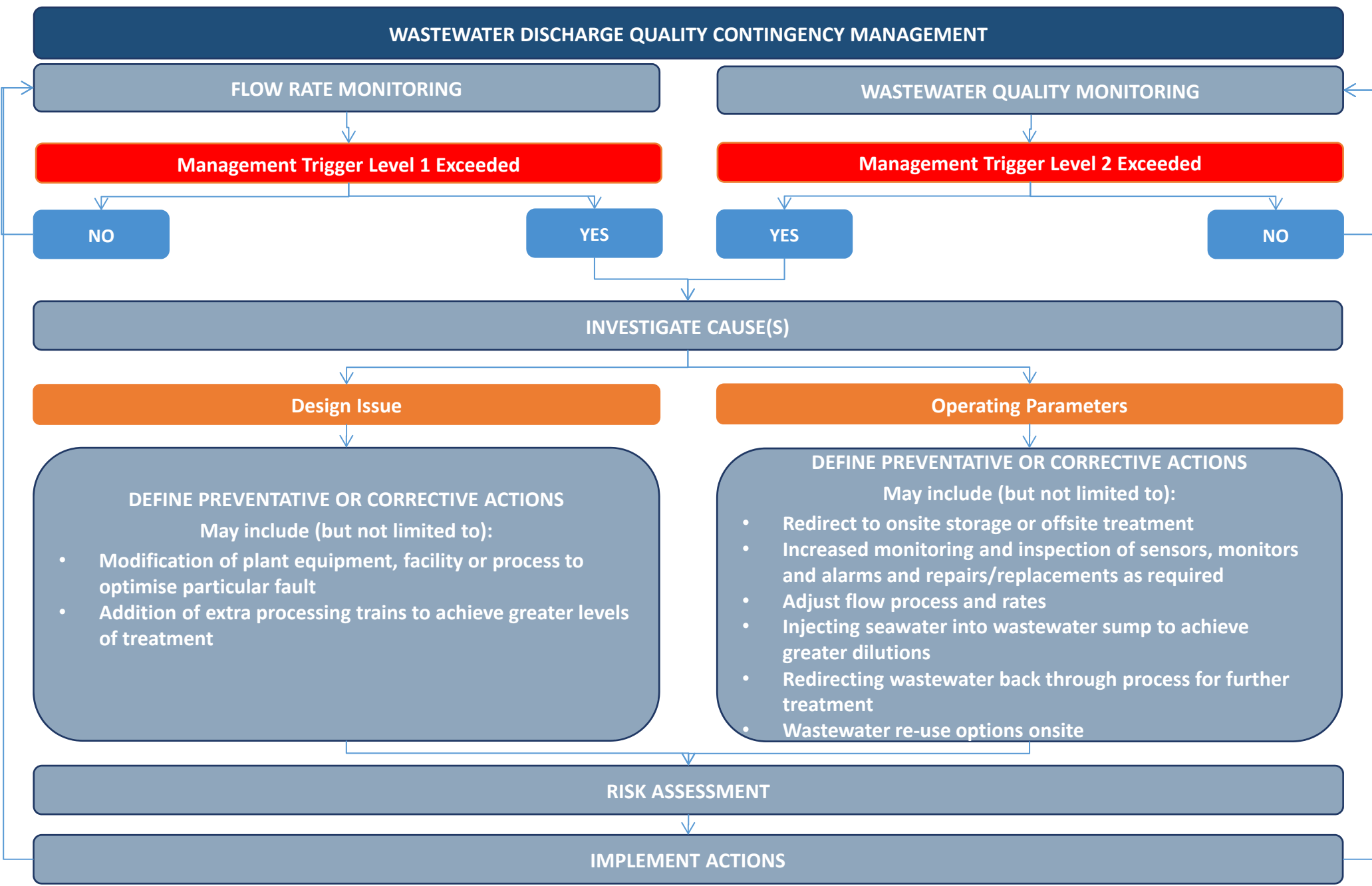


Figure 7-25: Contingency management framework for routine wastewater discharge quality

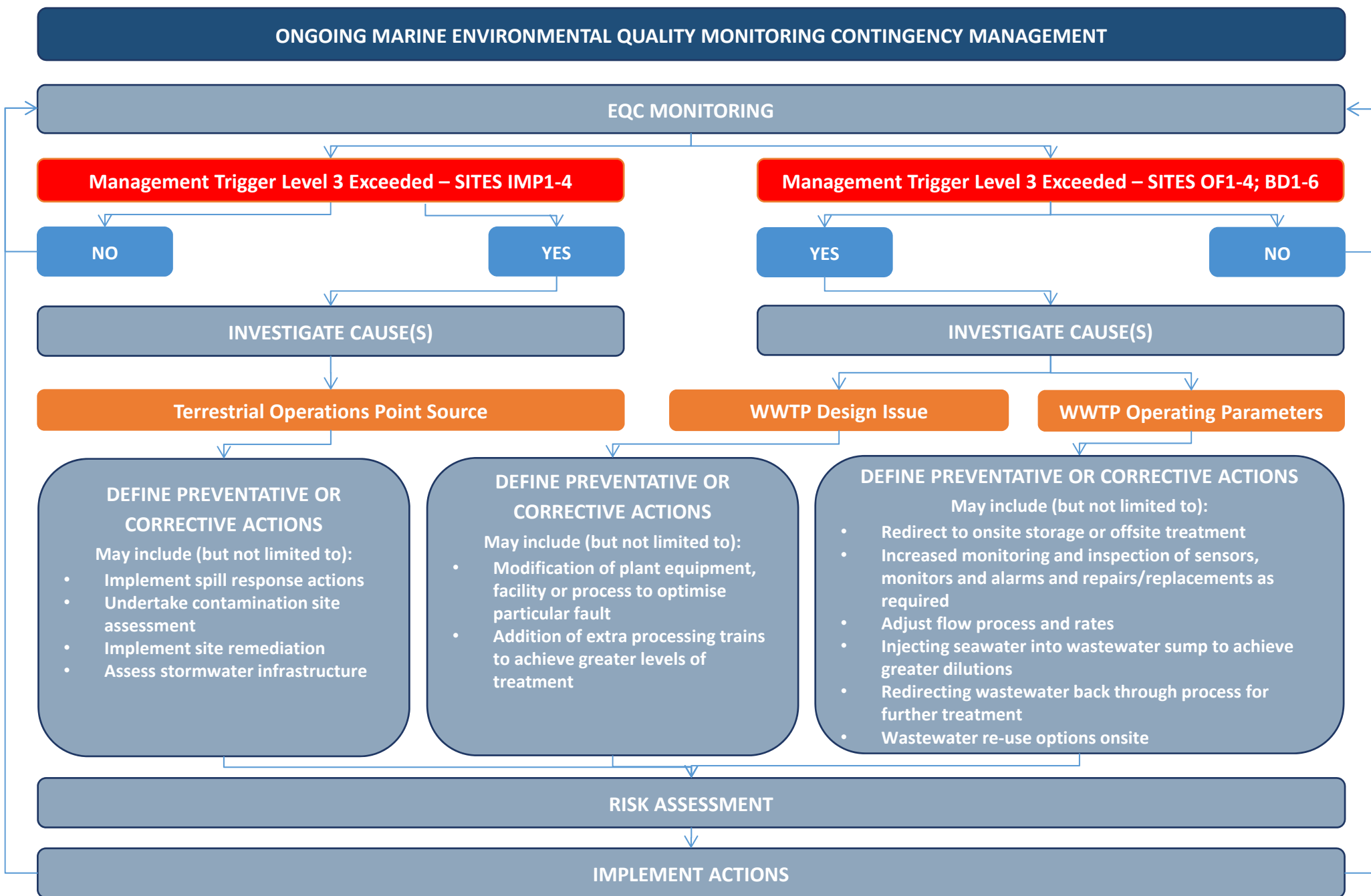


Figure 7-26: Contingency management framework for Ongoing Marine Environmental Quality Monitoring

7.7.7 Monitoring and reporting

The monitoring programs detailed above use appropriately selected EQIs with associated EQC. The EQC are separated into two levels to allow assessment of Project impacts against the EQIs. This process is presented within Figure 7-27. EQC are defined for both LEPs and are comprised of Environmental Quality Guidelines (EQGs) and more robust Environmental Quality Standards (EQS), as defined below:

Environmental Quality Guidelines: EQG are threshold numerical values or narrative statements which if met, indicate that there is a high degree of certainty that the associated EQO has been achieved. If the EQG is not met, then there is uncertainty as to whether the associated EQO has been achieved, and a more detailed assessment against an 'Environmental Quality Standard' (EQS) is triggered. This assessment is risk-based and investigative in nature.

Environmental Quality Standards: EQS are threshold numerical values or narrative statements that indicate a level beyond which there is a significant risk that the associated EQO has not been achieved and a management response is triggered. The response would normally focus on identifying the cause/source of the exceedance and eradicating or reducing the contaminant of concern.

In the first instance the monitoring program collects data to allow a comparison with the 'screening' levels defined as EQGs. If the monitoring data assessed is within the defined EQGs then the EQIs are considered to be under no threat and no further investigative monitoring is required at that point. However, if any EQG is exceeded a process of investigative monitoring commences as defined within Figure 7-27, with results compared against EQS until the full extent of the impact is understood and appropriate management and reporting can be undertaken.

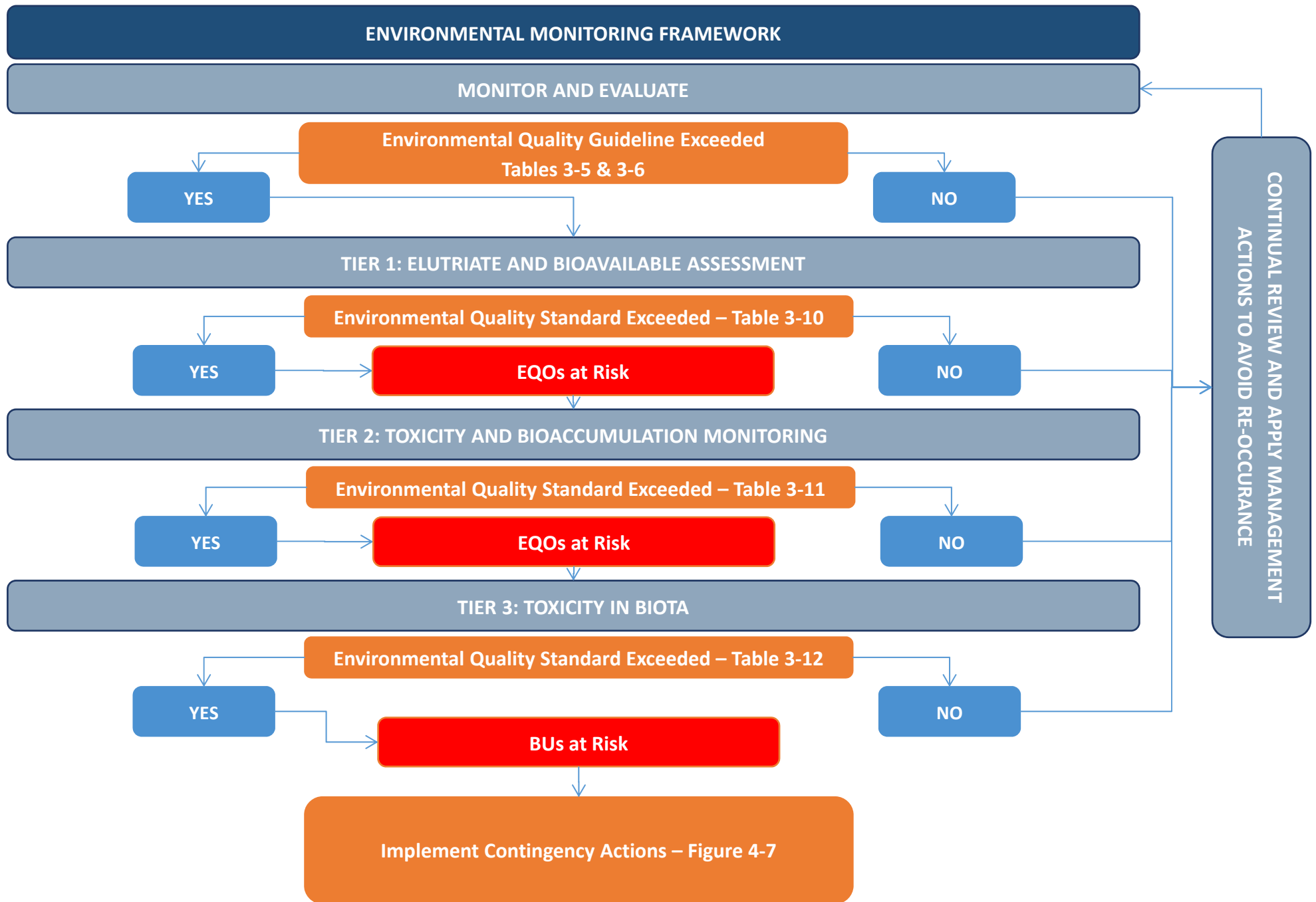


Figure 7-27: Environmental Monitoring Framework including elevation points when certain EQC are exceeded

The MEQMMP includes the monitoring programs as defined within Table 7-49. For a detailed sampling design, timing and methodology description refer to the MEQMMP attached as Appendix Q.

Table 7-49: Ongoing marine environmental quality monitoring components

Monitoring Component	Action	Parameters	Criteria
Water Quality Monitoring	Physico-chemical profiling	TSS DO Salinity Temperature pH	EQGs
	Water Sampling	Nutrients Chlorophyll a Metals Hydrocarbons Salts Organics	EQG
Sediment Quality Monitoring	Sediment Sampling	Metals Hydrocarbons Salts Organics	EQGs
Temporal Water Quality	Physico-chemical profiling	TSS DO Salinity Temperature pH	EQS
	Water Sampling	Nutrients Chlorophyll a Metals Hydrocarbons Salts Organics	EQS
Investigative Sediment Analysis	Sediment Elutriate and Bioavailability Assessment	Metals Organics	EQS
	Sediment Bioaccumulation and Toxicity Assessment	Metals Organics	EQS
Marine Fauna	Observational Monitoring	Faunal deaths	EQS
	Benthic Infauna	Species diversity Species abundance	EQS
	Intertidal Invertebrates	Species abundance No. burrows	EQS
Aesthetics	Observational Assessment	Odour Visible oil/grease Surface slicks/rubbish	EQS

Monitoring sites have been positioned to allow collection of data to facilitate assessment of impacts within spatially defined LEPs from the treated wastewater outfall and from terrestrial project related activities. Table 7-50 presents a summary of the sampling locations and Figure 7-28 presents them spatially.

Table 7-50: Ongoing marine environmental quality monitoring sampling locations, descriptions and justification for the sites

Site Name	Site Reference	Level of Ecological Protection	Justification
OF1-4	These four sites are located within the HD LEP positioned at equal distances from the diffuser to the north, east, south and west.	HD	Locations selected to assess the dilution of wastewater within the HD LEP to confirm compliance with defined EQC.
BD1-4	These four sites are located along the boundary between the HD and the SMD LEPs equidistantly positioned along the entire boundary typically representing the north, east, south	SMD	Locations selected to assess MEQ at the boundary of the mixing zone and the SMD LEP to confirm compliance with defined EQC.
IMP1-4	These four sites are located in the marine environment directly adjacent to the project envelope.	SMD	Locations selected to assess potential groundwater or stormwater impacts from land-based Processing Facility activities within the defined SMD LEP to confirm compliance with defined EQC.
REF1-4	REF 1 & 2 are located within East Arm in location unaffected by the discharge as identified by predictive modelling (Baird 2019). REF 3 & 4 are located within Elizabeth River upstream and downstream of the Project in similar environments.	SMD	REF 1 & 2 are reference sites for the outfall monitoring component located in sites comprising similar depths, tidal influence and background marine environmental quality. REF 3 & 4 are reference sites for the operational impact monitoring component located at comparable sites within the Elizabeth River.



Figure 7-28: Ongoing Marine Environmental Quality Monitoring sampling locations

Additional monitoring and reporting proposed to protect the marine environmental quality adjacent to the Project area is detailed in Table 7-40.

Table 7-51: Additional monitoring, inspections and reporting for marine environmental quality

Relevant Plan	Procedure (if relevant)	Monitoring/Inspections	Reporting
Environmental Management Plan	NA	Daily inspection of high-risk locations, including to identify any new risks / unmanaged risks.	Monthly Environmental Performance Report Half Year Report
	Water Management Procedure (EP-10)	Weekly inspection of swales and sediment traps.	Annual Report and Performance Review
	Domestic and Industrial Waste Management Procedure (EP-14)	Weekly housekeeping inspections at all works areas.	Volumes of waste material and recycled material will be reported via the Annual Report. Inappropriate waste disposal will be reportable as an incident and reported as per the TNG incident reporting processes.
	Hazardous Material Management Procedure (EP-13)	Daily monitoring to ensure site is cleared of waste, all POL/chemicals have been stored and disposed of correctly, and all spills have been identified and dealt with (see Daily Inspection Checklist) Regular inspection of bunds, where present, to check integrity and to detect leak and spills (see Weekly Inspection Checklist) Regular inspection of stormwater drains for any sediment capture (see Weekly Inspection Checklist)	Reporting for the Annual Report will include the volume of controlled wastes moved off site; All incidents will be reported in the Annual Report. Any site that requires notification or reporting to the NT EPA under the <i>Waste Management and Pollution Control Act 1998</i> .
Erosion and Sediment Control Plan		Weekly inspection of erosion and sediment controls during the wet season.	Monthly Environmental Performance Report

7.7.8 Statement of residual impact

Implementation of the Project in accordance with the defined mitigation, management and monitoring protocols will result in the following estimated residual impacts:

- Designation of a spatially defined HD LEP, or licenced mixing zone, required to provide a zone where initial dilution of wastewater discharge can occur prior to meeting the 20th or 80th percentile of natural background conditions. This is defined as the boundary between the HD and SMD LEPs as presented in Figure 7-13;
- Application of EQC, as defined within the MEQMMP, for the HD LEP nominally defined as the 10th or 90th percentiles of natural background conditions;
- Application of the EQC, as defined within the MEQMMP, for the SMD LEP nominally defined as the 20th or 80th percentiles of natural background conditions for all waters outside of the HD LEP; and
- Short term, highly localised stratification of the water column parameters salinity and temperature during and post discharge. Whilst this is a residual impact, the impact of this altered marine environmental quality on the systems they support is not considered to be significant or above the levels of species protection assigned to the HD LEP.

Based upon the above assessment no further residual impacts are considered to present from implementation of the Project if managed in accordance with defined management and monitoring programs.

TNG LIMITED

DRAFT ENVIRONMENTAL IMPACT
STATEMENT

DARWIN PROCESSING FACILITY

**ENVIRONMENTAL
FACTOR: BENTHIC
HABITAT AND
COMMUNITIES**

7.8 ENVIRONMENTAL FACTOR: BENTHIC HABITAT AND COMMUNITIES

7.8.1 NT EPA Objective

The NT EPA's objective for the factor Benthic Habitat and Communities is:

Protect benthic communities and habitats so that biological and functional diversity and ecological integrity are maintained.

Benthic Habitat and Communities (**BHC**) refers to biological communities that live in or on the seabed. These communities typically contain light-dependent taxa such as algae, seagrass, mangroves and corals, which obtain energy primarily from photosynthesis, and/ or animals such as molluscs, sponges and worms, that obtain their energy by consuming other organisms or organic matter.

Benthic habitats are the seabed substrates that benthic communities grow on or in. They can range from unconsolidated sand to hard substrates such as limestone or igneous rock and occur either singly or in combination.

The objective recognises that marine benthic communities are important components of almost all marine ecosystems and are fundamental to the maintenance of ecological integrity and biological diversity of the marine environment as a whole. In the context of this objective, ecological integrity is the composition, structure, function and processes of ecosystems, and the natural variation of these elements.

This chapter describes the existing BHC adjacent to the Project area, including Elizabeth River and East Arm, and identifies potential Project related impacts and risks. Mitigation and management activities required to ensure these risks do not result in unacceptable impacts to BHC are presented. This chapter also details the proposed monitoring and reporting requirements to determine if mitigation and management methods are adequate and presents the assessment of residual risk for the Project.

The content of this chapter has been developed specifically to address section 3.1 of the EIS TOR (Appendix A).

7.8.2 Technical Studies

Technical studies undertaken to support the assessment of BHC appear listed in Table 7-42.

Table 7-52: Benthic habitat and communities studies undertaken for the Project

Date	Study Title	Consultant	Description	Report
2019c	Benthic habitats and communities	O2 Marine	Baseline assessment of BHC in that may be affected by the Proposal	Appendix S

7.8.3 Existing Environment

Benthic habitat and communities play important roles in maintaining the integrity of marine ecosystems and the ecological services they supply. There is strong evidence that the presence of benthic communities can be important for the maintenance of biodiversity through provision of structurally complex and diverse habitat, provision of refuge, and increased food supply. Some of these complex habitats are important recruitment and nursery areas for many marine fauna species and may also provide essential food resources for large marine

mammals, such as dugongs and turtles. Benthic primary producer habitats form the foundation of many marine food webs which, in turn, support productive and economically important fisheries. They also attenuate wave and current energy which helps protect shorelines and coastal infrastructure.

Darwin Harbour is an extensive estuary with over 286 km² of open water (depending seaward boundary) and 38 km² of intertidal flats with three major arms fringed by some of the largest and floristically diverse mangrove communities (Wightman 2006). The harbour is a poorly flushed, semi-diurnal and macro-tidal system with a maximum spring tidal range of 7.8 m (Wang et al. 2011). Tropical monsoons provide seasonal freshwater inflows and increased sediment loads. Darwin Harbour is situated within a region recognised for its relative pristine condition (Halpern et al. 2008).

Existing mapping of intertidal and subtidal BHC have been reviewed and validated through ground-truth field investigations undertaken to improve knowledge and understanding of the BHC that may be impacted by the Project. Further desktop review has been undertaken to provide an assessment of the diversity, distribution, ecological role and environmental value of intertidal and subtidal BHC occurring within the Study Area.

The Study Area was originally proposed to consider Outfall Case 1 (Figure 7-17) located within, or immediately adjacent to, the Elizabeth River, and the assessment of BHC was spatially defined as extending approximately 5 km either side of the Development Envelope to the mouth of the Elizabeth River. However, Outfall Case 2 was subsequently selected for the proposal to improve mixing of discharge wastewater as simulated in numerical modelling, with the pipeline route for Outfall Case 2 extending out the mouth of the Elizabeth River and into the centre of East Arm estuary.

The outer boundary of the Study Area for this investigation was subsequently expanded comprising intertidal and subtidal habitat extending approximately 10 km either side of the Development Envelope to the mouth of East Arm, between East Arm Wharf and Wickham Point as shown in Figure 7-29.

The spatial extent of the historical map shapefile and validation fieldwork undertaken for the subtidal BHC assessment was restricted to the original Study Area within the Elizabeth River. An additional subtidal BHC map and desktop review of associated field investigations were subsequently used to inform the assessment of subtidal BHC for the broader Study Area in East Arm for Outfall Case 2 (Figure 7-30). The diversity and distribution of subtidal BHC is therefore presented in two sections: Elizabeth River and East Arm.

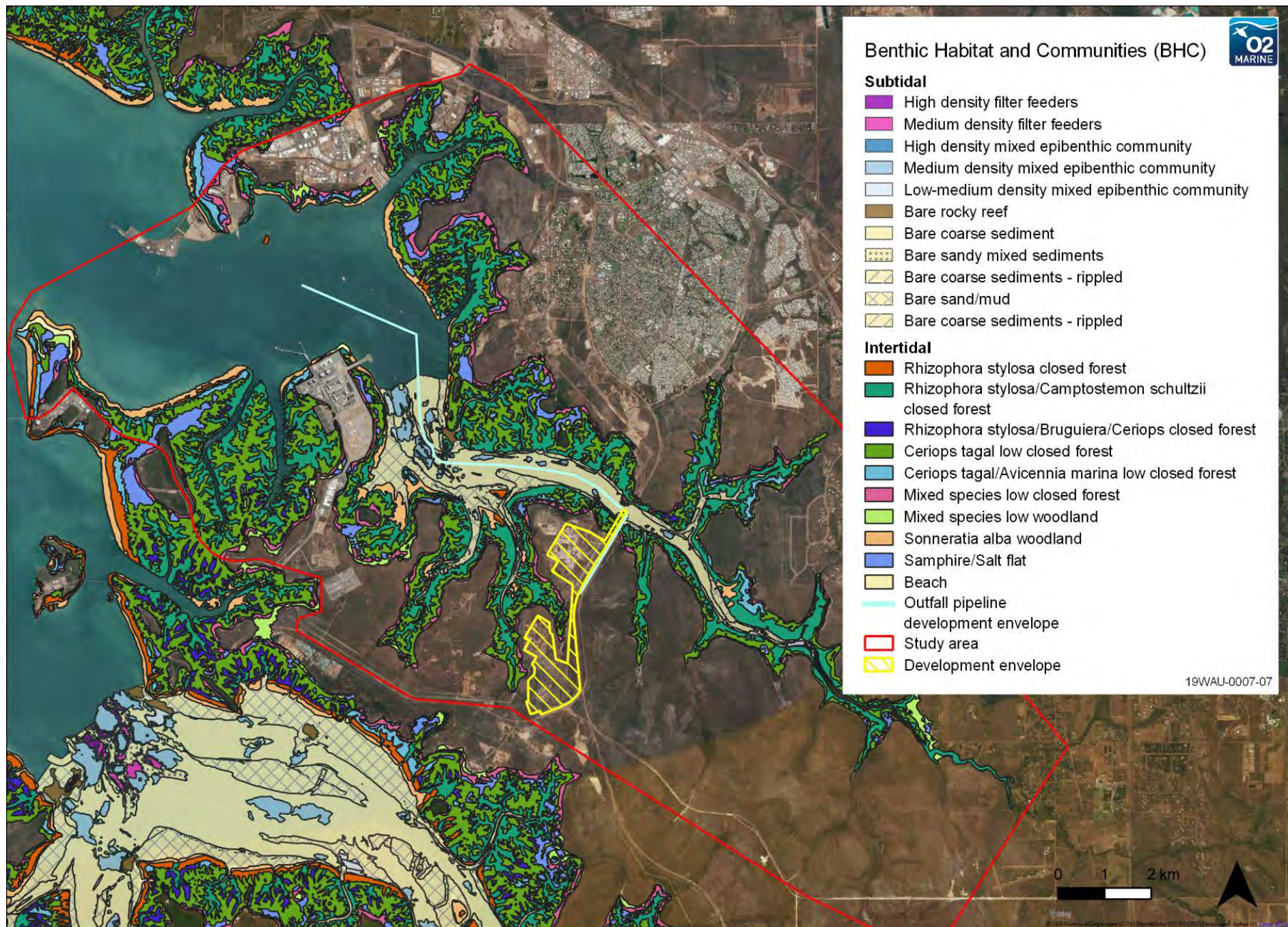


Figure 7-29: The Project Development Envelope, the Study Area and the mapped intertidal and subtidal BHC

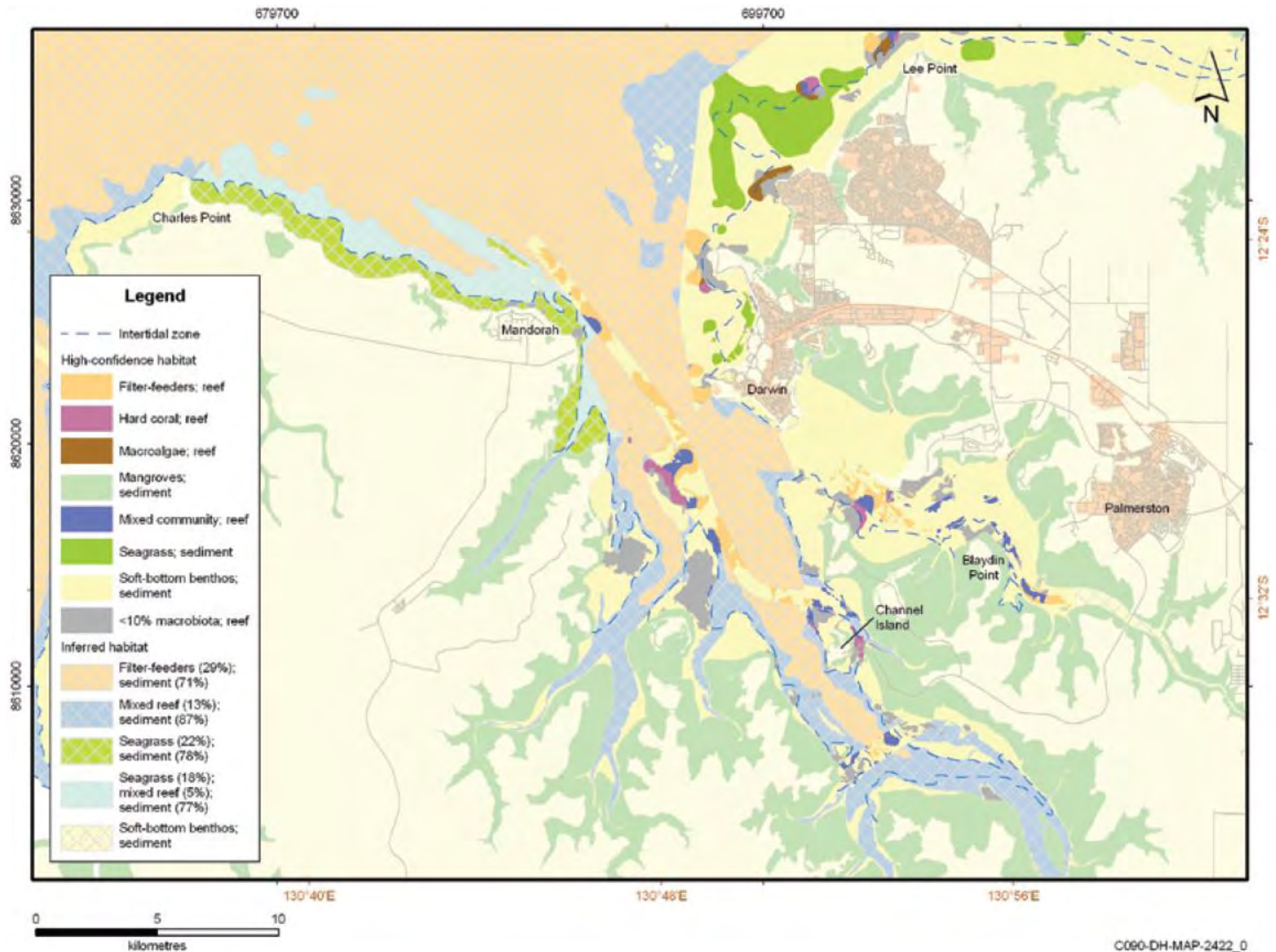


Figure 7-30: BHC mapping of Darwin Harbour prepared for the Ichthys Project (Source: Geo Oceans 2011a)

7.8.3.1 Intertidal Benthic Habitats and Communities

In 1994, as part of the National Forest Inventory, the Northern Territory Government undertook a detailed survey of Darwin Harbour intertidal BHC (Brocklehurst & Edmeades 1996). This detailed study mapped 12 intertidal BHC classifications, 10 of which were mangrove associations and the remaining two classes were Salt Flats and Beach. The classifications, total area for each intertidal BHC and relative composition mapped within the Study Area is presented in Table 7-53.

Table 7-53: Mapping unit classifications, total area and relative composition of intertidal benthic habitat and community within the study area

Habitat Code	Mapping Units*	Common Name	Study Area (ha)	Composition (%)
1	<i>Rhizophora stylosa</i> closed forest	Shoreline forest	40	<1%
2	<i>Rhizophora stylosa</i> / <i>Camptostemon schultzei</i> closed forest	Tidal creek	1,564	34%
3	<i>Rhizophora</i> / <i>Bruguiera</i> / <i>Ceriops</i> closed-forests	Transition	20	<1%
4	<i>Ceriops australis</i> low closed forest	Mid tidal flat	1,710	37%
5	<i>Ceriops australis</i> / <i>Avicennia marina</i> low closed forest	High tidal flat	130	3%
6	Mixed species low closed forest	Hinterland margin	367	8%
7	Mixed species low woodland	Low woodland	97	2%
8	<i>Sonneratia alba</i> woodland	Seaward	251	6%
9	<i>Rhizophora stylosa</i> low woodland	Islands, rocky shore	-	-
10	Low open woodland	Low tidal mudflat	-	-
11	Samphire/salt flat	Salt flat	383	8%
12	Beach	Beach	26	<1%
Total			4,587	100%

*From Brocklehurst & Edmeades 1996

Mangroves

The mangroves in Darwin Harbour are amongst the most floristically diverse in Australia, with 36 species covering an area of approximately 20,400 ha, which constitutes ~5% of mangrove habitat in the NT (Brocklehurst & Edmeades 1996). The floristic diversity and extent of mangroves in Darwin Harbour are a significant feature contributing to Commonwealth listing of this area in the Directory of Important Wetlands in Australia (DEE, 2019) and the Northern Territory Government listing as a Site of Conservation Significance (NRETAS 2019).

The mangrove communities of Darwin Harbour show pronounced shoreline zonation parallel to the coast associated with topographic elevation (or regime of tidal inundation). The pattern of zonation generally evident in Darwin Harbour is shown in Figure 7-31. Tidal inundation, rainfall, soil water, groundwater seepage and evaporation all influence soil salinity and have a profound effect on mangrove growth and distribution forming the distinct zonation observed in mangrove communities (Semeniuk 1983; 1985). Figure 7-31 shows the dominant mangrove zones of the Tidal flat and *Rhizophora* zone in Darwin Harbour comprise ~40% and 33% of intertidal BHC, respectively. These zones comprise a similar proportion of the Study Area as shown in Table 7-53 of 40% and 35%, respectively.

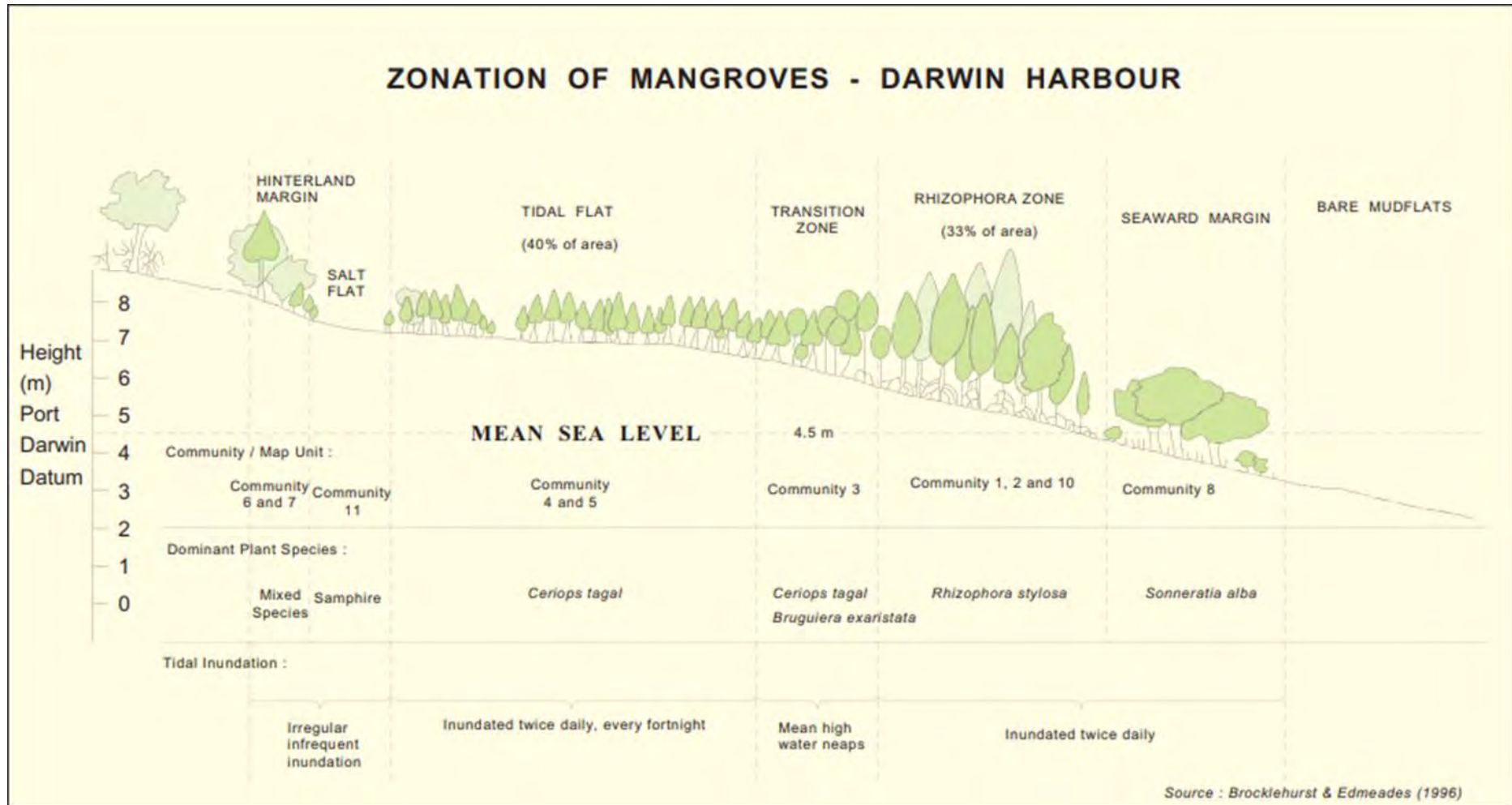


Figure 7-31: Schematic profile diagram of the typical pattern of mangrove zonation in Darwin Harbour

*This shows the predictable sequence of mangrove assemblages from landward to seaward (L to R). The percentage of the total mangrove area, tidal elevation (AHD or Australian Height Datum) and inundation frequency is also indicated. (Brocklehurst & Edmeades 1996).

Eight of the 10 mangrove associations have been identified and mapped within the Study Area; comprising a total of 4,178 ha (~91%) of intertidal BHC and ~20% of mangrove habitat within Darwin Harbour. Tidal flat (Map Unit 4) and Tidal Creek (Map Unit 2) are the dominant mangrove assemblages mapped within the Study Area, contributing ~71% intertidal BHC. These assemblages generally occur across the broadest sections of the intertidal zone. Comparably, Map Unit 6 and Map Unit 8 on the Hinterland and Seaward margins respectively comprise ~14%. The Shoreline forest (Map Unit 1), Transition (Map Unit 3), High tidal flat (Map Unit 5) and Low woodland (Map Unit 7) mangrove associations are interspersed between other dominant assemblages collectively forming only 7% of the intertidal BHC within the Study Area.

The Tidal flat (Map Unit 4) is the most widespread community, forming a monospecific *Ceriops australis* closed forest, low closed forest and open-forest; comprising 1,710 ha or 37% of the intertidal BHC in the Study Area. It occurs in mid and high tidal flat regions and hinterland regions. Tree canopy heights are small (2-6 m) although occur at high density collectively forming high canopy cover. The High tidal flat (Map Unit 5) is similar to Unit 4 with the primary difference being a greater presence of *Avicennia marina*. This unit comprises 130 ha or 2.8% of intertidal BHC in the Study Area in small pockets adjacent to the hinterland margin. The canopy cover, and tree density is generally less, although *A. marina* trees are typically larger with greater biomass.

Rhizophora stylosa closed-forest is also common, encompassing 1,564 ha (~34%) of intertidal BHC within the Study Area. The Tidal creek (Map Unit 2) assemblage occurs along protected tidal creeks and the seaward fringes of the main tidal flat from mean sea level to mean high water neaps (4-6 m LAT), which represents much of the habitat along the Elizabeth River. *Rhizophora stylosa* may be co-dominant or locally dominant with *Camptostemon schultzei* and *Bruguiera parviflora*. *Aegiceras corniculatum*, *Aegialitis annulata*, *A. marina*, *Xylocarpus mekongensis* and *Bruguiera gymnorhiza* may also commonly occur. The canopy cover, height and tree density are generally high from this zone. Tall monospecific stands of *Rhizophora* closed-forest also occur, backing stands of *Sonneratia alba* in more exposed areas of East Arm. This Shoreline forest (Map unit 1) composes only 40 ha or <1% of the intertidal BHC within the Study Area. This is typically the tallest assemblage where dispersed trees are separated by stilt roots forming a large stand basal area, with higher canopy cover than the Tidal creek.

A Transition assemblage (Map Unit 3) is found within the Study Area forming a narrow zone between the *Rhizophora* Zone (map units 1 & 2) and the Tidal flat (map units 4 & 5) in the broader mangrove assemblages near the mouth of East Arm towards Whickham Point; it comprises ~20 ha, or <1% of the intertidal BHC within the Study Area. *Rhizophora stylosa*, *Bruguiera exaristata* and *A. marina* are dominant, with *C. australis* and *A. annulata* included in the composition of lower canopy layers.

Two mixed species mangrove assemblages occur on the Hinterland Zone: a low closed forest (Map Unit 6) and a low woodland (Map Unit 7). Map Unit 6 occurs on the Hinterland margin as a narrow band on the landward side of the mangrove zone comprising 367 ha or 8% of the intertidal BHC in the Study Area. The Hinterland margin is typically dominated by reasonably *C. australis*, with *Lumnitzera racemosa*, *Excoecaria ovalis* and *B. exaristata*. The canopy cover and height is relatively high (i.e. *C. australis* taller in this zone than map unit 4) at a moderate density. Within the Study Area there are three small discrete stands of Low woodland (map unit 7) at Whickham Point, East Point and in the upper reaches of Elizabeth River, comprising only 97 ha or 2% of intertidal BHC. The assemblage is considered similar to the Hinterland margin although trees are generally smaller and more widely dispersed, occurring on salt flats or rocky gravelly substrate.

The Seaward margin (Map Unit 8) extending into the mudflats is generally open forest/woodland dominated by *S. alba*, whilst *R. stylosa*, *A. marina* and *A. corniculatum* may be common. This assemblage is generally found within the Study Area as the seaward community in more exposed areas towards the mouth of the Elizabeth

River and into East Arm, comprising a total of 251 ha or 6% of intertidal BHC. The large diameter *Sonneratia* trees are typically tall and generally hollow, although widely dispersed between *A. corniculatum* thickets.

Studies conducted in Darwin Harbour have estimated the productivity of mangroves through the collection and measurement of leaf litter fallen from particular areas over time (Metcalf 1999) and estimates of the standing above-ground biomass (the amount of living matter present) (DLRM 2013). The leaf litter rates are typically highest near the Seaward margin in *Sonneratia* trees and decline onto the Tidal flat, although increase to moderate rates again on the Hinterland margin. Leaf litter rates range from 3.9 tonnes per hectare per year (t/ha/yr) (Mid-tidal flat) to 12.6 t/ha/yr (Seaward). Conversely, the above-ground biomass rates range from 5 t/ha (Seaward) to 346 t/ha (Shoreline forest), where the biomass is regulated by a combination of tree size (basal area and height) and density. Productivity estimates indicate the Study Area represents approximately 21-23% of mangrove productivity within Darwin Harbour.

Mangroves are a diverse group of phylogenetically disparate trees and shrubs which have been separated into discrete assemblages within the Study Area. These plants have evolved to exploit the land-sea interface under conditions generally low in oxygen and highly saline that would severely stress other plants. They exist in tropical and subtropical coastal ecosystems worldwide. Their diverse assemblages form communities that provide a profound array of ecosystem services to estuarine and coastal habitats. Some of the key services mangroves provide include:

- stabilisation of coastal foreshores and habitats – both from coastal erosion and by moderating discharge loads from the terrestrial environment;
- incorporation of carbon and primary biomass to the estuary;
- provision of a substrate for epiphytic and periphytic flora and fauna;
- provision of three-dimensional habitats and ecosystem services to a multitude of fauna;
- the abundance of associated fauna are important areas for commercial fisheries, popular areas of community activities such as recreational fishing and birdwatching; and
- have cultural significance of historical use.

Salt flats

Salt flats are found in *Ceriops* forests (map unit 4) or adjacent to the hinterland and are generally devoid of vegetation with hypersaline soils, although in some instances may contain samphire species (Brocklehurst & Edmeades 1996). Small discrete areas of samphire/mudflats are found in the Elizabeth River adjacent to the Development Envelope on the mid to high intertidal zone, with larger salt flats located on the north side of the river mouth and Whickham Point, comprising a total area of 383 ha or 8% of the intertidal BHC within the Study Area.

Brocklehurst and Edmeades (1996) suggested salt flats may be significant areas in terms of primary productivity for the marine ecosystem. However, these flats are generally considered important where there are extensive areas of low lying salt flats with a cyanobacterial crust that contributes to primary production. The small areas of salt flat with no notable algal mat community in the Study Area are not considered to provide a significant contribution of phytoplankton or nutrients to the marine ecosystem of Darwin Harbour.

Beach

The Beach mapping unit is located at Bladin Point and Wickham Point adjacent to existing LNG plants, comprising 26 ha or <1% of intertidal BHC within the Study Area. The majority of this habitat located behind Seaward

mangroves (Map unit 8). The beaches mapped in the Study Area are not used for recreational purpose and are not identified as significant habitat for marine turtles or migratory bird species.

7.8.3.2 Subtidal Benthic Habitat and Communities

Previous studies of subtidal BHC within Darwin Harbour describe a complex assemblage of marine habitats consisting of hard corals, filter feeder, macroalgae, seagrass, a mixed reef community and soft sediment communities, with large differences in the extent, diversity and significance of the biological communities inhabiting them. Much of the benthic substrate of the lower intertidal zone of Darwin Harbour is described to be comprised of extensive mud flats interspersed with some areas of basement rock that may have a thin covering layers of sand or mud.

As described in chapter 7.8.2, the characterisation of subtidal BHC in the Study area is presented in two separate sections; Elizabeth River and East Arm.

Elizabeth River BHC

The subtidal BHC in the Middle Arm/Elizabeth River region was mapped by Smit et al. (2012) using 12 subtidal BHC categories. These classifications were based predominantly on six variables identified as the most important factors that contribute towards explaining the spatial distribution of BHC: latitude, longitude, backscatter, mean depth, planar curvature, and benthic position index (BPI 100 square radius). This was followed by an assessment of the relative contribution of the physical parameters to predict biotic variables and key parameters and taxa using aggregated boosted trees and boosted regression trees. The final community maps were created by using previous benthic habitat data collected by BMT WBM (2010) and the Marine Biodiversity Group overlaid onto the modelled species maps.

The mapped distribution of BHC within Elizabeth River prepared by Smit et al. (2012) was reviewed for this investigation and field validation works were conducted using a combined methodology of Acoustic Sidescan Sonar to identify consistent habitat features and Remotely Operated Vehicle (**ROV**) to ground-truth areas of interest based on identified features. The classifications, total area and relative composition for each subtidal BHC mapped within the Elizabeth River is presented in Table 7-54.

Table 7-54: Habitat classifications, total area and relative composition for each subtidal BHC within Elizabeth River

Habitat Code	BHC Classifications*	Study Area (ha)	Composition (%)
1	High Density Filter Feeders	0.4	<0.1%
2	Medium Density Filter Feeders	2.8	0.3%
3	High Density Mixed Epibenthic community	6.0	0.6%
4	Medium Density Mixed Epibenthic community	68.5	7.3%
5	Low-Medium Density Mixed community	18.1	2.0%
6	Bare Rocky Reef	8.8	0.9%
7	Bare coarse sediments	377.3	40.4%
8	Bare Sandy / Mixed sediments	10.5	1.1%
9	Bare Coarse sediments – rippled	28.2	2.2%
10	Bare sand / mud	404.2	44.3%
Total		925	100%

*From Smit et al. (2012)

Elizabeth River and the substrates of associated creeks include intertwining channels, ridges, reef edges, large extents of flats and many sand banks. The seabed BHC is predominantly mapped as Bare sand and mud (either flats/bars) (404 ha or 44%) and Bare coarse sediment (377 ha or 40%). Bare sand and mud (either flats/bars) occur on the intertidal zone to the LAT typically characterised by flat, bare and mobile muds or sand with occasional infauna (e.g. polychaetes, gastropods and bivalves) or mobile fauna (fishes, gastropods, crabs, prawns and shrimp). ROV imagery collected on the intertidal flats also identified microphytobenthos on the surface substrate. Bare coarse sediment describes a bare and mobile coarse sediment substrate with rocky outcrops and medium to high rugosity habitat in the aphotic zone (i.e. little to no sunlight). The diversity of associated fauna community is variable with occasional filter feeder habitat where rocky outcrops occur, although cover is typically low where these communities are present.

Towards the mouth of the Elizabeth River is a series of broad scale depressions in front of and north of Short Islet with complex bathymetry showing numerous rocky outcrops (i.e. narrow crests and depressions). These rocky outcrops represent filter feeder and mixed communities of varying density. Occasional rocky outcrops were also observed throughout the Elizabeth River and at the mouth of Slack Creek. Filter feeder habitat comprises only 0.3% of subtidal BHC within Elizabeth Creek and describes a medium to high rugosity reef or reef patches with moderate to high cover of heterotrophic non-photosynthetic epifauna consisting of sponges (encrusting & erect), azooxanthellate gorgonians and soft corals, ascidians and hydroids.

Mixed epibenthic communities contribute approximately 10% of mapped BHC within Elizabeth River; 2% at low to medium density, 7.5% at medium density and <1% at high density. The community is similar to filter feeders but occurs in the photic zone and includes photosynthetic epifauna such as hard corals, macroalgae, sponges and soft corals. The diversity of the community is generally representative of the density classification, although hard corals were not observed to occur in imagery of any mapped mixed epibenthic communities.

Bare rocky reef describes hard substrate within the intertidal zone which typically has little faunal association. Two areas on the north side of Elizabeth River occur upriver at the bridge and bordering Short Islet, comprising <1% of the subtidal BHC. Only small cover mapped as Bare Sandy/Mixed Sediments (1.1%) and Bare Coarse Sediments-Rippled (2.2%) occur within Elizabeth River. These communities are characterised by generally bare substrate and low fauna diversity and abundance if present.

The complex BHC towards the mouth of Elizabeth River is identified as an area of importance within the mapped unit. This section of Elizabeth River has protected small patches of hard substrates amongst larger areas of mobile sediments, which area more likely to be influenced by fresh water influx during the Wet, and more readily accumulates organic matter. However, these subtidal hard substrate reefs are likely to be less diverse and attract different assemblages than similar habitat in East Arm, which is evidenced by the mapped presence of additional mapping classifications for Darwin Harbour in Table 7-55. The benthos on these substrates may also be quite variable between seasons due to the freshwater flow during the Wet.

East Arm BHC

The subtidal BHC for all of Darwin Harbour, with focussed effort on East Arm, was undertaken by Geo Oceans (2011a). This mapping effort collated all existing data sources and undertook a range of targeted surveys to produce a total known-point dataset of available habitat data in Darwin Harbour. The known-point data were used to improve the resolution and accuracy of the existing subtidal BHC maps to quantify the spatial distribution of the biological communities and substrates found in Darwin Harbour. East Arm is mapped as a “high confidence” indicating areas that were surveyed with adequate data, whereas much of Darwin Harbour outside East Arm was mapped as “inferred habitat”.

Geo Oceans used the INPEX habitat classification scheme to combine the data and reclassify data from different sources, which was adapted from a national habitat classification scheme (Mount et al. 2007) and developed in consultation with the Department of Natural Resources, Environment, the Arts and Sport (NRETAS). The BHC of East Arm are defined using eight broad biological community classes which are presented with the total area and relative composition for each subtidal BHC in Table 7-55 and the distribution of these classes are presented in Figure 7-30.

Table 7-55: Community classifications, total area and relative composition of subtidal BHC within “high confidence” areas of Darwin Harbour

Habitat Code	BHC Classification	Description (area = 10 m ²)	Area Mapped “high confidence” (ha)	Relative Composition (%)
1	Filter feeders	>10% cover, >25% hard substrate	1,258	5.7%
2	Hard coral	>10% cover, > 25% hard substrate, <5 m depth	219	1.0%
3	Macroalgae	>10% cover, >25% hard substrate, <5 m depth	134	<1%
4	Mangroves	Removed as discussed in chapter 7.8.3.1		
5	Mixed community	Coral, macroalgae, filter feeder >10% cover, >25% hard substrate, <5 m depth	433	2.0%
6	Seagrass	>1% cover, <25% hard substrate, <5 m depth	1,734	7.9%
7	Soft-sediment benthos	<25% hard substrate	16,377	74.8%
8	<10% macrobiota	<10% cover, >25% hard substrate	1,749	8.0%
Total			21,904	100%

* from Geo Oceans (2011a)

A total of 16,377 ha (~75%) of subtidal BHC within “high confidence” mapped areas of Darwin Harbour, including East Arm, consists of soft bottom benthos communities living in unconsolidated sediments. The surficial sediments and thicker sediment deposits comprise of fluvial muds (i.e. clays and silts) sands and gravels with finer fractions becoming more dominant in the intertidal zones and in areas of more sheltered waters.

Comprehensive surveys of soft-bottom communities near Bladin Point and Wickham Point generally found low bioturbation (~10 burrows/m²) and a low abundance of animals and plants, typically consisting of sea whips and algal turfs (URS 2010). Benthic infauna sampled near Bladin Point identified ~18-20 individuals from up to 16 taxa within a 0.15 m² grab. The taxa were primarily composed of Amphipods (~30%) and Polychaetes (~27%).

The hard substrate comprises ~17% of the mapped area and consists of outcropping bedrock (reef) that varies in rugosity. The deeper exposed reef substrates are dominated by filter feeding communities composed of gorgonian fans and sea whips (family Gorgonia), soft corals (family Alcyonica) and sponges which thrive on the food provided by the strong currents and highly turbid waters. These filter feeder communities are predominantly located west of East Arm Wharf and in Elizabeth River, comprising ~6% of subtidal BHC within “high confidence” mapped areas of Darwin Harbour.

Small communities of hard corals (1%) are found in the shallow subtidal and intertidal reefs mixed with the filter feeder communities. Only two reefs mapped as hard coral occurs on the outer border of the Study Area; at the eastern edge of a rock platform extending from Wickham Point and at South Shell Island. These platforms

support a 10-20% cover of massive Faviids, laminar *Turbinaria peltata* and *Goniopora* colonies with lower composition of *Mycedium* spp. and small branching *Acropora* spp.. Sponges, soft corals (*Dendroephythya* spp.) hydroids, gorgonians (sea fans and sea whips) and crinoids were common and dominant in deeper areas (> 1.5 m LAT). Up to 123 species of hard corals have been recorded in Darwin Harbour (Wolstenholme et al. 1997), although subsequent studies have reported 44 hard coral species from five sites: Channel Island, South Shell Island, Weed Reef and two mixed platforms north of Bladin Point. Only nine species were recorded from Bladin Point mixed assemblages, 22 species from South Shell Island and 29 species and up to 50% cover at Channel Island (URS 2010).

The BHC mapped as mixed community and <10% macrobiota occurs adjacent to Bladin Point, East Arm Wharf and Wickham Point, comprising ~2% and ~8% of mapped area in Darwin Harbour, respectively. URS (2010) describes detailed surveys of these communities within East Arm. The mixed and <10% macrobiota communities adjacent to Bladin Point describe low to moderate faunal cover of soft corals (mainly *Sarcophyton* spp. and *Dendronephthya* spp.) where hard substrate is present, together with zoanthids, sponges (laminar, digitate and barrel), bryozoans, hydroids and sea squirts. At deeper sites where hard pavement is less exposed the faunal community typically comprised sea fans, seawhips, sea pens and large sponges, whilst on shallower areas (0 m LAT) mixed community platforms were dominated by green algae. The steel barge, Kelat wreck and five Catalinas (World War II flying boats) were also surveyed and observed to exhibit heavy growth cover of mixed community with a low abundance of solitary hard corals (URS 2010).

All seagrass BHC is located at the entrance and outside Darwin Harbour between Fannie Bay and Casuarina Beach comprising ~8% of mapped area. No seagrass or other epifauna were recorded growing in the sediments around East Arm.

The taxonomic groups and marine communities described in this section are well represented throughout marine environments of the Anson-Beagle Bioregion (NRETAS 2007c). The complex benthic habitats between Wickham Point and East Arm Wharf identify the most significant area of subtidal BHC within East Arm.

7.8.4 Potential impacts and risks

Development of the Darwin Processing Facility has the potential to impact BHCs. Table 7-56 uses the Source – Pathway – Receptor model to identify potential impacts to BHCs. The individual pathways are detailed in Table 7-56 below.

Table 7-56: Potential impact pathways for benthic habitat and communities

Source	Pathway	Receptor
Construction activities	Installation of the discharge pipeline between the terrestrial and subtidal environment.	Intertidal Benthic Habitat and Communities
	Installation of the sub-sea discharge pipeline.	Subtidal Benthic Habitat and Communities
Operations activities	Processing discharge water.	Benthic Habitat and Communities
	Chemical leaks or spillage.	
	Non-process waste.	
	Stormwater and sediment runoff	

7.8.4.1 Installation of discharge pipeline

The original subsea outfall pipeline proposed (Outfall Case 1) was planned to discharge directly adjacent to the Project area into the Elizabeth River. However, numerical modelling results of the produced water discharge indicated marine water quality target objectives would not be achieved at the Outfall Case 1 location and an alternative location (Outfall Case 2) was proposed which requires extending the pipeline route into the centre of East Arm estuary.

The discharge pipeline installation will result in small areas of direct impact on intertidal and subtidal BHC within a disturbance footprint which is either directly underlying the pipeline on the sea/riverbed or where mangroves will be removed along the intertidal zone of the pipeline Development Envelope. The mapping investigation of intertidal and subtidal BHC was evaluated to determine the most appropriate route which will avoid potentially significant direct impacts to BHC of significant ecological value.

Particular attention was paid to avoiding impacts on mangrove communities and areas of subtidal benthic complexity with hard substrate communities towards the mouth of the Elizabeth River. The area of estimated direct impact on the intertidal and subtidal BHC from the discharge pipeline is described below. The potential for indirect impact risk during construction on BHC from installation of the discharge pipeline is also discussed.

Installation of the discharge pipeline is not expected to have a significant impact on BHC within the Study Area.

Intertidal BHC

A small area of 2.0 ha of intertidal BHC adjacent to the existing railway and vehicle bridge will be removed for construction of the discharge pipeline. This is comprised of clearing the following intertidal BHC (Table 7-57) based on map units presented above in Table 7-53.

Table 7-57: Area of intertidal BHC proposed for removal

Map Unit	Description	Area (ha)	Percentage of Unit
6	Mixed species low closed forest Hinterland margin	1.53	0.41
4	<i>Ceriops australis</i> low closed forest Mid tidal flat	0.32	0.02
2	<i>Rhizophora stylosa/Camptostemon schultzei</i> closed forest Tidal creek	0.15	<0.01

The assemblages proposed for clearing in the intertidal BHC are well represented in the Study Area and direct impact is comparably very minor. The location of Disturbance Envelope has been targeted to already cleared or very degraded mangroves where possible. Loss of this BHC is not considered to impact upon the functional ecological value or diversity of the BHC system and is considered to be of low environmental risk.

Subtidal BHC

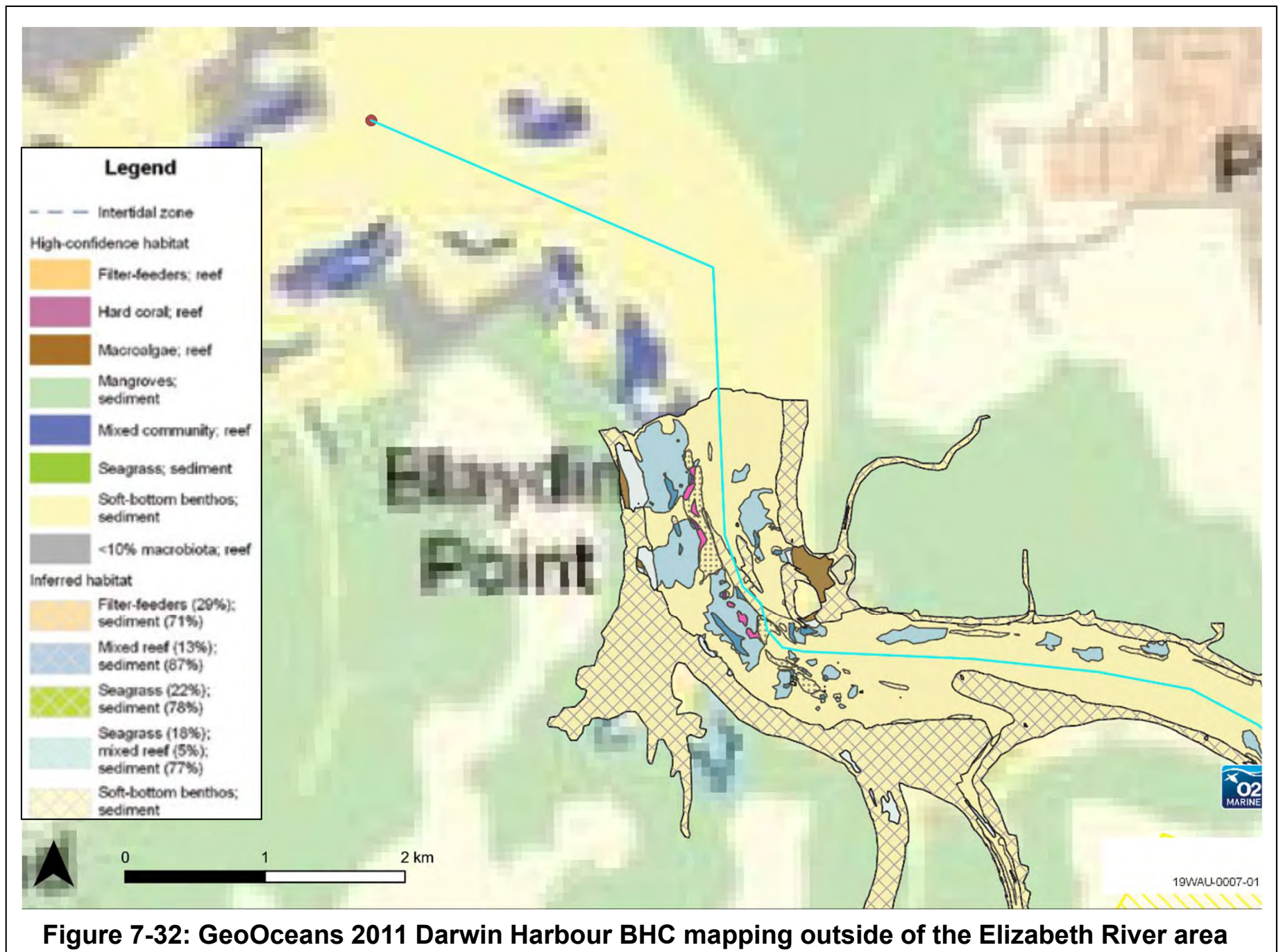
The installation of the discharge pipeline is expected to overlay and impact 2.3 ha of subtidal BHC within the Study Area. Of this 1.28 ha of subtidal BHC occurs within the Elizabeth River mapped area, as described below in Table 7-58.

Table 7-58: Subtidal BHC classes, area and proportion of the disturbance footprint for the discharge pipeline installation within the Elizabeth River

Map Unit	Name	Area (ha)	Percentage of Unit within Study area (%)
4	Medium Density Filter Feeders	0.03	0.04%
7	Bare coarse sediments	1.12	0.3%
8	Bare Sandy / Mixed sediments	0.02	0.17%
9	Bare Coarse sediments - rippled	0.09	0.33%
10	Bare sand / mud	0.02	<0.01%
Total		1.28	0.85%

The remaining length of the proposed pipeline route to the Outfall Case 2 location in East Arm assume the pipeline will overlay a subtidal disturbance footprint of 2 m width within the 22 m wide Development Envelope. The subtidal BHC assemblage is well represented in the Study Area and the direct impact is comparably very minor.

Approximately 98% of the Disturbance Envelope overlies bare substrate with only a small area of 0.03 ha of Medium Density Filter Feeders occurring within the proposed route, which represents only 0.04% of this BHC type within Elizabeth River. The remainder of the pipeline route to the Outfall Case 2 location has been overlaid onto a georeferenced image of the habitat map within East Arm to depict the Disturbance Envelope overlying habitat mapped as Soft-bottom benthos only (Figure 7-32).



Installation of the subsea pipeline is therefore not expected to have a significant impact on BHC within the pipeline route.

Unplanned Construction Risk

During construction, intertidal and subtidal BHC may be indirectly impacted to facilitate the construction of the discharge pipeline. Examples of potential impacts on BHC during construction may include clearing more area of mangroves than approved/planned, pipeline deployed in areas of sensitive subtidal BHC outside the disturbance footprint or vessel grounding on shallow reefs due to low tides or navigational error. Management and mitigation measures will need to be in place to ensure that the potential for unplanned risk to BHC during construction is kept to a minimum. Whilst this risk is evident, it is considered that construction unplanned risks can be managed to result in no impacts to BHC outside of the proposed disturbance footprint.

7.8.4.2 Processing discharge water

Discharge of process water from the outfall may result in altering physico-chemical, nutrient and toxicant loads in the marine environment, and potentially impacting the health of BHC through a reduction of ecological integrity or biological diversity and in extreme cases, cause mortality of BHC. Examples of potential effects may include:

- Physical: Elevated suspended solid concentrations reducing light in the water column for photosynthetic BHC, or changes in water temperature beyond the natural preference of benthic macrofauna resulting in a shift in community abundance and diversity;
- Chemical: Most aquatic organisms and some bacterial processes require pH be within a specified range and may alter the bioavailability of metals, inhibit shell growth and cause physical damage to the gills, skin and eyes of fish or increase susceptibility to infections; and
- Toxicological: Metals accumulate in BHC animals and plants causing impairment of metabolic function, with possible changes to the distribution and abundance of populations, whilst sublethal effects may include changes in morphology, physiology, biochemistry, behaviour and reproduction or mortality.

Management and mitigation measures of the discharge of process water is pivotal to protecting the objectives of the factor BHC. However, it is considered that process discharge water can be managed to result in minimal impacts to BHC above that which has been predicted through numerical dispersion modelling of the wastewater discharge.

Dispersion modelling identifies the temporal and spatial dilution of the constituents in the process water discharge plume returning to background levels within a small mixing zone of 1.3 ha around the immediate area of the outfall. This indicates there may be evidence of sub-lethal stress on subtidal BHC within the mixing zone, which is an area described as the Highly Disturbed Level of Ecological Protection (HD LEP). The bioindicators for sub-lethal stress describe subtle environmental effects on susceptible species or life-history stages of marine fauna without resulting in complete mortality, such as decreased rates of reproduction or larval development rates, shifts in communities of less vulnerable species or increasing biological concentrations of contaminants.

The location of the outfall and mixing zone has been selected to avoid hard substrate sensitive receptor BHC within East Arm, with a minimum proximity of 250 m to the nearest sensitive receptors. Assessment of soft-bottom communities at the outfall location describe a comparably low abundance and diversity of animals and plants, indicating soft-bottom communities provide an optimal location for the outfall and mixing zone to result in minimal potential impacts on BHC and associated fauna. Impacts on subtidal BHC within the Study Area will

be managed to limit the extent of the potential for sub-lethal effects to within the small mixing zone HD LEP area (1.3 ha) immediately surrounding the outfall.

7.8.4.3 Chemical leaks or spillage

Leaks or spills of process chemicals, reagents or concentrates have the potential to cause indirect impacts to BHC by flowing into the marine environment from the Project operations site through groundwater or surface water (stormwater). Intertidal BHC communities, particularly mangroves, are highly susceptible to contaminated water quality, reducing their value as primary producers within the marine nutrient, carbon and food chains.

Stormwater is considered below in chapter 7.8.4.5. Groundwater has potential to move through the wet season laterite aquifer, acting as a potential pathway for contaminants. Polluting substances used on site may include POL, reagents and other hazardous materials, paints and thinners and litter.

It is expected that the use of chemicals and the potential pathway to the marine environment can be suitably managed onsite to prevent significant impact on BHC. Management to prevent flow-down impacts from these substances on BHC, is considered in detail in chapter 7.2.

7.8.4.4 Non-process waste

Non-process waste such as municipal waste streams entering the marine environment can result in physical effects on BHC such as smothering or inhibiting photosynthesis of sensitive BHC. The ecotoxicological effects of litter are considered in chapter 7.8.4.3. Appropriate disposal activities and actions, including the collection, transport, treatment and disposal of non-process waste, are required to reduce adverse effects of waste on the marine environment. It is expected that handling of non-process waste can be effectively managed to prevent significant impact on BHC.

The impacts of non-process waste and appropriate management to prevent litter entering the marine environment is considered in detail in chapter 7.2. It is expected that this will be of low environmental risk given appropriate management of non-process waste.

7.8.4.5 Stormwater

Development of the Project will lead to altered stormwater and runoff regimes. An increase in sealed areas will ultimately increase stormwater volumes which may enter the marine environment. Unmanaged stormwater provides a pathway for potentially contaminated runoff from Project related activities (i.e. chemical management, vegetation clearing, waste management, ASS) to enter the marine environment. Poor water quality can lead to a decline in BHC health or potential fatalities of species, possibly leading to a reduction in associated primary productivity outputs.

Altered stormwater and runoff flow regimes may lead to erosion of the coastal and intertidal environment. Erosion can be responsible for directly removing BHC or cause an overall decline in health. This will ultimately lead to loss of mangrove areas and a reduction in associated primary productivity outputs for the Study Area.

Changes to groundwater seepage or stormwater runoff flow regimes from the project site has the potential to influence the salinity of sediment pore water in the intertidal area, which is considered the primary environmental feature controlling the distribution of mangroves. Mangrove communities adjacent to the Development Envelope show pronounced shoreline zonation forming distinct mangrove communities parallel to the coast associated with topographic elevation and changes in the salinity of sediment pore waters. Tidal inundation, rainfall, soil water, groundwater seepage and evaporation all influence the salinity levels which in turn regulate the distribution of mangrove assemblages based on their salinity tolerance. Salinity concentrations

typically increase from 33‰ on the seaward margin up to 196‰ or more on the tidal and salt flats, although freshwater seepage on the hinterland margin, either perennially or annually, precludes formation of extreme hypersalinity and varies from 14‰ to 48‰ in Darwin Harbour (Semeniuk 1985). Therefore, the closed forest on the landward margin (Map Unit 6) is the most vulnerable assemblage to the groundwater and stormwater flow regimes being modified from project activities. Altered groundwater or runoff flows and volumes as a result of onshore development may result in subsequent changes to the distribution, abundance and overall structure of mangrove communities, or as a worst-case loss of mangrove communities.

The impacts of potential changes to groundwater seepage and stormwater runoff and management to maintain natural water flow through the site to prevent impacts on BHC is considered in detail in chapter 7.5. Stormwater and groundwater seepage will require management to prevent it from being a moderate to high risk.

7.8.5 Mitigation and management

The mitigation measures appearing in Table 7-59 will be implemented to reduce the risk of impacts on BHC. More detail is provided in the management plans and procedures developed through the EMP (Appendix D) and MEQMMP (Appendix Q).

Table 7-59: Benthic habitat and communities – potential impacts and mitigation measures

Pathway	Mitigation hierarchy	Mitigation measure
Installation of outfall/discharge pipeline impacting intertidal and subtidal BHC	Avoid, minimise	- Undertake a survey of the pipeline route prior to installation. - Detailed high resolution BHC validation mapping of pipeline corridor to ensure avoidance of higher value BHC. - Utilise existing disturbed areas to locate pipeline. - Locate pipeline in area of least sensitive BHC environments. - Implementation of the EMP to minimise risk of unplanned disturbance on BHC during pipeline installation.
Discharge of process wastewater impacting BHC	Minimise	- Process wastewater discharge is detailed in Marine Environmental Quality Environmental Factor (chapter 7-7). - Detailed high resolution BHC mapping of proposed outfall location, mixing zone and surrounding sensitive areas. - Outfall location to be selected based upon suitable void of 250 m minimum to the nearest sensitive hard substrate communities. - Dispersion modelling to ensure dilutions are adequate to reduce concentrations within small mixing zone; - Implementation of the MEQMMP; - Develop wastewater treatment plans and quality control processes to support operation of the Processing Facility; - Obtain and comply with Mixing Zone Licence Conditions; - Obtain and comply with Waste Discharge Licence Conditions;
Uncontrolled stormwater flows causing erosion of coastal areas impacting BHC	Avoid, minimise	- Implementation of the ESCP (Appendix N) and Water Management Procedure (EP-10) to avoid erosion. - Vegetation clearing to be undertaken in stages and in dry season conditions wherever possible. - Erosion protection measures (bundling, spoon drains, silt fencing and sediment ponds) will be installed to contain any erosion.

Pathway	Mitigation hierarchy	Mitigation measure
		- Establish buffer zones between the intertidal BHC and the adjacent Development Envelope. - Maintain natural groundwater seepage and stormwater runoff flows into the adjacent intertidal zone.
Contamination during Project operations phase from chemical leaks or spills impacting BHC	Avoid, minimise	Hazardous materials management at the Project is detailed in Terrestrial Environmental Quality Factor (chapter 7-2). - Implement the Hazardous Material Management Procedure (EP-13). - Materials management to be in accordance with Australian Standard 1940: The Storage and Handling of Flammable and Combustible Liquids, MSDS, licences and permit requirements. - Spill response protocols developed to ensure uncontained materials are addressed prior to entering the marine environment.
Non-process waste impacting BHC	Avoid, minimise	Appropriate Domestic and Industrial Waste Management Procedure (EP-14) to be implemented for the Site. - Recyclable materials, including cardboard, paper, glass, batteries, waste hydrocarbon drums and scrap metal, will be recycled wherever possible; - Housekeeping inspections of all work areas will be undertaken weekly; - Littering on site is prohibited and work and office sites are to be kept clean and tidy; - Rubbish containers are to be carried in all vehicles and provided at all work area; - Waste management will be addressed in the site induction.

7.8.6 Monitoring and reporting

The MEQMMP, EMP and associated sub-plans detail objectives, monitoring procedures and performance indicators, as well as corrective actions and reporting requirements. These are outlined below in Table 7-61.

Table 7-60: Monitoring and reporting for benthic habitat and communities

Action	Timing	Methods used	Criteria
Marine Environmental Quality Management and Monitoring Plan	Ongoing	Refer to Table 7-44. Marine Fauna, Benthic Infauna, Intertidal Invertebrates	Reporting as required under endorsement of the Marine Environmental Quality Management and Monitoring Plan

Table 7-61: Other inspection and reporting for benthic habitat and communities

Relevant Plan	Procedure (if relevant)	Monitoring	Reporting
Environmental Management Plan	NA	Daily inspection of high-risk locations, including to identify any new risks / unmanaged risks.	Monthly Environmental Performance Report Half Year Report
	Water Management Procedure (EP-10)	Weekly inspection of swales and sediment traps.	Annual Report and Performance Review
	Domestic and Industrial Waste Management Procedure (EP-14)	Weekly housekeeping inspections at all works areas.	Volumes of waste material and recycled material will be reported via the Annual Report. Inappropriate waste disposal will be reportable as an incident and reported as per the TNG incident reporting processes.
	Hazardous Material Management Procedure (EP-13)	Daily monitoring to ensure site is cleared of waste, all POL/chemicals have been stored and disposed of correctly, and all spills have been identified and dealt with (see Daily Inspection Checklist) Regular inspection bunds, where present, to check integrity and to detect leak and spills (see Weekly Inspection Checklist) Regular inspection of stormwater drains for any sediment capture (see Weekly Inspection Checklist)	Reporting for the Annual Report will include the volume of controlled wastes moved off site; All incidents will be reported in the Annual Report. Any site that requires notification or reporting to the NT EPA under the <i>Waste Management and Pollution Control Act 1998</i> .
Erosion and Sediment Control Plan		Weekly inspection of erosion and sediment controls during the wet season.	Monthly Environmental Performance Report

7.8.7 Statement of residual impact

Impacts from Project activities fall into two main categories:

- Direct impacts: this includes the removal, burial or replacement of existing substrate and is considered a permanent impact. Direct impacts are predicted during installation of the discharge pipeline and within the immediate area surrounding the outfall in the mixing zone.
- Indirect impacts: these are areas potentially impacted as a result of possible impacts extending beyond the immediate Development footprint. Except for the potential to alter salinity levels in adjacent mangrove communities, indirect impact is considered temporary in that the substrate is not altered permanently and recovery, at varying time scales, of BHC is expected. However, altered groundwater and stormwater flow regimes due to construction of the Processing Facility represents a more permanent risk to intertidal BHC.

All potential risks to the Factor Benthic Habitat and Communities can be managed in accordance with management plans and protocols (identified in chapter 7.8.5 above) to minimise potential impacts to BHC in the Study Area. Therefore, the NT EPAs objective for the Factor Benthic Habitat and Communities is considered to be met.



DRAFT ENVIRONMENTAL IMPACT
STATEMENT

DARWIN PROCESSING FACILITY

**ENVIRONMENTAL
FACTOR: MARINE
FAUNA**

7.9 ENVIRONMENTAL FACTOR: MARINE FAUNA

7.9.1 NT EPA Objective

The NT EPA's objective for the environmental factor Marine Flora and Fauna is to:

Protect marine flora and fauna so that biological diversity and ecological integrity are maintained.

Marine fauna refers to animals that live in the ocean or rely on the ocean for all or part of their lives. The marine fauna objective acknowledges the importance of protecting marine fauna for their ecological roles, in addition to recognising the iconic nature of many of these animals and the importance society places on them, including traditional aboriginal cultural usage.

This chapter describes the existing marine fauna that are known or have a high potential to occur within the Project area, identifies potential Project related risks to marine fauna and proposes the mitigation and management required to ensure these risks do not result in unacceptable impacts to marine fauna, including marine fauna listed under the EPBC Act as 'Matters of National Environmental Significance'. This chapter also presents the proposed monitoring and reporting requirements to determine if the mitigation and management methods are adequate and presents the assessment of residual risk from the proposed Project.

It is noted that marine flora refers to seagrass, algae and mangroves which are discussed and assessed in the Benthic Habitat and Communities chapter (chapter 7.8).

The content of this chapter has been developed specifically to address section 3.1 of the EIS TOR (Appendix A).

7.9.2 Technical Studies

Technical studies undertaken to support the assessment of Marine Fauna appear listed in Table 7-62.

Table 7-62: Marine fauna studies undertaken for the Project

Date	Study Title	Consultant	Description	Report
2019d	Marine fauna	O2 Marine	Desktop assessment of marine fauna	Appendix T

7.9.3 Existing Environment

Darwin Harbour provides habitat for a range of marine fauna species including conservation significant marine fauna species such as dolphins, dugongs, turtles, sea snakes, crocodiles, sawfish and bony fish species. The marine fauna species that are found within Darwin Harbour are found in other regions of the Northern Territory, and some species are distributed nationally within Australian waters and globally.

Extensive marine fauna and other environmental monitoring has been conducted across Darwin Harbour, extending to adjacent regions, by the Northern Territory Government and also as part of environmental monitoring conditions applied to the Ichthys LNG Project and regional monitoring programs (Table 7-63). The surveys have used a variety of methods to describe the extent, distribution and habitat preferences of marine fauna present across Darwin Harbour.

These studies have used a range of database searches, as well as field methods, including:

- Net and cage trapping;
- Nocturnal spotlight surveys;
- Targeted search transects;
- Boat-based surveys; and
- Aerial surveys.

Table 7-63: Marine fauna studies undertaken in the vicinity of the Project area

Date	Study Title	Author	Description
June, July and October 2012	Turtle and Dugong Monitoring Program	Cardno	Targeted baseline Dugong and Turtle surveys for the Turtle and Dugong monitoring program, to monitor for potential impacts to the distribution and abundance of turtles and dugongs around Darwin Harbour and surrounding inshore waters.
1990 – 2004 (2008)	The distribution and status of marine turtle nesting in the Northern Territory	Chatto & Baker	Marine Turtle nesting surveys on island and mainland beaches in the Northern Territory.
2011b	Potential effects of underwater blasting, piledriving and dredging on sensitive marine fauna in Darwin Harbour	URS	For the Ichthys Gas Field Development Project - Modelling of potential underwater noise generated by the INPEX Project and potential adverse impacts on marine fauna.
2011-2015	The Darwin dolphin monitoring program	Pollock and Brooks	Coastal dolphin monitoring program for the Ichthys LNG Project in Darwin Harbour. Comprising a capture-recapture study and a spatial habitat use study on humpback, bottlenose and snubfin dolphins in Darwin Harbour and two adjacent sites, Bynoe Harbour and Shoal Bay. Abundance, apparent survival, movements and habitat use of each species in the Darwin area was assessed.
2008-2010	Darwin Harbour Coastal Dolphin Project	Palmer	Targeted dolphin surveys within Darwin Harbour. Assessment of spatial distribution, habitat use and related behaviour. Methodology includes photo identification, boat-based transects and opportunistic sightings.
2011b	Benthic Habitat Mapping of the Darwin Region	Geo oceans	Benthic habitat survey of the Darwin region for the Ichthys Project involving methods of data collection, collation and map production to classify available marine habitat on the seafloor substrates and biological communities. Maps show the distribution of sediment particle size and the

			benthic habitats in the waters surrounding the Darwin Harbour region.
2012	Assessment of marine biodiversity and habitat mapping in the Weddell region, Darwin Harbour	Smit et al.	Assessment of the diversity, distribution and conservation values of benthic fauna, fish and marine megafauna using historical and recent survey data. Description of benthic habitats and associated maps using remote sensed and survey data.
January to March 2011	Summary report of dolphin surveys in the Middle Arm and West Arm of Darwin Harbour	GHD	Boat based dolphin surveys within Darwin Harbour.
2018	Darwin region coastal dolphin monitoring program	Flora and Fauna Division	Capture-recapture survey for three species of coastal dolphins in the Darwin region

Current information on marine turtles, crocodiles, dolphins and dugongs within Darwin Harbour is substantial. However, there are gaps in the current knowledge of abundance, distribution and habitat use by sawfish, sea snake and pipefish species within Darwin Harbour. Therefore, evaluation of impacts to these species is largely based on known habitat preferences, biology and geographical distribution.

7.9.3.1 Conservation Significant Species

Database searches identified a total of 23 listed threatened species and a further 53 species listed as marine under the EPBC Act that have the potential to occur within the Study Area. However, a likelihood of occurrence assessment was undertaken for each species and only 20 species were regarded as either known (based on historic records) or highly likely to occur given the presence of suitable habitat within Darwin Harbour. These included:

- Six (6) reptile species including:
 - Four (4) Turtles: Green Turtle, Hawksbill Turtle, Flatback Turtle and the Olive Ridley;
 - Two (2) Crocodiles: Freshwater Crocodile and Salt-water Crocodile;
 - Two (2) Sea snakes: Black-ringed Seasnake and Northern Mangrove Seasnake;
- Four (4) mammal species:
 - Dugong; and
 - Three (3) Dolphins: Australian Humpback, Indo-Pacific Bottlenose and Australian Snubfin Dolphin;
- Three (3) elasmobranch species:
 - Dwarf Sawfish;
 - Green Sawfish; and
 - Largetooth Sawfish.
- Five (5) fish species:
 - Short-keel Pipefish;
 - Flat-face Seahorse;
 - Lowcrown Seahorse;
 - Tidepool Pipefish; and

- o Straightstick Pipefish (or long-nosed pipefish).

A complete list of the conservation species that may occur (based on database searches), those that have been recorded, and the likelihood of occurrence for those that have not, is included in Appendix T.

The following chapters discuss, in more detail, the species of conservation significance that have a high likelihood of occurrence within the Project area. This excludes species that are listed only as 'Least Concern' under the TPWC, or 'Marine/Migratory' under the EPBC. In particular, this chapter will discuss species vulnerabilities, whereas further details on lifecycle phases, distribution, abundance, significance and habitat requirements are provided in Appendix T.

7.9.3.2 Marine Turtles

The following four (4) marine turtle species are known or have a high likelihood of occurring within 10 km of the Project area:

- Green turtle (*Chelonia mydas*) – Vulnerable/Marine Migratory (EPBC), Endangered (IUCN);
- Hawksbill turtle (*Eretmochelys imbricata*) – Vulnerable/Migratory Marine (EPBC), Vulnerable (TWPC), Critically endangered (IUCN);
- Flatback turtle (*Natator depressus*) – Vulnerable/Migratory Marine (EPBC), Data Deficient (IUCN); and
- Olive ridley turtle (*Lepidochelys olivacea*) – Endangered/Migratory Marine (EPBC), Vulnerable (TWPC), Vulnerable (IUCN).

Marine turtles have a complex lifecycle that spans a large geographic range over multiple habitats and many decades. All marine turtles are migratory during some life phases and several turtles utilise Australian waters for either foraging or nesting, or both. Migratory pathways for marine turtles nesting in the Northern Territory region include the coastal waters of Darwin Harbour. Turtles spend their lives in the sea however females require terrestrial habitat for nesting such as on sandy island and mainland beaches. Suitable nesting habitat does not exist in the Project Area as the Elizabeth River and East Arm Area banks are lined with mangrove and mudflat habitat which is extensive within Darwin Harbour. Suitable nesting habitat is found outside of the Harbour on Casuarina Coastal reserve near Lee Point on the north-eastern shore of the harbour and on offshore Islands.

Turtles visiting the harbour are most likely to be foraging for food. Flatback and hawksbill turtles forage on the filter-feeder communities which are extensive in the harbour. The hawksbill turtle also forages on seagrass and macroalgal communities in addition to filter-feeders. Green turtles forage amongst seagrass and macroalgal communities.

Within Darwin Harbour no significant nesting or foraging habitat has been recorded or identified. However, their presence within the Project Area makes them susceptible to potential impacts from the Projects activities.

The life history characteristics of marine turtles, including long life spans and late sexual maturity, make them vulnerable to a range of pressures in the marine environment. While at sea marine turtles are vulnerable to impacts from marine debris as floating plastics can resemble prey items.

Sea turtles have life history characteristics, physiology and behavioural traits that are heavily influenced by environmental temperature however, this is of most relevance during the egg incubation phase within turtle nests.

7.9.3.3 Crocodiles

The following two (2) crocodile species are known or have a high likelihood of occurring within 10 km of the Project area:

- Saltwater Crocodile (*Crocodylus porosus*) – Marine Migratory (EPBC), Least Concern (IUCN); and
- Freshwater Crocodile (*Crocodylus johnstoni*) – Marine (EPBC), Least Concern (IUCN).

Both the Saltwater and Freshwater crocodiles have been sighted as well as captured within Darwin Harbour and the Project Area. Both species are found in both freshwater and saltwater environments, although the freshwater crocodile typically prefers freshwater rivers and creeks further upstream. Saltwater crocodiles are much more likely to be found within the Project Area as they are known to occur in tidal areas of mangrove lined rivers in the Northern Territory. Both species are fairly adaptable and in the case of potential impacts they would likely shift their range (DSEWPC 2012a). The greatest vulnerability associated with crocodiles is egg mortality due to increase in sea temperatures.

There is no Recovery Plan for the Saltwater or Fresh Water Crocodile listed under the EPBC Act.

7.9.3.4 Sea Snakes

The following two (2) sea snake species are known or have a high likelihood of occurring within 10 km of the Project area:

- Black-ringed Seasnake (*Hydrelaps darwiniensis*) – Marine (EPBC), Least Concern (IUCN)
- Northern Mangrove Seasnake (*Parahydrophis mertoni*) – Marine (EPBC), Data Deficient (IUCN)

Both species of sea snakes can be found within estuarine environments such as that of the Darwin Harbour. Sea snakes are found in coral reefs, lagoons, bays and estuaries. Mixed benthic habitats exist within the Project Area, including coral reef habitat, as well as mangrove and mudflat habitat, which are all habitats utilised by sea snakes. However, rare sightings of sea snakes within the Project Area indicate the area is not a significant habitat for either species and therefore the Project activities would have little impact on the species population, although individual impacts may be possible. The slow growth rate, low fecundity, restricted diet of gobies and eels in the region, makes sea snakes more susceptible to changes in trophic structures. Sea snakes are vulnerable to indirect impacts such as habitat destruction and disruption of the trophic structure.

7.9.3.5 Sawfish

The following three (3) sawfish species are known or have a high likelihood of occurring within 10 km of the Project area:

- Dwarf Sawfish (*Pristis clavata*) – Vulnerable (EPBC), Vulnerable (TPWC), Endangered (IUCN);
- Largetooth Sawfish (*Pristis pristis*) – Vulnerable/Migratory (EPBC), Vulnerable (TPWC), Critically Endangered (IUCN); and
- Green Sawfish (*Pristis zijsron*) – Vulnerable/Migratory (EPBC), Vulnerable (TPWC), Critically Endangered (IUCN)

Sawfish inhabit coastal/inshore and freshwater/estuarine habitats for a large proportion of their life history. Freshwater environments are important nursery habitats for freshwater sawfish. This reliance on a physically restricted environment contributes to their susceptibility by limiting their ability to evade the pressure. Repeated use of small areas of habitat means these species are susceptible to localised depletion. Research suggests populations are in decline globally.

Biologically, elasmobranchs are characterised by their 'limited' life history (late age maturity, slow growth rate, low fecundity, longevity, low rate of natural mortality), which results in restricted productivity. Sawfish are top level predators that occupy a high trophic level. They are viviparous, giving birth to well developed live young. The female residency at place of birth means a localised decline in females would not be replenished by other females in the region (as females remain residents to their place of birth). This combination of life history traits makes them susceptible to developments and slow to recover. However, most aspects of the reproductive biology of sawfish species are unknown and the sawfish of northern Australia are generally poorly understood. Reproductive periodicity is unknown for all species.

7.9.3.6 Dolphins

The following three (3) dolphin species are known or have a high likelihood of occurring within 10 km of the Project area:

- Australian Snubfin Dolphin (*Orcaella heinsohni*) – Migratory (EPBC), Vulnerable (IUCN);
- Australian Humpback Dolphin (*Sousa sahulensis*) – Migratory (EPBC), Vulnerable (IUCN); and
- Indo-Pacific Spotted Bottlenose Dolphin (*Tursiops aduncus*) – Migratory (EPBC), Data Deficient (IUCN).

The species' vulnerability to pressures is intensified due to their life history characteristics (they are long-lived, females take many years to reach sexual maturity, (e.g. around nine years for the Australian Snubfin Dolphin); and they have a low rate of reproduction (one calf every 2-3 years)). Evidence suggests the three dolphin species distributions are severely fragmented, at least in some parts of their range. All three species exhibit site fidelity and long-term associations between individuals. The populations of dolphins in the region may be genetically distinct from populations elsewhere.

The Australian Snubfin and Australian Humpback Dolphin occur mostly in shallow waters up to 10 km from the coast and 20 km from the nearest river mouth and forages in a variety of habitats, ranging from mangrove communities to seagrass beds, sandy bottom communities and open coastal areas with rocky shores and coral reefs. With the exception of seagrass beds, all of these habitats occur widely throughout Darwin Harbour.

The Indo-Pacific Spotted Bottlenose Dolphin tend to occur in deeper, more open coastal waters, primarily in continental shelf waters (up to 200 m deep), although still including coastal areas and around oceanic islands.

7.9.3.7 Dugong

Dugong (*Dugong dugon*) are listed as Migratory Marine under the EPBC Act, Near threatened under the TPWC Act and Vulnerable by the IUCN.

Within Darwin Harbour Dugongs have been observed at Channel Island in Middle Arm, where they were thought to be feeding on macroalgae. These areas are not near the Project Area and therefore not expected to be affected by the Project. Dugongs could potentially utilise algal communities within East Arm as a food source. Although dugongs regularly inhabit Darwin Harbour, it is not the most important dugong habitat in the region, possibly due to limited seagrass communities. Within the Anson-Beagle Bioregion the Vernon Islands Gunn Point are more significant dugong habitats and are known to support relatively large populations. Dugongs prefer to forage in seagrass and macroalgal beds, which do not occur at the Project site and are relatively rare within Darwin Harbour.

Specific vulnerabilities to populations of dugongs include long gestation (12-14 months), single offspring, long intervals between births (more than 2.5 years), prolonged periods until sexual maturity (6-17 years), and high

temporal stable adult survival. Adult survival is the most important determinant of population growth. The maximum rate of population increase under optimum conditions when natural mortality is low is approximately 5 per cent per year. The maximum sustainable mortality rate of adult females killed by human activities is approximately 1 or 2 per cent and lower when food supplies are low. Pressures that cause dugong mortality are therefore of potential concern if such pressures occur over wide geographic area, even if the magnitude of the pressures is uncertain.

7.9.3.8 Bony Fish

The following five (5) syngnathid (Pipefish) species are known or have a high likelihood of occurring within 10 km of the Project area:

- Short-keel Pipefish (*Hippichthys parvicarinatus*) – Marine (EPBC), Least Concern (IUCN);
- Flat-face Seahorse (*Hippocampus planifrons*)– Marine (EPBC), Least Concern (IUCN);
- Lowcrown Seahorse (*Hippocampus dahli*) – Marine (EPBC), Least Concern (IUCN);
- Tidepool Pipefish (*Micrognathus micronotopterus*) – Marine (EPBC), Least Concern (IUCN) and
- Straightstick Pipefish (or long-nosed pipefish) (*Trachyrhamphus longirostris*) - Marine (EPBC), Least Concern (IUCN)

Many syngnathids, particularly seahorses, are susceptible to habitat degradation as a result of their biology (Commonwealth of Australia 2012). Syngnathids are characterised by relatively low population densities (which means that lost partners are not quickly replaced); Natural rates of adult mortality may be low (short lived); low adult mobility and small home range sizes (may restrict the recolonization of depleted areas or colonization of new areas, although juveniles may be the primary disperses); dependency at birth and offspring dependence on the survival of the males; monogamous breeding (a ‘widowed’ partner may stop reproducing until another mate is found); small brood sizes (production of few young per breeding cycle limits the potential reproductive rate, however they have advanced development of the young when they leave the pouch); and strong association with preferred habitats (specific habitat requirements). Habitat protection is one of the most important factors in protecting seahorses (Commonwealth of Australia 2012; DSEWPAC 2012e).

In contrast, a number of pipefish species that live in coastal waters have high population densities and live in unstable habitats subject to damage from storms and dramatic changes in temperature or salinity. These species can quickly colonise patches of suitable habitat.

7.9.4 Potential impacts and risks

Development of the Darwin Processing Facility has the potential to impact Marine fauna. Table 7-64 uses the Source – Pathway – Receptor model to identify potential impacts. The individual pathways are detailed below.

Table 7-64: Potential impact pathways for marine fauna

Source	Pathway	Receptor
Construction activities	Non-process waste	Marine fauna and marine fauna habitat
	Sediment runoff	
	Chemical leaks or spillage.	
	Loss of habitat	
Operations activities	Processing discharge water.	
	Chemical leaks or spillage.	
	Non-process waste.	
	Sediment runoff	

7.9.4.1 Non-process waste

Juveniles of dolphin, dugong, turtle, crocodile and sawfish species may be impacted by strangulation to a greater extent than adults of those species, as juveniles continued growth restricts them (DSEWPC 2012b). Entanglement can cut into the skin of adults and lead to infection and eventual death. Entanglement may involve flippers, tails or flukes and may lead to a protracted amputation of limbs (DSEWPC 2012b).

Entanglement in marine debris can also cause restricted mobility, drowning, starvation, and smothering. If the debris is large, it may cause considerable drag as the animal swims, contributing to inefficient hunting and a faster consumption of body reserves.

Marine debris may also be ingested, if the debris resembles prey species consumed by marine fauna as it confuses them. Most marine species consume non-selectively and may consume marine debris, particularly ones accumulated in the vicinity of food items. Marine debris usually causes a physical blockage in the digestive system, leading to internal injuries and pain. Eventually starvation may occur.

Marine turtles are particularly vulnerable to the ingestion of marine debris and entanglement (CoA 2017). The internal structure of marine turtles' throats prevents regurgitation of swallowed items, trapping items in the gut where they decompose, leaking gases into the body cavity and thereby causing the animal to float and ultimately die. White plastic debris (e.g. plastic bags) are of most concern to marine turtles as they mistake the debris for jellyfish, a key prey species (DSEWPC 2012b). In addition to the direct impacts of plastic ingestion, research also indicates that toxins in the materials are being absorbed by marine turtles, with unknown but potentially adverse effects on their demography (DSEWPC 2012b).

Marine debris cause injury or death to dolphin individuals (DSEWPC 2012d). Cetaceans can be affected by marine debris through entanglement or ingestion (Action plan) (DSEWPC 2012d). Entanglement can cause drowning, suffocation, strangulation, starvation and other injuries; ingestion can cause blocking or perforation of the digestive tract, resulting in injury or death. The full impact of marine debris on inshore dolphins is largely unknown (DSEWPC 2012d).

Injury or death to dugongs through entanglement and ingestion has been recorded (DSEWPC 2012b). Sawfish have a saw-like rostrum and are therefore susceptible to entanglement which could cause serious or fatal injury (DSEWPC 2012f).

Appropriate disposal activities and actions, including the collection, transport, treatment and disposal of non-process waste, are required to reduce adverse effects of waste on the marine environment. It is expected that handling of non-process waste can be effectively managed to prevent significant impact on marine fauna.

7.9.4.2 Sediment runoff

Clearing of terrestrial vegetation and exposing underlying soils has the potential to result in increased sediment loads entering the marine environment via windblown or stormwater transportation mechanisms. This may result in smothering of benthic habitat utilised by fauna for foraging (DSEWPC 2012c).

It is however anticipated that this risk will be relatively low for the Project, as mangrove clearing only constitutes a small area (2 ha) and is completed during the construction phase. Clearing of other terrestrial vegetation at the site is not expected to impact the marine environment.

7.9.4.3 Chemical leaks or spillage

Unauthorised discharges of chemicals, such as fuel, oil, lubricants and process chemicals through groundwater and surface water mechanisms could impact marine environmental values. Chemicals can have a wide range of effects based upon type, concentration and extent of exposure. These effects can be species specific or effect an ecosystem.

Stormwater is considered above in 7.8.4.5.

Groundwater has potential to move through the wet season laterite aquifer, acting as a potential pathway for contaminants. Polluting substances used on site may include POL, reagents and other hazardous materials, paints and thinners and litter. It is expected that the use of chemicals and the potential pathway to the marine environment can be suitably managed onsite to prevent significant impact on marine fauna.

The impacts of the use of process and project required chemical substances and management to prevent flow-down impacts on marine fauna is considered in detail in chapter 7.2.

7.9.4.4 Loss of Habitat

Mangrove habitats serve as an important nursery area and foraging area for sawfish. Mangroves may be used as a nursery for both conservation significant species such as juvenile sawfish and non-conservation significant species such as fish which in turn are an important food source to conservation significant species such as dolphins and some species of turtles. Mangroves are also an important food source for the Green turtle. Subtidal reefs in the Study Area can also support a more diverse and abundant benthic faunal community, representing predation areas for listed turtles, seasnakes, dolphins, sharks and fish species.

The risk for loss of habitat is described in chapter 7.8. The project activities identified which can potentially impact BHC include:

- Direct removal or smothering of intertidal and subtidal BHC for the discharge pipeline installation;
- Sub-lethal impacts to BHC from the discharge of process water within the small mixing zone of the outfall; and
- Altered groundwater and stormwater runoff regimes causing intertidal erosion or changing the salinity of sediment pore waters in mangrove communities.

- Pollution of the marine environment altering water quality and potentially impacting subtidal BHC, resulting in different community structures or a decrease in density leading to a reduction in associated primary productivity outputs.

The predicted area of direct and indirect impact comprises an insignificant loss of BHC which will not impact upon the functional ecological value or diversity of the BHC in the Study Area. No marine fauna are predicted to be impacted from the loss of small areas of BHC predicted for project activities.

7.9.4.5 Processing Water Discharge

Treated wastewater discharge within East Arm will contain water quality constituents that differ from natural conditions. Altered water quality could potentially affect the distribution, species range, changes in behaviour or life-history characteristics of marine fauna (DSEWPC 2012b, 2012f), or as a worst case, result in mortality.

The outfall location has been selected to avoid sensitive receptor BHC communities and occurs over bare substrate which is less likely to form critical habitat for marine fauna. Dispersion modelling identifies the temporal and spatial dilution of the constituents in the process water discharge plume returning to background levels within a small mixing zone of 1.3 ha around the immediate area of the outfall. The presence of any mobile marine fauna within the mixing zone is therefore likely to be transitory, and fauna will be able to actively vacate and evade the small zone.

Due to the small spatial scale of the HD LEP, appropriate implementation of proposed management of the potential risks will not significantly impact the biological diversity and ecological integrity of marine fauna.

7.9.5 Mitigation and management

The mitigation measures appearing in Table 7-65 will be implemented to reduce the risk of impacts on marine fauna and fauna habitats. More detail is provided in the management plans and procedures developed through the EMP (Appendix D) and the MEQMMP (Appendix Q).

Table 7-65: Marine fauna and fauna habitat potential impacts and mitigation measures

Pathway	Mitigation hierarchy	Mitigation measure
Death or injury to fauna from ingestion or entanglement in non-process waste	Avoid, minimise	Litter that is generated during both construction and operation phases of the Project will be managed in accordance with the Domestic and Industrial Waste Management Plan (EP-14) and compliance with the requirements of the <i>Marine Pollution Act</i> (NT) and the <i>Waste Management and Pollution Control Act</i>.
Changes in habitat quality due to increased sedimentation	Avoid, minimise	- Implementation of the ESCP (Appendix N) and Water Management Procedure (EP-10) in the EMP to avoid erosion. - Vegetation clearing to be undertaken in stages and in dry season conditions wherever possible. - Erosion protection measures (bundling, spoon drains, silt fencing and sediment ponds) will be installed to contain any erosion.
Exposure to contaminants from leaks or spillage of hazardous substances	Avoid, minimise	- Implement the Hazardous Material Management Procedure (EP-13) , within the EMP (Appendix D). - Construct containment areas compliant with appropriate standards well clear of any waterway or drainage system. - Educate workforce on reporting and management of spillages. - Actively manage all spillages and recover contaminated material. - Construct bunding and pipelines with spill protection. - Erosion protection measures (bundling, spoon drains, silt fencing and sediment ponds) will be installed to contain any erosion. - Rehabilitation of disturbed areas not required for infrastructure - Undertake regular inspections. - Remediate contaminated soils in accordance with applicable regulations.
Loss of habitat	Avoid, minimise	- Undertake a survey of the pipeline route prior to installation. - Utilise existing disturbed areas to locate pipeline. - Detailed high resolution BHC mapping survey of pipeline corridor and outfall area is required to ensure avoidance of higher value BHC that may be of significance to marine fauna.
Changes in marine habitat quality from the treated wastewater ocean outfall	Avoid, minimise	- Design of the Wastewater Treatment Plant to criteria that: - meets the ANZG (2018) 95% SPL default guideline values - do not result in an accumulation of contaminants over time - Discharge only during ebb tides to ensure maximum dilutions are achieved and marine environmental impacts do not arise upstream during flood tides - Selection of a wastewater ocean outfall locations that ensures an appropriate level of ecological protection can be achieved - Monitoring water quality parameters at the ocean outfall - Updating predictive numerical modelling of water quality associated with the outfall using monitoring data

7.9.6 Monitoring and reporting

The MEQMMP, EMP and associated sub-plans detail objectives, monitoring procedures and performance indicators, as well as corrective actions and reporting requirements. These are outlined below in Table 7-66 and other inspections and reporting are outlined in Table 7-67.

Table 7-66: Monitoring and reporting for marine fauna and marine fauna habitat

Action	Timing	Methods used	Criteria
Marine Environmental Quality Management and Monitoring Plan	Ongoing	Refer to Table 7-44. Marine Fauna, Benthic Infauna, Intertidal Invertebrates	Reporting as required under endorsement of the Marine Environmental Quality Management and Monitoring Plan

Table 7-67: Monitoring and reporting for marine fauna and marine fauna habitat

Relevant Plan	Procedure (if relevant)	Monitoring	Reporting
Environmental Management Plan	NA	Daily inspection of high-risk locations to identify any new risks / unmanaged risks.	
	Water Management Procedure (EP-10)	Weekly inspection of swales and sediment traps.	Monthly Environmental Performance Report Half Year Report
	Ground Disturbance and Vegetation Clearing Procedure (EP-05)	Daily inspection during vegetation clearing to ensure ground disturbance permits have been issued and clearing is within the allowed boundary	Annual Report and Performance Review
	Domestic and Industrial Waste Management Procedure (EP-14)	Daily inspection of waste storage areas. Weekly housekeeping inspections at all works areas.	Volumes of waste material and recycled material will be reported via the Annual Report. Inappropriate waste disposal will be reportable as an incident and reported as per the TNG incident reporting processes.
	Hazardous Material Management Procedure (EP-13)	Daily monitoring to ensure site is cleared of waste, all POL/chemicals have been stored and disposed of correctly, and all spills have been identified and dealt with (see Daily Inspection Checklist)	Reporting for the Annual Report will include the volume of controlled wastes moved off site; All incidents will be reported in the Annual Report. Any activity/incident that requires notification or reporting to the NT EPA

Relevant Plan	Procedure (if relevant)	Monitoring	Reporting
		Regular inspection of any bunds to check integrity Regular inspection of bunds, where present, to check integrity and to detect leak and spills (see Weekly Inspection Checklist) Regular inspection of stormwater drains for any sediment capture (see Weekly Inspection Checklist)	under the <i>Waste Management and Pollution Control Act 1998</i> .
Erosion and Sediment Control Plan		Weekly inspection of erosion and sediment controls during the wet season.	Monthly Environmental Performance Report

7.9.7 Statement of residual impact

Implementation of the Project in accordance with the defined mitigation, management and monitoring plans will result in the following residual impacts:

- There are no significant habitats (i.e. nesting, nursery, foraging or breeding areas), for any marine fauna species listed under the EPBC Act or TPWC Act within the Project area;
- It is unlikely individual harm will occur to any of the listed marine fauna species as they are all highly mobile species and would move away from affected areas;
- There will be no declines in the populations of the range of species protected under both Commonwealth and state legislation;
- No reductions in populations of species of local and regional importance; and
- No reduction in the biodiversity of marine fauna in the Project area or surrounds.

The combined impact of the Proposal activities and the consequent outcomes are not considered to pose any significant residual risks to the protection of marine fauna and therefore biological diversity and ecological integrity can be maintained.

In respect of the proposed design and management of the Proposal, the Proponent considers that the EPA's objective for marine flora and fauna has been met and no offsets are proposed.



DRAFT ENVIRONMENTAL IMPACT
STATEMENT

DARWIN PROCESSING FACILITY

**ENVIRONMENTAL
FACTOR: AIR
QUALITY AND
GREENHOUSE
GASES**

7.10 ENVIRONMENTAL FACTOR: AIR QUALITY AND GREENHOUSE GASES

7.10.1 NT EPA Objective

The NT EPA's objective for the environmental factor Air Quality and Greenhouse Gases (GHGs) is to:

Maintain air quality and minimise emissions and their impact so that environmental values are protected.

Air quality and GHG impacts have been considered for the operational and construction phases of the Project. The purpose of the air quality assessment was to evaluate the potential impacts of air pollutants generated from the Project, taking into account existing ambient air quality in the Project area and criteria for human health, and to provide recommendations to mitigate any potential impacts that might have an effect on nearby sensitive receptors. A GHG and climate change impact assessment were also undertaken for the Project.

The contents of this chapter specifically address section 4.6 of the EIS TOR (Appendix A).

7.10.2 Technical Studies

Technical studies undertaken to inform assessment of potential impacts of the Project on Air Quality and Greenhouse Gases are listed in Table 7-68.

Table 7-68: Air quality and greenhouse gas studies undertaken for the Project

Date	Study Title	Consultant	Description	Report
September 2019	Darwin Processing Facility – Climate Change Impact Assessment	Aurora Environmental	Climate change impact assessment	Appendix V
September 2019a	Darwin magnetite concentrate processing facility – Air quality assessment	Vipac Engineers and Scientists Ltd	Air quality assessment	Appendix U

7.10.3 Existing Environment - Air Quality

Air quality refers to the condition of the air within our surroundings and is determined by assessing a variety of pollution indicators. Air quality can be influenced by a number of factors, including climatic influences and local and regional activities.

7.10.3.1 Climatic Influences

A detailed description of the Project area climate is provided in chapter 3.4. A brief summary of climatic conditions influencing air quality is provided below.

Two major atmospheric pressure systems affect the Project area and Greater Darwin:

- A subtropical ridge of high pressure cells (highs or anticyclones); and
- A broad tropical low pressure region called a monsoon trough.

The monsoon trough is an area of low atmospheric pressure running east-west through the tropics in summer months that brings large amounts of rain when passing near or over land. Seasons are characterised by a dry season between May and September and a wet season from October to April.

Winds

The long term wind roses (1942-2019) recorded daily at the Darwin Airport BoM station (Site number 014015) at 9am and 3pm indicate winds to be primarily from the east - southeast in the mornings and from the northwest in the afternoons. Stronger winds (>40km/hr or >11.1m/s) occur infrequently.

Wind roses for the Project are provided in chapter 3.4.1.5,

Figure 3-10.

Atmospheric Stability

Atmospheric stability refers to the tendency of the atmosphere to resist or enhance vertical motion of pollutants. The Pasquill-Turner assignment scheme identifies six Stability Classes (Stability Classes A to F) to categorise the degree of atmospheric stability. These classes indicate the characteristics of the prevailing meteorological conditions and are used in various air dispersion models.

Temperature inversions, a reversal of the normal behaviour of temperature in the troposphere, are defined as Class F; these scenarios only occur with clear and calm conditions during the evening and night time periods. The frequency of occurrence for each stability class for 2017 data is detailed in Table 7-69 below.

Table 7-69: Annual Stability class distribution predicted [TAPM-CALMET, 2017]

Stability Class	Description	Frequency of Occurrence (%)	Average Wind Speed (m/s)
A	Very unstable low wind, clear skies, hot daytime conditions	3.8	1.6
B	Unstable clear skies, daytime conditions	16.4	2.6
C	Moderately unstable moderate wind, slightly overcast daytime	20.8	3.6
D	Neutral high winds or cloudy days and nights	9.6	4.1
E	Stable moderate wind, slightly overcast night-time conditions	3.5	3.5
F	Very stable low winds, clear skies, cold night-time conditions	45.9	1.5

Mixing Heights

Mixing height refers to the height above ground within which particulates or other pollutants released at or near ground can mix with ambient air. During stable atmospheric conditions, the mixing height is often quite low and particulate dispersion is limited to within this layer.

Diurnal variations in mixing depths are illustrated in Figure 7-33. As would be expected, an increase in the mixing depth during the morning is apparent, arising due to the onset of vertical mixing following sunrise. Maximum mixing heights occur in the mid to late afternoon, due to the dissipation of ground-based temperature inversions and the growth of the convective mixing layer.

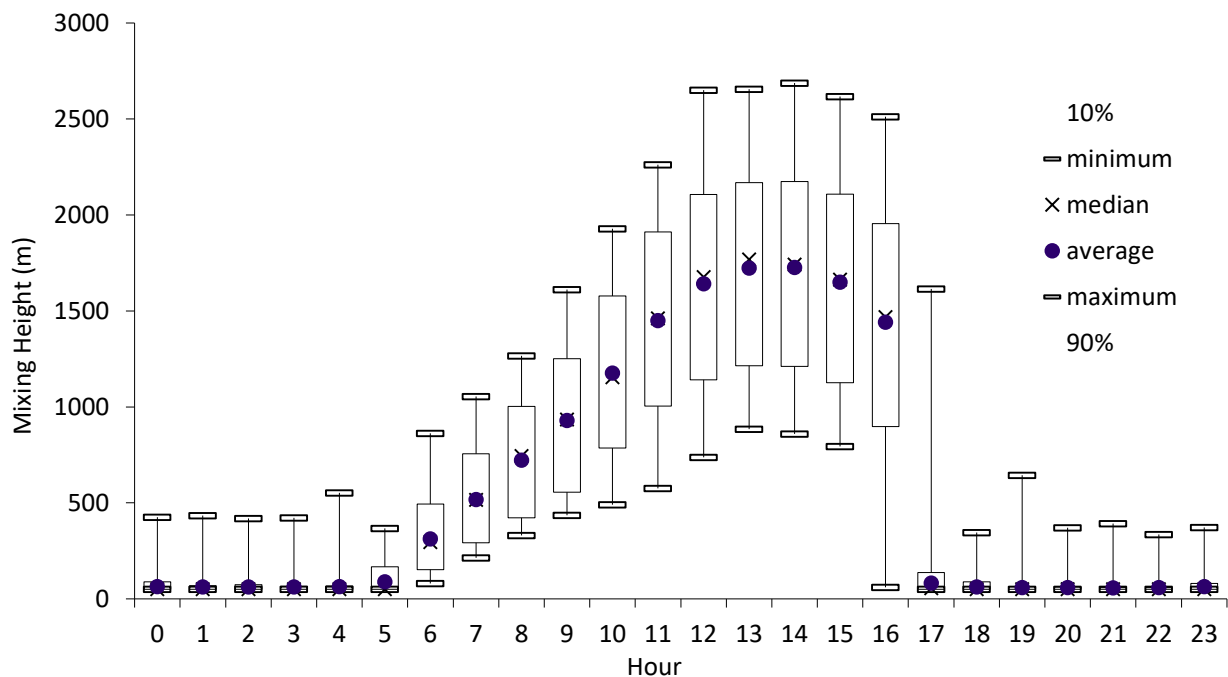


Figure 7-33: Mixing height [TAPM-CALMET, 2017]

7.10.3.2 Existing Sources of Potential Air Quality Impact

The Project area is situated within a rural environment, approximately 16 km in a direct line to Darwin City centre and 7.4 km in a direct line to Palmerston City centre. Within the region, anthropogenic sources of emissions with the potential to impact upon air quality include:

- Motor vehicles in Darwin and surrounding suburbs;
- Conoco Phillips gas processing plant including the gas power generation station;
- Channel Island Power Station;
- Weddell Power Station;
- Emissions from ships; and
- INPEX Ichthys LNG Facility.

In addition, regional smoke from wild fires and prescribed burning activities both locally and distant have the potential to contribute to air quality pollution.

7.10.3.3 Air Quality Criteria

The main regulatory framework for air quality is provided in the *National Environment Protection Measure for Ambient Air Quality 1998* (Air NEPM), which establishes national standards for the following key pollutants:

- Carbon monoxide;
- Ozone;
- Sulfur dioxide;
- Nitrogen dioxide;
- Lead; and

- Particles (PM₁₀ and PM_{2.5}).
- Given that specific air quality guidelines are not available for the NT, the goals set within the Air NEPM air quality standards have been used as the applicable criteria for the proposed Project.
- Modelling of air quality impacts has been undertaken utilising the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (NSW EPA 2016) guideline. The Approved Methods include criteria for individual toxic air pollutants based on a 1 hour averaging period and deposited dust as a maximum incremental and total level.
- Criteria specified for individual pollutants are presented in Table 7-70. Figure 7-34 indicated the sensitive receptor locations adopted for the modelling assessment.

Table 7-70: Project air quality goals

Pollutant	Basis	Criteria	Source	Averaging Time
Carbon monoxide	Human Health	11 mg/m ³	Air NEPM	8-hour
PM ₁₀	Human Health	50 µg/m ³	Air NEPM	24-hour
	Human Health	25 µg/m ³	Air NEPM	Annual
PM _{2.5}	Human Health	25 µg/m ³	Air NEPM	24-hour
	Human Health	8 µg/m ³	Air NEPM	Annual
Nitrogen Dioxide	Human Health	250 µg/m ³	Air NEPM	1-hour
	Human Health	62 µg/m ³	Air NEPM	Annual
Sulfur Dioxide	Human Health	570 µg/m ³	Air NEPM	1-hour
	Human Health	230 µg/m ³	Air NEPM	24-hour
	Human Health	57 µg/m ³	Air NEPM	Annual
Deposited dust	Nuisance	2 g/m ² /month ^a	Approved Methods	Annual
	Nuisance	4 g/m ² /month ^b	Approved Methods	Annual
Chlorine	Human Health	50 µg/m ³	Approved Methods	Annual
Hydrogen chloride	Human Health	140 µg/m ³	Approved Methods	Annual

a maximum increase in deposited dust level

b maximum total deposited dust level

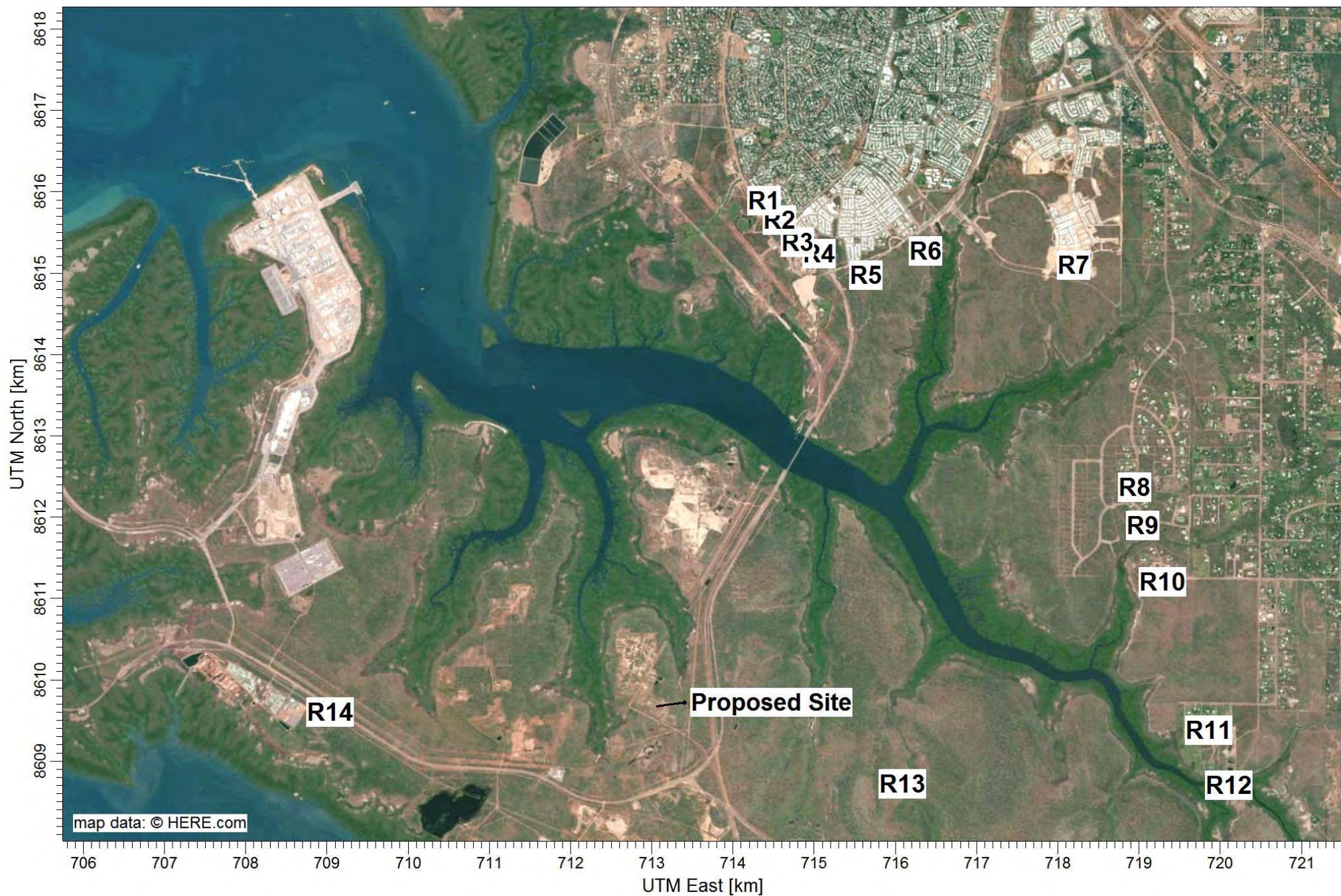


Figure 7-34: Sensitive receptor locations adopted for modelling assessment

7.10.3.4 Background Air Quality

The NT EPA monitors air quality at stations in Winnellie and Palmerston. These stations monitor a number of different pollutants and collect meteorological data. The Palmerston Air Quality Monitoring Station was established in 2010 and is located approximately 4km north of the Project site. Data from this station is used as a conservative representation of background air quality levels at the Project site.

The 90th percentile measured concentrations from the Palmerston Air Quality Monitoring Station are adopted as a conservative estimation of background air quality. Table 7-71 summarises the assigned background concentrations for the Project and compares them with the relevant criteria.

Table 7-71: Assigned air quality background level for the Darwin Processing Facility

Parameter	Criteria (µg/m ³)	Period	Applied Background (µg/m ³)
PM ₁₀	50	24 Hour	34.0
	25	Annual	19.9
PM _{2.5}	25	24 Hour	16.3
	8	Annual	7.6
SO ₂	570	1 Hour	17.2
	230	24 Hour	16.2
	57	Annual	7.4
NO ₂	250	1 Hour	11.5
	62	Annual	4.7
CO	11,000	8 Hour	596
Dust deposition	2 ^a 4 ^b	Annual	2

a maximum increase in deposited dust level in g/m²/month

b maximum total deposited dust level in g/m²/month

There are no significant sources of hydrochloric acid (**HCl**) and chlorine gas (**Cl₂**) in proximity to the Project site. Background levels of these pollutants are therefore estimated as negligible.

7.10.4 Existing Environment - Greenhouse Gases

A GHG is a gas that absorbs and emits radiant energy within the thermal infrared range. GHGs cause the greenhouse effect, a natural process that warms the Earth's surface by trapping heat from the sun in the atmosphere. Without GHGs, the average temperature of the Earth's surface would be around -18 °C (0 °F) rather than the present average of 15 °C (59 °F) that sustains life on Earth as we know it. The primary (natural) GHGs in the Earth's atmosphere include water vapour, carbon dioxide (**CO₂**), methane (**CH₄**), nitrous oxide (**N₂O**) and ozone (**O₃**).

Prior to the industrial era, concentrations of gases were roughly constant, however since the beginning of the industrial era (i.e. since 1750) human activities such as burning fossil fuels, farming and land clearing have increased the amount of GHGs released into the atmosphere. This traps more heat, causing the Earth's temperature to rise. The primary anthropogenic GHGs involved in global warming are CO₂, CH₄, N₂O and fluorinated gases; however, GHGs are generally measured using the standard unit, CO₂ equivalent (**CO₂ eq**). The existing emissions of GHG as a state, national, and international level are outlined in Climate Change chapter (chapter 7.10.5).

7.10.5 Existing Environment – Climate Change

7.10.5.1 Political Context

Australian Government

The Australian Government has stated its commitment (Commonwealth of Australia 2017) to addressing climate change while ensuring the maintenance of energy security, affordability and the competitiveness of industries. Through policy development, target setting and management strategies, Australia is contributing to global efforts to reduce emissions, while maintaining economic benefits and facilitating the transition to a lower-emissions future.

Climate change is a global issue that requires international action. Australia is a relatively small contributor to global emissions, accounting for 1.3 per cent of the global total. This compares to China (with 23.7 per cent), the United States (12.9 per cent) and India (6.6 per cent). Australia's per capita emissions and the emissions intensity of the economy are at their lowest levels in 28 years, partly due to Government policies, as well as slowing of the Australian economy (Commonwealth of Australia 2017).

Australia's target in the first commitment period of the Kyoto Protocol was to limit emissions to 108 per cent of 1990 levels over the period 2008–2012. This target was exceeded by 128 million tonnes of carbon dioxide equivalent (Mt CO₂-e). Australia is currently on track to over-achieve the 2020 target of reducing emissions by 5 per cent below 2000 levels by 294 Mt CO₂-e. The Australian Government has ratified the Paris Agreement with a target of reducing emissions by 26 to 28 per cent below 2005 levels by 2030.

Northern Territory Government

The NT is a relatively young economy that has recently started to grow and diversify (Northern Territory Government 2018). Growth is resulting in a larger environmental footprint from development, including rising emissions of GHG. The Territory has identified that it has a role to play in international and national efforts to reduce emissions and adapt to the impacts of a changing climate.

The NT has a distinct emissions profile due to its developing economy, small population, remote communities, agricultural focus and minimal land clearing. The Territory currently generates 3% of Australia's GHG emissions (Northern Territory Government 2018), with expectations that this will increase with ongoing industrial development.

Climate change impacts in the NT may affect weather patterns and could increase the intensity, if not occurrence, of extreme events like cyclones and heat waves. Climate change will require more intensive responses to natural disasters like drought, bushfire and flood.

The NT Government has committed to achieving 50% renewable energy by 2030, introducing new environmental protection legislation and developing an offsets policy. This will result in investment in broad-scale research to promote adaptation and resilience to impacts on agricultural systems, natural environment and industry.

7.10.5.2 Climate Change Predictions for the Darwin Area

The NT Government (2018) has released the following predictions for expected climate change impacts in the Northern Territory:

1. **Intensity of extreme weather events:** The frequency of tropical cyclones is expected to remain constant or decrease, however they are expected to be more intense. Higher storm surges are expected to impact the northern coast.
2. **Sea level rise:** Sea levels could rise by 65 cm to 87 centimetres (cm) above 2005 levels by 2100. This could lead to larger king tides and storm surges.
3. **Temperatures:** Over the past 100 years, average temperatures have already risen by around 1°C, and are expected to continue to rise a further 2.7°C to 4.9°C by 2100.
4. **Days over 35°C:** Hot spells and the number of days over 35°C are expected to be experienced for around 33% of the year by 2100.
5. **Variable rainfall:** There is uncertainty in the total projected rainfall for the northern region, but intensity of extreme rainfall is expected to increase.
6. **Bushfire intensity:** Fire intensity is expected to increase in the northern half of the Territory, while fire frequency is not expected to change.
7. **Evapotranspiration:** Evapotranspiration (a combination of evaporation and plant transpiration from the Earth's land and ocean surface to the atmosphere) is expected to increase in all seasons and is expected to be exacerbated by higher temperatures.
8. **Droughts:** Droughts are expected to continue, particularly in the southern region.
9. **Economic costs:** Total economic costs of extreme weather events in the Northern Territory were estimated at \$1.3 billion per year in 2017. This is expected to rise to \$3.3 billion per year by 2050. These figures do not factor in the impacts of heatwaves and other climate change events.

A detailed summary of predicted impacts of climate change in the Northern Territory is included in Appendix V.

The NT Government (2018) has noted that the challenge is to manage the impacts of climate change through a combination of avoiding and minimising impacts and implementation of mitigation and adaptation strategies.

7.10.6 Potential Impacts and Risks

Development of the Darwin Processing Facility (including the construction and operation stages) has the potential to impact air quality and will emit greenhouse gases. In addition, there are risks to the Project arising from climate change. The source-pathway-receptor model was used to identify potential impacts (Table 7-72). Individual pathways are discussed in the sections below.

Table 7-72: Potential impact pathways for air quality, GHG emissions, and climate change.

Source	Pathway	Receptor
Construction activities	Fugitive dust	Air Quality GHG emissions
	CO ₂ emissions from mobile plants/equipment	
Operation activities	Fugitive dust	
	Particulate emissions from point and fugitive emission sources	
	CO ₂ emissions from mobile plants/equipment	
	Stack gaseous emissions	
	Indirect CO ₂ emissions from use of electricity	
Extreme storm surges due to climate change	Inundation from extreme storm surge	Site infrastructure and surrounding environment

7.10.6.1 Fugitive dust

Dust discharges to air during the construction phase are primarily a management issue and can be minimised with good management practices.

During construction and operations, all dust deposition at the modelled sensitive receptors (including background levels), are below the relevant criteria. The most affected of the modelled receptors are the two closest (R13 and R14); at the planned future residential/urban area located in Weddell and Bladin Village – Workers Accommodation, which is west of the Project and of the prevailing winds (from the east) which have the potential to carry dust to the receptors.

7.10.6.2 Particulate emissions

During construction and operational phases, predicted levels of PM₁₀ and PM_{2.5} (including background levels), at the modelled sensitive receptors are well below the relevant criteria. The most affected of the modelled receptors are the two closest (R13 and R14) at the planned future residential/urban area located in Weddell and Bladin Village – Workers Accommodation, although both of these receptors are still within acceptable criteria.

7.10.6.3 CO₂ emissions from mobile plants

No specific data is available on the extent to which this equipment will be used at this stage, nor the type and quantity of fuel the equipment will use. However, given the limited surface area of the processing facility and that most of the facility will be used intermittently, it is inferred that fuel usage will be low and the associated CO₂ emissions were neglected from analysis.

7.10.6.4 Stack gaseous emissions

The predicted ground-level concentrations of combustion gases (nitrogen dioxide (**NO₂**), sulfur dioxide (**SO₂**) and carbon monoxide (**CO**) at the nearest sensitive receptors are below the adopted criteria for the Project (in isolation and including background). In addition, the maximum predicted concentrations of Cl₂ and HCl are well below the adopted criteria for sensitive receptors modelled.

Based on a typical process facility availability of 8,000 hours per year, the total CO₂ production from process sources is 76,149 tpa CO₂ EQ. These emissions account for residual CO₂ emitted to atmosphere from the use of natural gas and coke as a reductant in various processes. It is probable that both carbon rich feedstocks provide a thermal input to the process and so act as a fuel to some extent, however much of the carbon contained in these feedstocks will be sequestered in products and or residues as carbonates and similar compounds.

7.10.6.5 Indirect CO₂ emissions from use of electricity

The total CO₂ emitted externally to the Project as a result of electricity consumption is 204,711 tpa CO₂ EQ. This figure was determined using the annual estimated electricity consumption (1316 TJ) and the emission factor for the Darwin-Katherine interconnected grid. The Darwin-Katherine interconnected grid has one of the lower emission factors in Australia because natural gas is almost exclusively used to generate electrical power for the grid. The published factor for this grid is 0.56 kg CO₂ EQ - e/Kw-hr. The total of 204,711 tpa CO₂ EQ accounts for the greenhouse impact of CH₄ and N₂O as well.

National GHG impacts resulting from the Project

The most recent estimate of the NT's total annual GHG emissions was provided in the 2017 *State and Territories Greenhouse Gas Inventories* (DoEE 2019). This report indicated that the total emission of GHG in the NT in 2017 was 16.6 million tonnes of CO₂ eq. This figure incorporated estimates of emissions due to land use, land use change and forestry. This 2017 emission figure represented 3.1% of Australia's overall emissions.

The climate change discussion paper (NGT 2018) indicates that the Ichthys 1 and 2 gas trains will by themselves add a total of 7 million tonnes per year of CO₂ eq from 2019.

The calculated increase in emissions due to the operation of this Darwin Processing Facility (1,033,021 tpa) represents an increase of around 6.2% over the projected 2019 emissions for the NT and an increase of around 0.18% in Australia's overall emissions.

Whilst the increases in greenhouse gas emission are not regarded as highly significant in the context of either the National or Territory emissions inventories, they are large enough to exceed the facility threshold for NGERs reporting and are also sufficient to justify a focus on energy efficiency to minimise energy consumption and therefore GHG emissions.

In the absence of a NT climate change mitigation policy specifying a threshold for mandatory emissions offsets, the emissions from the facility are not regarded as being of such significance as to warrant the use of off-sets to mitigate the increase to the GHG inventory of the NT.

7.10.6.6 Inundation from extreme storm surge

The proposed site layout has been positioned landward of the secondary storm surge hazard zone. This provides substantial mitigation of inundation hazards. For the proposed site layout, there is no infrastructure below +7m AHD. Consequently, inundation risk is considered to be very low (<1%) through to negligible (<0.2%) across the site, for the proposed lifetime of the facility. Risks of inundation due to storm surges is dealt with in detail in chapter 7.6 and 7.7.

7.10.7 Mitigation and Management

The mitigation measures outlined in Table 7-73 will be implemented to reduce the risk of impacts to air quality and GHG emissions, as well impacts to the site arising from extreme storm surges due to climate change. More detail is provided in the management plans and procedures developed through the EMP (Appendix D).

Table 7-73: Air quality and GHG – potential impacts and mitigation measures

Pathway	Mitigation hierarchy	Mitigation measure
Fugitive dust	Avoid/Minimise	- Implement the Dust Emission Management Procedures (EP-11) within the EMP (Appendix D), including: - Regular watering of active areas and stockpiles areas; - Use of dust control equipment and housekeeping practices within the Processing Facility; and - Vehicle speeds on site roads will be restricted.
Particulate emissions	Minimise	All predictions for pollutants at the modelled sensitive receptors for the operation of the Project (including background) are below the relevant criteria and therefore no mitigation measures are required.
CO ₂ emissions from mobile plants	Minimise	Implement the Greenhouse Gas Emissions Procedures (EP-12) within the EMP (Appendix D).
Stack emissions	Minimise	- Use scrubbers for the control of atmospheric emissions from the Project stack sources, including stacks in the following process areas: - Oxide roasting; - Acid regeneration; and - Tail gas scrubber. - Key process vessels and equipment should be insulated to minimise energy loss. - Comply with requirements of the Environmental Protection Licence, where applicable.
Indirect CO ₂ emissions from use of electricity	Minimise	- Implement the Greenhouse Gas Emissions Procedures (EP-12) within the EMP (Appendix D), including: - Energy saving devices will be used where possible and based on the energy star ranking standard. - Consideration will be given to the use of alternative energy sources such as solar panels where feasible, as the Project progresses. - Key process vessels and equipment should be insulated to minimise energy loss.
Inundation from extreme storm surge	Avoid/Minimise	Mitigation measures for storm surges are detailed in the chapter 7.6.

7.10.8 Monitoring and Reporting

The EMP and associated sub-plans detail objectives, monitoring procedures and performance indicators, as well as corrective actions and reporting requirements. The sub-plans and procedures are reported through the EMP. Monitoring activities are outlined in Table 7-74, and other inspection and reporting measures are outlined in Table 7-75 below. The criteria for air quality were outlined in 1998 as part of the *National Environment Protection*

Measure for Ambient Air Quality, and in the Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (NSW EPA 2016). For more information, see Appendix V.

Table 7-74: Monitoring activities for air quality and GHG

Action	Timing	Methods	Criteria (derived from Air NEPM, or relevant NSW methods)
Air and Dust Monitoring	As per Environmental Protection License	As per Environmental Protection License	Carbon Monoxide – 11 mg/m ³ (8 hr average)
			PM ₁₀ – 50 µg/m ³ (24 hr average)
			PM ₁₀ – 25 µg/m ³ (annual average)
			PM _{2.5} – 25 µg/m ³ (24 hr average)
			PM _{2.5} – 8 µg/m ³ (annual average)
			Nitrogen Dioxide - 250 µg/m ³ (1 hr average)
			Nitrogen Dioxide - 62 µg/m ³ (annual average)
			Sulfur Dioxide - 570 µg/m ³ (1 hr average)
			Sulfur Dioxide - 230 µg/m ³ (24 hr average)
			Sulfur Dioxide - 57 µg/m ³ (annual average)
			Deposited Dust – 2 g/m ² /month (annual average)
			Deposited Dust – 4 g/m ² /month (annual average)
			Chlorine - 50 µg/m ³ (annual average)
			Hydrogen Chlorine - 140 µg/m ³ (annual average)

Table 7-75: Other inspections and reporting for air quality and GHG

Relevant Plan	Procedure (if relevant)	Monitoring	Reporting
Environment Management Plan	Dust Emission Management	The Production Superintendent and the Environmental Superintendent will carry out visual dust assessments on an ongoing basis. Monitoring in accordance with occupational exposure standards by Occupational Health and Safety Superintendent.	Significant dust emissions will be reported as an incident as per TNG Incident Reporting procedures. Annual Environmental Report Occupational exposures above standard to be reported in accordance with legislative requirements.
	Greenhouse Gas Emission	Monthly data collection of land cleared, fuel usage, electricity generation, rehabilitation, blasting and the quantity of material recycled. Annual compilation of monthly data.	Land cleared; fuel usage, electricity generation, rehabilitation and blasting will be reported in the Annual Report. Usage and production figures will be used to generate National Pollutant Inventory and National Greenhouse and Energy Reporting reports submitted on an annual basis as required.
Environmental Protection Licence	N/A	Monitor air stack emissions in accordance with Environmental Protection Licence requirements.	Annual Environmental Report Exceedance of emission criteria will be reported as an incident as per TNG Incident Reporting procedures. Incident reporting to NT EPA should exceedances occur.

7.10.9 Statement of Residual Impacts

In consideration of the outcomes of the EIA and proposed management measures, TNG considers that the EPA's objective for air quality, GHG emissions, and climate change can be achieved. However, some residual impacts remain after the application of mitigating factors.

Residual impacts occur for:

- Stack emissions; and
- CO_{2eq} emissions from Project operations.

As air quality at sensitive receptors is within criteria, and through implementation of management measures detailed above, the residual impact is not considered significant and no offsets are deemed to be required.



DRAFT ENVIRONMENTAL IMPACT
STATEMENT

DARWIN PROCESSING FACILITY

**ENVIRONMENTAL
FACTOR: SOCIAL,
ECONOMIC AND
CULTURAL
SURROUNDINGS**

7.11 ENVIRONMENTAL FACTOR: SOCIAL, ECONOMIC AND CULTURAL SURROUNDINGS

7.11.1 NT EPA Objective

The NT EPA's objective for the environmental factor Social, Economic, Cultural and Surroundings is to:

Protect the rich social, economic, cultural and heritage values of the Northern Territory.

This objective recognises the requirement to consider social, economic and cultural values as part of the holistic Project assessment and the importance of not significantly impacting these values as a result of a proposal.

This chapter describes the social and economic characteristics of communities near the Project area and identifies potential impacts and opportunities, mitigating measures and residual outcomes associated with development of the Project. Cultural aspects and the potential for heritage sites and Aboriginal Sacred Sites to occur within the project area are also considered.

TNG undertook a number of studies to inform this chapter, along with consideration of stakeholder engagement outcomes. The contents of this chapter specifically address chapter 3.2 and 3.3 of the EIS TOR (Appendix A).

7.11.2 Technical Studies

Technical studies undertaken to inform assessment of potential impacts of the Project on Social, Economic and Cultural Surroundings are listed in Table 7-76.

Table 7-76: Social, economic and cultural studies undertaken for the Project

Date	Study Title	Consultant	Description	Report
2019	Darwin Processing Facility – Socio-economic Impact Assessment	Elton Consulting	Documents the assessment method employed to scope, identify, analyse and manage all identified social and economic impacts of the Project.	Appendix F
2019a	Proposed Magnetite Processing Facility – Traffic Impact Assessment	Tonkin Consulting	This report presents a traffic impact assessment for the proposed development, detailing the likely traffic impacts on the wider road network.	Appendix X
2019b	Darwin Magnetite Concentrate Processing Facility – Noise Impact Assessment	Vipac Engineers and Scientists	Evaluation of potential impacts of noise generated from the construction and operational stages of the Project and to provide recommendations to mitigate any potential impacts that might have an effect on nearby sensitive receptors.	Appendix Z

7.11.3 Existing Environment and Values

7.11.3.1 Locality

The project is located in the Litchfield Council local government area (**LGA**). This large LGA has a land area of 308,306 ha and a population of 25,598 in 2018 (ABS 2018). The Litchfield LGA is a sparsely populated area with a population density of 0.8 persons per ha. Like many large-scale infrastructure projects, the likely social impacts can extend beyond one LGA; communities within the Palmerston LGA are more likely to be impacted by the Project due to the low population density of the Litchfield LGA. The Palmerston LGA covers an area of 5,641 ha

and recorded a population of 37,862 people in 2018. The City of Palmerston is a rapidly growing residential area, with light industrial areas in the suburbs of Pinelands and Yarrawonga.

7.11.3.2 Local Communities

The key communities considered to be part of the Project's area of influence are the Greater Darwin Area, Litchfield LGA, Darwin LGA and Palmerston LGA (Figure 7-1). The social baseline study focused on Palmerston LGA and the suburb of Bellamack (within the Palmerston LGA) for the following reasons:

- Bellamack is one of the more densely populated suburbs in the Greater Darwin Region;
- Bellamack is the closest significant community in terms of population density to the Darwin Processing Facility, despite being in a different LGA to the project; and
- Palmerston LGA is densely populated compared to the Litchfield LGA and contains the Palmerston Central Business District (CBD).

Greater Darwin Area

The Greater Darwin Area includes all areas mapped in Figure 7-35, which includes Darwin LGA, Litchfield LGA, Palmerston LGA and five unincorporated land parcels.

The Greater Darwin Area is home to more than half (59.8 percent) of the Northern Territory's population, around 136,830 residents. The median age is 33 which is slightly higher than the median age for the rest of the Territory of 32. Nearly three-quarters (73.2 percent) of households are family households where couples with children represent 46.5 percent of family compositions. The Greater Darwin Area has a lower proportion of Aboriginal and Torres Strait Islander residents than the rest of the Territory, 8.7 percent compared to 25.5 percent.

Litchfield LGA

Despite the size and proximity of the Litchfield LGA to Darwin and Palmerston CBDs, it is home to only 23,855 residents – equal to 10.5 percent of the Territory's population. The LGA has a significantly older population than the rest of the Territory and the Greater Darwin Area with a median age of 37. Families comprise the biggest household group representing 78.4 percent of all homes. Within this household group, the proportion of couples without children was higher than couples with children (47.5 percent compared to 39.5 percent). This is in step with the LGA being older. While the proportion of Aboriginal and Torres Strait Islander residents is higher than the Greater Darwin Area (9.7 percent compared to 8.7 percent) it is still significantly lower than that of the Territory (9.7 percent compared to 25.5 percent).

Major infrastructure projects important to the Litchfield LGA, outlined in the Litchfield Council Strategic Plan 2018-2022, include:

- Palmerston Regional Hospital;
- Ichthys LNG Project / INPEX natural gas facility;
- Emergency Waste Management Facility (planned); and
- Second Darwin International Airport (planned).

Darwin LGA

The Darwin LGA is home to 34.4 percent of the Territory's population, 78,804 residents. With the same median age as the rest of the Northern Territory, 32, the area is moderately young. Compared to the Greater Area of Darwin, there are slightly fewer family households (70.0 percent compared to 73.2 percent), with the representation of couples with children and couples without children fairly similar (44.4 percent compared to

40.0 percent). The Darwin LGA has the lowest representation of Aboriginal and Torres Strait Islander residents out of all the areas identified in this social baseline (7.4 percent).

The Darwin LGA has key infrastructure which supports the Darwin CBD, the major economic centre in the Northern Territory, including;

- The Darwin Airport;
- Major ports for export; and
- Tourism and hospitality hub.

Palmerston LGA

Palmerston LGA houses 14.8 percent of the Territory's population, roughly 33,790 people. The LGA is young with a median age of 30 and is primarily comprised of family households (78.5 percent). Of all family households, couples with children represent 50.6 percent while couples without children represent 31.8 percent. Palmerston LGA has the highest representation of Aboriginal and Torres Strait Islander residents out of all the surrounding areas, representing 11.3 percent of the residential population. While this is high compared to the surrounding areas it is still less than half the rate of the Northern Territory. The younger median age, high proportion of family households and high representation of couples with children reflects a community which is young and family orientated. New land release areas in the southern part of the LGA also reflect a narrative of a young and emerging community.

Palmerston LGA is one of the least disadvantaged LGAs in the country, with an Index of Relative Socio-Economic Disadvantage decile number of 9. The Index of Relative Socio-Economic Disadvantage measures the relative disadvantage of areas across Australia. There are 10 deciles evenly divided between 1 and 10. 1 indicates the 10 percent most disadvantaged areas and 10 the least disadvantaged areas. This means Palmerston is amongst the least disadvantaged LGAs in the country.

Bellamack

Bellamack is a small suburb on the southern fringe of the Palmerston LGA. It is a new development of approximately 2,458 people. Since the 2011 Australian Census the area has grown to become its own small suburb. Of notable importance to the area is its proximity to Palmerston City (10 minute drive) and Darwin (20 minute drive). Its unique location provides the opportunity for residents to live in detached dwellings in close proximity to regional economic hubs.

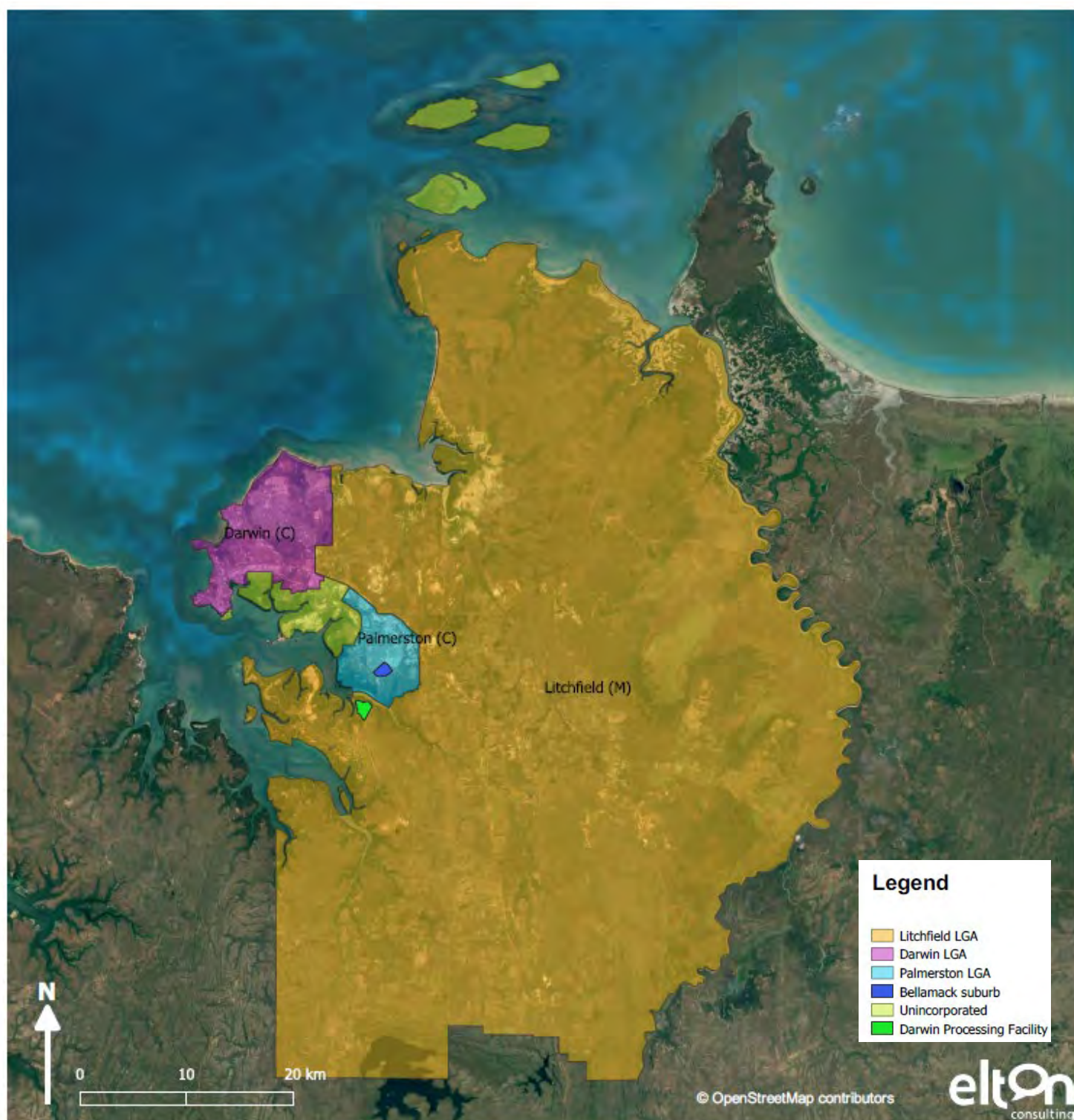


Figure 7-35: Local Government Areas located within the Greater Darwin Area

7.11.3.3 Education Profile

The highest level of education obtained by the majority of people aged 15 and over in Bellamack and the Palmerston LGA is a Certificate III or IV, with 26.6 percent and 24 percent of people having obtained this certification respectively. This figure drops to 16.5 percent for the rest of the Northern Territory.

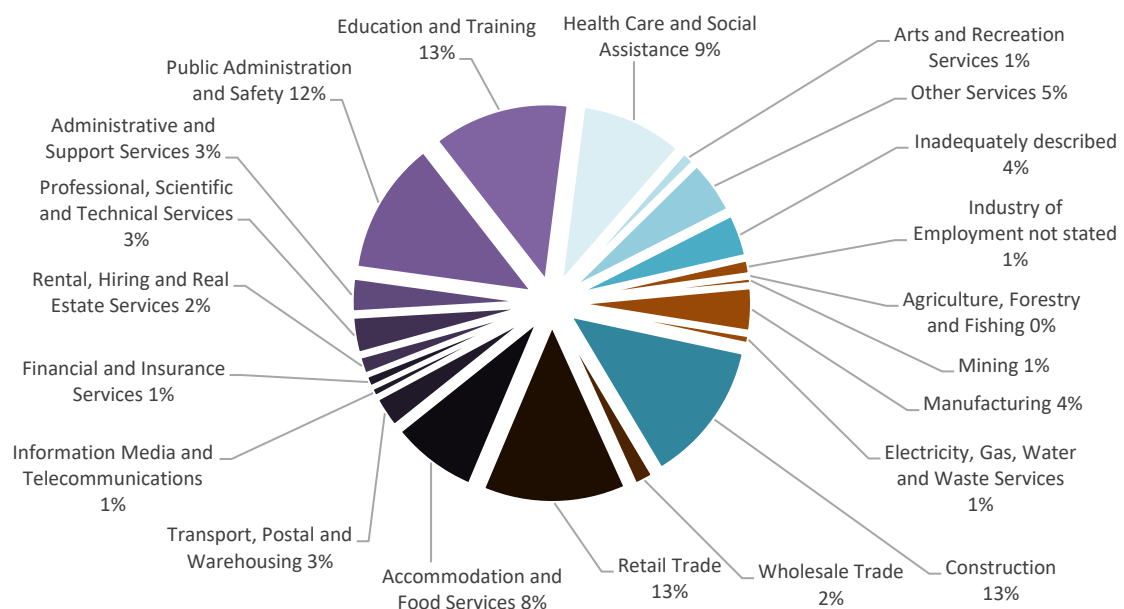
The number of people in Bellamack to complete a bachelor's degree or higher is 15.5 percent, which is higher than the number of people in the Palmerston LGA (14 percent) but lower than the rest of the Northern Territory (17.1 percent). The proportion of people reported having completed Year 12 as their highest level of educational attainment is 17.5 percent. This is higher than both the Palmerston LGA (15.4 percent) and the rest of the Northern Territory (12.7 percent). The high levels of TAFE completion or similar qualifications in Bellamack and the Palmerston LGA reflects the high proportion of trade workers and construction workers in the area.

7.11.3.4 Employment Statistics

With nearly three quarters of residents in fulltime work (73.2 percent) and fewer than one in five working part-time (16.9 percent), Bellamack has a high proportion of residents engaged in regular fulltime employment. When compared to the Palmerston LGA and the Northern Territory, the unemployment rate of 3.5 percent is lower than the rest of the Palmerston LGA (5.1 percent) and the Northern Territory (7.0 percent).

Industries of Employment

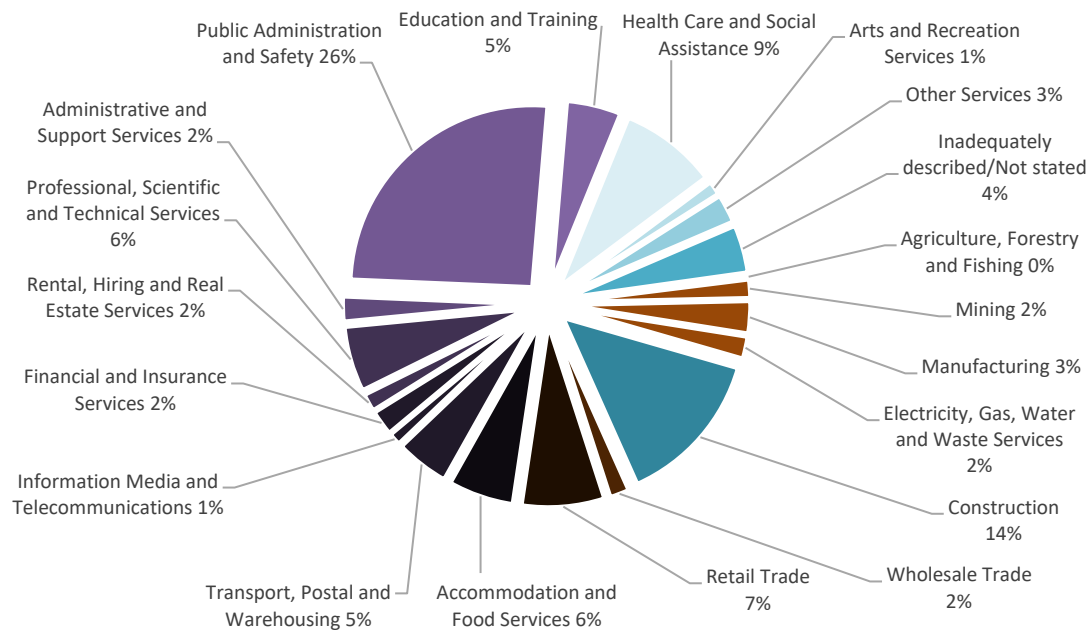
Figure 7-36 provides an indication of the industries of employment for the Palmerston LGA. Construction (13%), education and training (13%) and public administration and safety (12%) are the three biggest employers for residents of the Palmerston area.



Source: ABS Community Profile, Industry of Employment, Palmerston, 2016

Figure 7-36: Industries of employment, Palmerston LGA

The major source of employment for Bellamack residents is public administration and support services, accounting for 26% of all employment (Figure 7-37). Construction is the second largest industry of employment, accounting for 14 percent. Residents of Bellamack are engaged in slightly less diverse industries of employment compared to the Palmerston LGA, with the top two industries of employment accounts for 40 percent of employment in Bellamack compared to 26 percent in Palmerston LGA. The close proximity to Darwin evidently provides a range of employment opportunities for local residents in the construction industry



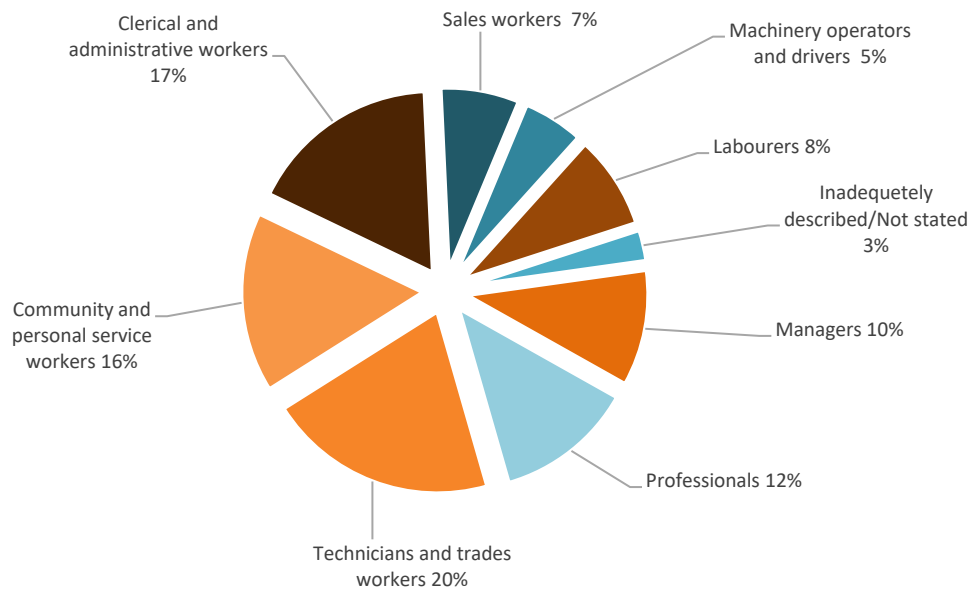
Source: ABS Community Profile, Industry of Employment, Bellamack, 2016

Figure 7-37: Industries of employment, Bellamack NT

Occupation types

The top three occupation types in Bellamack are technicians and trade workers (20%), clerical and administrative workers (17%) and community and personal workers (16%) (

Figure 7-38). The high proportion of residents who are technicians and trade workers is unsurprising considering the moderately high proportion of residents engaged in the construction industry.



Source: ABS Community Profile, Occupation by Sex (combined), Bellamack, 2016

Figure 7-38: Occupation statistics, Bellamack NT

7.11.3.5 Economy

Macroeconomic data published by the Australian Bureau of Statistics (ABS) and the Northern Territory Department of Treasury and Finance indicates that the Northern Territory recorded modest annual economic (Gross State Product (GSP)) growth – between 1.0% and 3.0% – over the last 4 years (2014-2018). In comparison, national Gross Domestic Product (GDP) growth remained between 2.0% and 3.0% over this time period. This is primarily due to the more pronounced cyclical nature of the Territory's economy, which is greatly influenced by the effect of large investment projects within the resources sector and corresponding transient inter-state migration.

More specifically, GSP increased by 1.7% to \$26.2 billion in 2018. This was the lowest economic growth rate recorded by any State or Territory in Australia that year. In comparison, the Australian Capital Territory (ACT) recorded the highest economic growth rate at 4.0% while national Gross Domestic Product (GDP) strengthened by 2.8%.

The GSP has been declining over the past three years, with the 2019 value forecast to be negative (recession). This trend correlates with increasing unemployment, projected to peak in 2020 at 4.6%.

On a more local scale, the Bellamack area has strong economic capital reflected by low unemployment (3.5 percent), relatively high income, with a median weekly personal income of \$1,089, and low levels of mortgage stress.

7.11.3.6 Population Growth

Rate of population increase

The southern part of the Palmerston LGA experienced substantial population growth over the 2011-2016 census period. The population statistics are presented in Table 7-77 below.

In 2011, Bellamack and Rosebery were counted as the same suburb with a total resident population of 3,745. Since then, Bellamack and Rosebery have become their own separate suburbs with a collective population of 6,676. Consequently, it is not possible to calculate the rate of population growth for Bellamack over this period, however three main factors suggest the area has undergone significant population growth:

- Bellamack and Rosebery were separated in the 2016 census
- Bellamack is a relatively new development implying rapid population growth from a low existing base rate
- The combined area of Rosebery and Bellamack increased by 78.3 percent between 2011 and 2016, both supporting the above points and indicating rapid growth in the two areas.
-

Table 7-77: Details the population growth between 2011 and 2016

	Bellamack	Rosebery	Rosebery - Bellamack	Palmerston LGA	Northern Territory
2011	N/A	N/A	3,745	27,703	211,945
2016	2,458	4,218	N/A	33,786	228,833
Rate of Population Increase	-	-	-	22.0%	8.0%

Source: ABS QuickStats 2011, 2016.

7.11.3.7 Local Infrastructure

Overall, Bellamack is a well serviced area with close access to education and healthcare services. The completion of a new hospital in Palmerston in 2018 will provide residents of Bellamack access to new and high-quality health services. There is a limited number of homes for rent, and even fewer units for sale, reflecting limited housing choice in the area. However, considering the size of the suburb, the number of homes for sale represents a relatively moderate availability. The closest police station to the Site is approximately 10 km away in Palmerston.

Access to the Project area is via Channel Island Road, which borders the Site to the west and the south. Channel Island Road is a two-lane sealed road under the care and control of the Northern Territory Government (Department of Infrastructure, Planning and Logistics). It consists of a single carriageway with one lane in each direction (each lane is 3.5m wide) and the posted speed limit is 90km/h at the proposed location of the processing facility. Channel Island Road extends from Palmerston to the north and Channel Island power Station to the south-west. Given the primarily industrial area to south-west of Channel Island Road, it is understood that most of the traffic utilising the road is generated by industry.

There is a level rail crossing on Channel Island Road, approximately 500m north-east of the intersection with Jenkins Road. The intersection with Jenkins Road has dedicated turn lanes provided. Jenkins Road is a two-lane (one lane in each direction) sealed road which connects Channel Island Road to the Stuart Highway south of the Arnhem Highway. Each lane provided on Jenkins Road has a width of approximately 3.5m.

There is no pedestrian or cycling infrastructure in the vicinity of the proposed site. Given the rural/industrial location of the site, pedestrians and cyclists are not expected to utilise Channel Island Road, and so the infrastructure is not considered to be required. It is noted that the road reserves are typically large and if demand for pedestrian and cyclist facilities increases, there is a potential to provide this infrastructure within the road reserve.

7.11.3.8 Sensitive Receptors

The environment in the vicinity of the Project can be characterised as rural, with more densely populated areas also within the vicinity. The locations of the nearest sensitive receptors to the Project are shown in Figure 7-39 and detailed below. In total, 4 sensitive receptors are located within the locality of the proposed Project:

- R1: Residential Receivers located on Gerardine Crescent, Bellamack – approximately 2.7km from the nearest site boundary.
- R2: Residential Receivers located on Boyd Court, Virginia – approximately 4.8km from the nearest site boundary.
- R3: Planned future residential/urban area located in Weddell – approximately 2.4km from the nearest site boundary.
- R4: Bladin Village – Workers Accommodation for the Bladin Point LNG Facility – approximately 4.3km from the nearest site boundary



Figure 7-39: Sensitive Receptor locations surrounding the Project Site

Legend

- Sensitive Receptors
- Development Envelope



Date: 22/11/2019



GDA 94 MGA Zone 52
Scale 1:15,000
Drawn by ems@animalplantmineral.com.au

7.11.3.9 Cultural and Heritage Sites

The traditional owners of the land on which the site sits and the wider Darwin area are the Larrakia people. There are approximately 2000 Larrakia people and eight major Larrakia family groups in the Northern Territory today. The Larrakia people have appointed the Larrakia Nation Aboriginal Corporation as the legal representative, responsible for ensuring that their country and people are looked after and that they play an active role in the decisions that affect them.

In a letter dated 31 July 2019, AAPA advised that there are no records of Aboriginal Sacred Sites listed within the Project area. TNG subsequently received an Authority Certificate for the Project site, issued under section 22 of the Northern Territory *Aboriginal Sacred Sites Act 1989*.

Despite the absence of known sacred sites, the letter indicates that the Project area is of cultural importance to the Larrakia people and reference was made by Aboriginal custodians to the possibility of burial sites being located within the Project area.

7.11.4 Project Economic Details

7.11.4.1 Economic Feasibility

TNG's strategy for the Mount Peake Project (incorporating both the Mount Peake mine site and the Darwin Processing Facility) is to develop dedicated mining and processing operations to produce three high-value, high-purity products for export - vanadium pentoxide, titanium dioxide and ferric oxide - through the application of the TIVAN® process.

In support, TNG has completed a number of studies for the Project, including a Definitive Feasibility Study (July 2015) and an Updated Feasibility Study (November 2017). In November 2018, TNG appointed German-based metallurgical engineering group SMS group to commence a Front-End Engineering and Design study for the Mount Peake Project.

In September 2019, as part of the ongoing Front-end Engineering and Design process, TNG completed an optimised project execution and delivery strategy, with the objective of simplifying the Project to make it more amenable to project financing. TNG is progressing with a development strategy based on a single stage production rate of 2 Mtpa ore throughput at the Beneficiation Plant at the Mount Peake mine site and 700,000 tpa feed of magnetite concentrate through the Darwin Processing Facility.

The development strategy is supported by an updated Interim Financial Model incorporating financial analysis of a revised mining schedule for the Project that focuses on two higher-grade vanadium pits within the Resource during the first 10 years of operations. The Interim Financial Model has confirmed the robust economics of the Project and identified pre-production capital expenditure of A\$824 million for development. The Mount Peake Project is forecast to achieve a pre-tax and pre-finance Internal Rate of Return of approximately 33% and a Net Present Value of approximately A\$2.8 billion (at an 8% discount rate). A summary of the key outcomes of the Interim Financial Model is provided below in Table 7-78.

Table 7-78: Key outcomes of the interim financial model

Metric	Interim Financial Model
Pre-production Capex	A\$824 million
Pre-tax IRR	33%
Pre-tax NPV _{8%}	A\$2.8 billion
Payback	2.8 years
Pre-tax net annual average cash-flow	A\$359 million
Life-of-mine net cash-flow	A\$12.2 billion
Mine life	37 years
Ore throughput	2Mtpa
Processing Facility life	40 years
Concentrate throughput	700,000 tpa

7.11.4.2 Economic Stimulus

The total capital investment value of the Darwin Processing Facility is estimated at between \$500m-\$600m. Considering this amount, the total stimulus into the economy based on applying investment in the Project is as follows. It should be noted however that this application is broad and should not be counted on top of other generating features such as employment and other taxation revenue.

- \$318.5 million in value add;
- 1,311 full time equivalent jobs;
- \$15.3 million in welfare savings; and
- \$100.6 million in taxes in Australia.

7.11.4.3 Tax Impacts

The Project will generate tax inputs for both the NT and Commonwealth economies. Key taxes include:

- Corporate Taxes – to be realised by the Commonwealth Government; and
- Payroll Taxes – to be realised by the NT Government.

Estimated taxation benefits likely to be achieved from the Project are as follows:

- \$0.03 in corporate tax on every \$1 generated in income for construction and \$0.02 in corporate tax on every \$1 generated in income for manufacturing (primary metal and metal product manufacturing).
- Construction phase payroll tax obligation estimate of approximately **\$3,361,372 per annum** based on multiple project parameters.
- Operational phase payroll tax obligation estimate of approximately **\$1,911,516 per annum** based on multiple project parameters.

7.11.5 Assessment of Opportunities

The social impact assessment undertaken by Elton Consulting (2019) (refer Appendix F) identified potential opportunities and impacts associated with the construction/operational phases of the proposal. The key opportunities considered in the assessment are:

- Boost to direct and indirect local employment;
- Provision of skills training, apprenticeships and scholarships to local people, especially Aboriginal and Torres Strait Islander people;
- Local business benefit from project-related contracts;
- Boost to local housing market; and
- Increased population.

Each of the potential opportunities are discussed in the chapters below.

7.11.5.1 Employment opportunities

The construction and operation of the Darwin Processing Facility will require a significant number of highly skilled, skilled and unskilled workers. Total workforce numbers are expected to peak at 700 to 1000 during construction, with approximately 600 required throughout the expected 40 year operational phase. As a result, there will be an increase in employment opportunities for local area residents and Greater Darwin residents; particularly those with skills in construction and trades, those currently looking for work (on unemployment registers), recent school graduates considering vocational careers from around Bellamack (high youth population) and those looking to up-skill or diversify their work experience.

TNG is committed to maximising employment opportunities for local workers and ensuring ongoing communication with the local community and businesses regarding job numbers and opportunities. Details of how TNG will prioritise local recruitment are detailed in the Economic and Social Impact Management Plan (EIMP), which is provided as Appendix W.

7.11.5.2 Provision of skills training, apprenticeships and scholarships

The Project will provide opportunities for local skills and training development, particularly to Aboriginal and Torres Strait Islander people and other focus groups. Skills training schemes, such as sponsored apprenticeships or scholarship programs will target local community groups, especially those experiencing socio-economic disadvantage, unemployed people in the area of social influence, or local youth.

These training schemes will involve the development of partnerships with local training providers to co-deliver training programs that will lead to improved education levels and diversification of industry-related skills in the Greater Darwin area, bringing about improved social capital, employability, increased household incomes and general community wellbeing.

7.11.5.3 Local business opportunities

The construction and operation of the Project will require regular services and supplies. There is an expectation that this will provide service and supply opportunities to local businesses in the area, particularly Palmerston and Darwin. This will further stimulate the local economy through direct and indirect jobs, business growth and new opportunities for Darwin-based goods and service providers, including nearby accommodation providers, transport, food and beverage businesses and catering services for the incoming construction workforce.

To enhance the opportunity for local business, TNG will ensure that recruitment and procurement processes prioritise the local market. Local service and supply requirements will be specified in agreements with

contractors. Tenders will be packaged to suit local capacity where possible. Tender opportunities will be promoted early to allow businesses to prepare for competitiveness and to meet the standards required.

TNG is also committed to proactively identifying local businesses with the capability to work on the Project. Ongoing communication will occur with the community and business sector about Project details to ensure that expectations about job numbers and business contracts associated with the Project are realistic.

7.11.5.4 Boost to local housing market

The potential influx of interstate workforce and their families relocating into existing residential areas could see a boost to the local housing market. Property price inflation may benefit those looking to sell their homes or new residential developments, as the incoming skilled worker population will have a proportionately high household income and will likely settle in Bellamack or other new residential localities in Palmerston LGA, where there is an existing supply of new housing and shortage of buyers.

7.11.5.5 Increased population

Personnel and their families who choose to reside in Palmerston and Litchfield LGAs may result in a population growth of approximately 1.5%. This will facilitate population diversification, increasing the critical mass to improve public infrastructure and services over time, and align with the LGA's strategic liveability priorities.

TNG will ensure that relocating workers and their dependents are incentivised to informally and formally interact and integrate with the local residential population, to ensure positive social outcomes as a result of the incoming resident workforce.

TNG will also aim to develop strong partnerships with the Litchfield and Palmerston Councils to collaborate on mutually beneficial community programs and local growth initiatives in order to align local government strategies with implications of the project on the local area. Furthermore, TNG will continually consult with the local councils to ensure community investment programs are consistent and complimentary to government plans.

7.11.6 Potential Impacts and Risks

Social impacts are subjective, with activities having a different impact on individuals depending on their specific circumstances, personal level of concern for an aspect and proximity to activities. The social impact assessment undertaken by Elton Consulting identified the following positive impacts associated with the Project:

- The social wellbeing benefits that result from expectant economic gains the project will bring to the NT and Greater Darwin area through employment;
- The provision of skills training, apprenticeships and scholarships to local workers and people looking for work, especially local Aboriginal job-seekers;
- The economic stimulus expected to result for local suppliers due to the incoming workforce creating an increased demand for a number of service industries and suppliers;
- The benefits the incoming worker population will bring to the local housing market through local property inflation, in particular the benefit for those looking to sell their homes;
- The moderate increase in population likely to materialise across the Palmerston LGA brought about through the incoming workforce and their dependents is expected to drive investment in social infrastructure and bring indirect local economic benefits.

Negative impacts potentially associated with the Project proposal appear in Table 7-79.

Table 7-79: Potential pathways for impact on social, economic and cultural surrounds

Source	Pathway	Receptor
Construction and Operation activities	Contamination or restriction of use of the Elizabeth River and the Darwin Harbour	River and Harbour users
	Reduction in housing availability and affordability	Low-income and vulnerable groups
	Public access and safety	Recreational users of the Site, General Community
	Impact to cultural or heritage values	Traditional owners, General community
	Reduced amenity due to noise and vibration impacts from Project activities	Nearby residents, workers at nearby locations, professional road transport vehicle operators
	Traffic delays, congestion and increased road safety risk	Vehicle operators in the vicinity of the Project
	Visual amenity impacts	Nearby residents, workers at nearby locations, river and harbour users
	Light impacts	Nearby residents, vehicle operators in the vicinity of the Project, river and harbour users

A comprehensive list of all the potential negative impacts associated with the Project can be found in the Impact and Risk Assessment section of the SEIA. Discussion of the above potential negative impacts and mitigation measures are included in the chapters below.

7.11.6.1 Contamination or restriction of use of the Elizabeth River and the Darwin Harbour

During the Social Impact Assessment, potential contamination of the Elizabeth River and the Darwin Harbour from construction and operation of the Project was recognised as a high concern for community members and other stakeholders. The key concerns relevant to social factors were impacts on fish stocks and amenity for recreational pursuits in the Darwin Harbour.

Potential water quality impacts in the Darwin Harbour system, and possible secondary effects on fish species as a result of Project activities, have been detailed, along with proposed mitigation measures, in chapters 7.6, 7.7 and 7.8.

Access to the Elizabeth River from the Elizabeth River Boat Ramp will not be restricted by Project activities; Project operations will be contained within the boundary of Lot 1817. The outfall pipeline will be situated on the riverbed and will not impact on recreational users.

7.11.6.2 Reduction in housing availability and affordability

An incoming Project workforce has the potential to have a positive effect on homeowners, with the potential for property values and rental returns to increase. However, adverse effects may result from decreased housing availability and affordability in surrounding suburbs; this would mostly affect low-income earners, vulnerable groups and renters.

7.11.6.3 Public access and safety

The site is currently degraded and utilised for illegal dumping of rubbish and vehicles; it is also regularly used by off-road motorbikes and four-wheel-drive vehicles.

Public access to the site following commencement of TNG activities could pose a safety risk to members of the community. In order to reduce the risk of harm to members of the public, TNG will implement mitigation and management strategies, as detailed in the below chapters.

7.11.6.4 Reduced amenity due to noise

During consultation, some stakeholders expressed an interest in the potential for noise and vibrations from the Project site and transportation routes, particularly for residents of nearby communities.

TNG has engaged Vipac Engineers & Scientists Limited (**Vipac**) to conduct a noise impact assessment for the construction and operational phases of the Project. Outcomes of the assessment are tabulated below and presented in Appendix B of the Noise Impact Assessment (Appendix Z).

The assessment has been undertaken in accordance with the NT EPA *Northern Territory Noise Management Framework Guidelines*.

Construction Noise

The construction phase will necessitate the use of a range of noise generating equipment at the site including, but not limited to:

- Earthmoving equipment (e.g. front end loaders, grader, scraper);
- Cranes;
- Concrete mixers and pumps;
- Generators;
- Compressors;
- Pile drivers; and
- Pneumatic and hydraulic breakers.

Modelling of Project construction noise impacts at the four sensitive receptor locations identified on Figure 7-39 was completed by Vipac for both neutral and worst-case climatic conditions. Results are presented in Table 7-80 and Table 7-81.

Table 7-80: Predicted construction noise levels – neutral climatic conditions

Receptor ID	Predicted Noise Levels L _{Aeq} dB(A)	Recommended Assigned Noise Affected Level L _{Aeq} dB(A)		Complies with Criteria?	
	Neutral Climatic	7am-7pm	7pm-7am	7am-7pm	7pm-7am
R1	29	45	37	✓	✓
R2	24			✓	✓
R3	36	37	29	✓	+7
R4	24			✓	✓

Table 7-81: Predicted construction noise levels – worst climatic conditions

Receptor ID	Predicted Noise Levels L _{Aeq} dB(A)	Recommended Assigned Noise Affected Level L _{Aeq} dB(A)		Complies with Criteria?	
	Worst Climatic	7am-7pm	7pm-7am	7am-7pm	7pm-7am
R1	35	45	37	✓	✓
R2	29			✓	✓
R3	42	37	29	+5	+13
R4	32			✓	+3

Construction noise is predicted to comply with criteria for standard and non-standard operation hours with the exception of the following:

- Criteria is exceeded at Receiver 3 during non-standard hours in neutral climatic conditions;
- Criteria is exceeded at Receiver 3 for all time periods in worst case climatic conditions;
- Criteria is exceeded at Receiver 4 during non-standard hours in worst case climatic conditions.

TNG intend to conduct noise generating activities during standard operating hours throughout the construction period. This will avoid noise criteria exceedances within non-standard hours.

Currently, Weddell Urban Area (Receiver 3) is yet to be developed. Should development of this area coincide with construction of the Project, TNG will initiate measures to mitigate noise impacts on that receptor.

Operational Noise

Operation of the Darwin Processing Facility will be continuous and will incorporate a range of fixed and mobile plant and equipment.

Results, provided in Table 7-82, indicate that operational noise from the Project site is predicted to comply with the day, evening and night time criteria at all receivers during neutral and worst case climatic conditions without the need for site specific noise mitigation.

Table 7-82: Predicted operational noise levels

Receptor ID	Predicted Noise Levels L _{Aeq} dB(A)		Project Specific Assigned Noise Levels L _{Aeq} dB(A)			Complies with Criteria?		
	Average Climatic	Worst Climatic	Day	Evening	Night	Day	Evening	Night
R1	15	20	40	40	35	✓	✓	✓
R2	14	19				✓	✓	✓
R3	27	33	36	35	35	✓	✓	✓
R4	17	23				✓	✓	✓

Rail Noise

Calculations were conducted to predict noise from diesel freight locomotives from the proposed rail siding at the Project. The predicted noise levels of rail movements specific to the Project site, inclusive of the conservative assumptions, are detailed in Table 7-83 below.

Table 7-83 Predicted rail noise levels

Receptor	Predicted Noise Levels			Complies with Criteria?		
	Day (7am-10pm)	Night (10pm-7am)	L _{Amax}	Day (7am-10pm)	Night (10pm-7am)	L _{Amax}
	L _{Aeq} (15hr)	L _{Aeq} (9hr)		L _{Aeq} (15hr)	L _{Aeq} (9hr)	
				60	55	80
R1	38	41	71	✓	✓	✓
R2	38	41	71	✓	✓	✓
R3	41	44	74	✓	✓	✓
R4	38	41	71	✓	✓	✓

Noise from rail pass-bys associated with the Project site are predicted to comply with the relevant NT rail criteria during all time periods at all receivers, without the need for noise mitigation.

7.11.6.5 Traffic delays and congestion

The areas most sensitive to traffic delays or congestion as a result of the Project are along Channel Island Road and more specifically, the two level rail crossings at Channel Island Road and Jenkins Road. As part of the proposed facility, the following transport infrastructure will be required:

- Road access to/from the existing Channel Island Road.
- A rail siding running parallel to the Adelaide-Darwin railway.

A traffic impact assessment has been prepared by local specialists Tonkin Consulting Pty Ltd to assess the impacts of project traffic on the existing road network in terms of increases in traffic and congestion (Appendix X).

Construction Traffic

The construction phase is estimated to take approximately 24 months and will be undertaken over both the wet and dry season. Daily vehicle movements between the camp and the site during the construction phase will include:

Daily vehicle movements external to the site (primarily between the port and the site) will include:

- 4 crane movements
- 8 flatbed truck movements
- 4 fuel/lubrication truck movements
- 4 light vehicle movements

In addition to the above, there are potentially light vehicle and/or bus movements associated with transporting workers to and from the site.

Considering the identified staffing numbers and proposed roster, it is anticipated that a total maximum daily traffic generation of up to 2,020 vehicles per day could be expected (worst case).

Based on the yearly traffic counts undertaken on Channel Island Road by DIPL, the current daily traffic volume is approximately 3,055 vehicles per day. Adding the maximum traffic anticipated to be generated by the Project during construction, total daily traffic of 5,075 vehicles per day could be expected. This would be approximately 500vpd higher than the observed traffic volume in 2014 and therefore could reasonably be accommodated by the road network.

This traffic could be significantly reduced if buses were adopted to transport workers to and from the site. If all workers travel by bus, the total daily traffic is anticipated to be approximately 95 movements per day. This reduces the anticipated traffic on Channel Island Road to approximately 3,150 vehicle movements per day.

It is anticipated that even assuming a worst case traffic generation, the available capacity within the road network would allow the identified development to operate without issue.

Operational Traffic

Upon completion of the construction phase, usage of the site will consist of operational and maintenance related traffic. Vehicle movements within the site will be on purpose-built roads and have not been discussed further within this section.

Daily vehicle movements external to the site (primarily between the site and the Darwin Port) will include:

- 4 isotainer truck movements
- 10 quad road train movements
- 2 flatbed truck movements
- 4 fuel/lubrication truck movements
- 16 light vehicle movements

It is identified that the above (36) movements would occur outside of the peak hours for staff movements.

In addition to the above, there will be light vehicle and/or bus movements associated with employees travelling to and from the site.

The total daily traffic movements for the operations/maintenance phase is approximately 985 vehicles per day if all staff drive independently to and from the site. If it is assumed (worst case) that if each staff member drives, the following hourly movements are anticipated:

- 7am – 189 movements away from the site;
- 8am – 284 movements to the site;
- 4pm – 91 movements away from the site;
- 6pm – 193 movements away from the site;
- 7pm – 189 movements towards the site.

It is expected that the majority of staff movements will be to and from the north along Channel Island Road (as this provides access to Palmerston and Darwin).

Assuming a worst case traffic generation, the available capacity within the road network would allow the identified development to operate without issue. However, a small fleet of buses could reduce traffic movements to 75 per day, greatly reducing the potential impact on Channel Island Road and the wider road network.

Rail Movements

The site will be serviced with a rail siding that facilitates movement of materials to and from the Processing Facility. There are proposed to be 3 cycles per week to and from the south and 7 cycles to and from East Arm per week. The proposed maximum train length is approximately 1,200m.

There are two level crossings nearby (Channel Island Road and Jenkins Road). Both level crossings currently have advance warning signage on the approaches to the level crossings. The operation of these level crossings will be impacted by the trains travelling to and from the south.

Approximately 30 seconds clearance plus advance warning time of 10 seconds is required in addition to the clearance time for a train. The total clearance time would be approximately 7 minutes if the train was travelling at 10km/h.

This represents a significant delay to traffic along Channel Island Road and Jenkins Road. Mitigating measures will be implemented wherever possible to reduce rail movement impacts on traffic congestion.

7.11.6.6 Visual Amenity Impact

Large areas of degradation and high voltage power lines dissecting the Project area have resulted in reduced on-site visual amenity. Notwithstanding this, from an off-site perspective, particularly from the Elizabeth River aspect, the site currently has no built infrastructure and is screened by the mangrove belt, resulting in little visual impact on the skyline.

An indicative artist impression of the Facility is provided in Figure 7-40. The site will consist of multi-story buildings, 7 stacks ranging between 22 m – 40 m in height, rail siding, carparking, laydown areas and water storage dams.

In an effort to reduce the visual impact of the Project, particularly from the Elizabeth River Boat Ramp, TNG repositioned the Processing infrastructure to the southern peninsula of the site. With retention of the mangrove belt, this amendment will result in only the top of stacks being visible at the Jetty; no aspect of the Project is anticipated to be visible at river level.

Some site infrastructure will be momentarily visible from the Elizabeth River Bridge and when travelling along parts of Channel Island Road; this is not expected to reduce the amenity of the area, however, as it is a designated industrial precinct.



Figure 7-40: Indicative artist impression of the Darwin Processing Facility

7.11.6.7 Light Impact

Glare can have significant nuisance and safety consequences where lighting has been designed without any consideration for the effects on adjoining properties or road users.

Light nuisances depend on:

- the intensity of the light;
- the duration and rate of emission of the light;
- the sensitivity of the environment and the impact of the light.

The Facility site will use visual light only, suitable for human movement. The light design will aim to control the effects of exterior lighting on neighbouring properties and to minimise the effect on road safety.

Australian Standard AS 4282 - 1997 '*Control of the obtrusive effects of Outdoor Lighting*' will be used as a basis for determining intrusive nuisance resulting from the glare effects of outdoor lighting.

The standard takes account of several aspects of potential obtrusiveness, the light falling on surrounding properties, the brightness of the luminaries in the field of view of nearby receptors, glare to users of adjacent transport systems and the effects of astronomical observations.

Setting a maximum lux level in accordance with the Australian Standard will assist in safeguarding amenity values. All lighting fixtures shall be designed and installed to be directional; ensuring light outside of target areas is minimised.

7.11.6.8 Cultural and Heritage Risks

The key potential impact and risks to cultural and heritage values includes the destruction of any culturally significant site (including burial sites), which would have implications for cultural and spiritual connections and potentially ceremony and passing-on of knowledge.

AAPA advised that there are no records of aboriginal sacred sites listed within the Project area and have issued TNG with an Authority Certificate for the Project site. The certificate covers the Project site and all ancillary works including routine and ongoing maintenance of any infrastructure and or services. It confirms that there are no Registered or Recorded Sacred Sites in the area, although archaeological places or objects may exist within the subject land for the certificate.

Due to the absence of known aboriginal sacred sites within the Project area, the risk of disturbance or destruction to a site is low. However, if a previously unrecorded archaeological site is encountered the Northern Territory Heritage Branch will be contacted for advice. Furthermore, as per a request from the Larrakia people, all excavated soil will be utilised in its area of origin and none of it will be removed off-site.

Whilst the cultural and heritage risks on-site are anticipated to be low, TNG recognises that mitigating actions for the Project are essential to ensure impacts from Project activities do not occur on downstream cultural or heritage sites. Applicable mitigating measures are described below and also throughout the EIS document.

7.11.7 Mitigation and Management

The mitigation measures outlined in Table 7-84 will be implemented to reduce the risk of impacts on social, economic and cultural factors. More detail is provided in the management plans and procedures developed through the EMP (Appendix D), ESIA (Appendix F), ESIMP (Appendix W) and Traffic Management Plan (Appendix Y).

Table 7-84: Social, economic and cultural aspects – potential impacts and mitigation measures

Opportunity / Risk	Mitigation hierarchy	Mitigation measure
Employment opportunities	Promote	- Develop an Employment Strategy and Local Recruitment Policy. - Employ local personnel, wherever possible and where necessary skills are available. - Develop employee relocation incentives to encourage a greater residential workforce. - Utilise local businesses wherever possible to increase indirect local employment opportunities.
Provision of skills training	Promote	- Establish a skills training scheme. - Liaise with local institutions to ensure skills required for the Project are catered for in education programs.
Local business opportunities	Promote	- Establish partnerships with local businesses, such as food catering companies, transport companies and a range of other service providers. - Initiate early engagement with potential local businesses to ensure Project requirements are understood and businesses have an opportunity to review capabilities to be able to service Project needs.
Reduced Housing Affordability	Minimise	- Establish partnerships with Litchfield and Palmerston Councils to collaborate on local housing issues. - Investigate options for entering into partnerships and share-value agreements with local temporary accommodation providers to house construction and operational staff.
Public Access and Safety	Avoid/Minimise	- Install a boundary fence, entry gate, gate house and signage to deter unauthorised access to the site - Develop a Supply Chain Management Plan covering a wide range of transportation and supply chain matters, including public safety along transport routes and managing third party personnel conduct at work. - Ensure emergency exit points are situated at strategic locations around the site, for use in an emergency. - Ensure sufficient lighting and signage is installed to avoid injury to public within the vicinity of the site.
Contamination or restriction in use of Elizabeth River resulting in impacts on recreational pursuits	Avoid/Minimise	- Implement mitigating strategies detailed in chapter 7.5 – Hydrological Processes - Implement mitigating strategies detailed in chapter 7.7 – Marine Environmental Quality - Ensure Elizabeth River Boat Ramp access is maintained at all times - Develop a Community and Stakeholder Engagement Plan, including mechanisms for providing information on Project activities and for identifying and addressing ongoing concerns throughout the life of the Project - Implement a Complaints and Grievance Protocol, incorporating prompt mitigation of concerns as appropriate.

Opportunity / Risk	Mitigation hierarchy	Mitigation measure
Noise Impacts	Avoid/Minimise	• Implement mitigation strategies detailed in the Noise Management EP-21 from the EMP (Appendix D). • Provide an induction to construction personnel (including sub-contractors) addressing responsibilities with regard to noise management outlined in the EMP (Appendix D). • Ensure truck drivers are informed of designated vehicle routes, parking locations, delivery hours and minimising engine braking and idling. • Provide education of supervisors, operators and sub-contractors on the need to minimise noise through toolbox meetings. • Select appropriately sized equipment for the task, such as earthmoving/excavation equipment. • Avoid noisy plant working simultaneously where possible. • Ensure all equipment is equipped with appropriate noise controls (e.g. mufflers, silenced exhausts, acoustic enclosures, flashing lights as an alternative to reversing beepers) and equipment is shut down and not left idling when not in use. • Ensure equipment is operated in the correct manner and adequately maintained - including replacement of engine covers, tightening of rattling components, repair of leakages in air lines and shutting down equipment not in use. • Consider the use of temporary solid screens for mitigation of noisy stationary equipment. • Consider the use alternatives to 'beeper' style reversing alarms, such as broadband style alarms (or quacker alarms). • Establish a Complaints and Grievance Protocol to address noise complaints.
Traffic Impacts	Avoid/Minimise	• Develop a Traffic and Transport Management Plan (Draft version included as Appendix Y. This document will be finalised as part of final design stage of the Project). • Design site access and egress to ensure safety is maintained for TNG staff and public road users. • Liaise with appropriate regulators to ensure adequate signage is installed to notify public road users of trucks entering and exiting the site. • Provide a bus service to and from the site for staff, reducing traffic volumes on roads in the vicinity of the Project. • Investigate options of utilising existing infrastructure for 'Park and Ride' locations. • Review the potential for cyclist infrastructure to provide a safe link for staff travelling to and from the site by bicycle. • Develop safe and efficient parking on the site. • Maximise the length of the proposed rail siding line to minimise the potential for delay at the level crossings. • Liaise with rail providers to review timing of rail movements to minimise impact on road traffic as much as practicable.
Visual amenity	Avoid/Minimise	• Ensure core Processing Facility infrastructure is constructed on the southern peninsula of the site, reducing visual impacts from Palmerston and the Elizabeth River Boat Ramp. • Maintain the mangrove belt around the boundary of the site. • Maintain screening vegetation along Channel Island Road wherever possible. • Establish landscaping around the site to improve amenity.

Opportunity / Risk	Mitigation hierarchy	Mitigation measure
Light impacts	Avoid/Minimise	- Design lighting in accordance with Australian Standard 4282:1997 '<i>Control of the obtrusive effects of Outdoor Lighting</i>' - Install directional lighting wherever possible to reduce 'light spill' effects. - Establish a Complaints and Grievance Protocol to capture any issues related to light impacts from the Project.
Cultural Heritage	Avoid	- Include management of Cultural Heritage values into the EMP (refer to Aboriginal and Cultural Heritage Procedure (EP-04) in Appendix D). - Develop a Code of Conduct for workers and inductions that cover awareness and protection of heritage values. - Any previously unrecorded archaeological sites encountered will be reported to the Northern Territory Heritage Branch for advice on how to respond. Procedures for unexpected heritage finds will be included in the EMP (refer to Aboriginal and Cultural Heritage Procedure (EP-04) in Appendix D). - Ensure soil material originating from the site remains within the site and is not disposed off-site. - Comply with the conditions and requests of the Authority Certificate obtained from AAPA. - Establish a process of stakeholder engagement and participatory planning with the Larrakia people. - Engage with relevant Indigenous stakeholders to ensure traditional activities in nearby areas are understood and not impacted. - In the event that any skeletal remains are unearthed TNG will stop work and immediately report such disturbance to the Northern Territory police, and to the Director Heritage Branch, Department of Tourism and Culture (refer to the ERP – Appendix AA). - Implement mitigating strategies for environmental factors applicable to the Project to ensure no downstream impacts occur to heritage items and values as a result of Project activities.

7.11.8 Monitoring and Reporting

Initial monitoring and reporting strategies for social, economic and cultural impacts are identified below in Table 7-85. Requirements for monitoring and reporting will change over time, as the Project develops and the socio-economic environment alters. As such, review of these strategies will be incorporated into operational processes to ensure Project activities remain current with social issues and expectations.

Table 7-85: Monitoring for social, economic and cultural impacts

Action	Timing	Methods used	Criteria
Traffic monitoring	After a complaint is received.	Traffic survey.	Recognised traffic monitoring practices.
Noise monitoring	After a complaint is received.	Recognised sound monitoring methodologies.	In accordance NT Noise Management Framework Guidelines.

Table 7-86: Reporting and other inspections for social, economic and cultural impacts

Impact	Monitoring/Inspections	Reporting
Housing Impacts	Maintain records of the number of employees housed within residential areas and within designated accommodation areas.	
Public safety and Access	Maintain a Complaints Register. Maintain incident reporting records for any public safety or access incidents, along with implemented corrective action details. Undertake daily inspections of the site boundary to ensure it has not been compromised.	
Noise	Maintain a Complaints Register. Undertake noise modelling for any Project changes that could affect noise generation impacts on sensitive receptors.	Monthly Environmental Performance Report Half Year Report
Traffic	Maintain a Complaints Register Undertake periodic employee surveys to determine preferred transport modes to site.	Annual Report and Performance Review Regulatory Incident Report, as required.
Visual Amenity	Maintain a Complaints Register. Undertake regular inspections of the site to ensure housekeeping is acceptable and landscaping and general site amenity are adequate.	
Light Impacts	Maintain a Complaints Register. Undertake weekly inspections of all lighting to ensure it is operating effectively.	
Cultural Heritage	Maintain training records for employees to ensure Cultural Awareness Training has been conducted for all employees. Maintain an Incident Register for any incidents associated with cultural heritage impacts.	

Impact	Monitoring/Inspections	Reporting
	Maintain minutes, or other appropriate records, of meetings with Larrakia people. Maintain records of compliance with AAPA certificate.	

Proposed methodologies to monitor the water quality of the Elizabeth River is discussed in Chapter 7.7.6.

7.11.9 Statement of Residual Impact

During the construction phase of the Project, issues related to recreational amenity, social cohesion and community wellbeing are likely to be at the forefront. Longer-term, the operations of the Project will have positive impacts on the economic prosperity of Greater Darwin and across the Northern Territory, including significant potential to bring about employment, skills development and training for the existing Greater Darwin population. Additionally, the Project's operations will influence issues surrounding housing and liveability in the local area.

Identified negative social impacts can be mitigated or enhanced through the implementation of effective management plans, as detailed above and in the ESIMP. The Socio-economic Impact Assessment emphasised that engagement with, and participation of, the various project stakeholders through the life of the project will be critical to its success.

Overall the Project is perceived as extremely positive by the community. The SEIA concluded that the Darwin Processing Facility will bring positive social impacts for the Territory and the local region via economic stimulus, through the incoming workforce and the possibility for local skills and development training.

TNG consider that development of the Project will be consistent with the NT EPA's objectives for social, economic and cultural values and will have a net positive impact on the local, regional and national community and economy.



DRAFT ENVIRONMENTAL IMPACT
STATEMENT

DARWIN PROCESSING FACILITY

**ENVIRONMENTAL
FACTOR: HUMAN
HEALTH AND
SAFETY**

7.12 ENVIRONMENTAL FACTOR: HUMAN HEALTH AND SAFETY

7.12.1 NT EPA Objective

The NT EPA's objective for the environmental factor Human health is to:

Ensure that risks to human health are identified, understood and adequately avoided and/or mitigated.

The World Health Organization defines human health as “a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity”. The human health objective recognises the importance of ensuring that human health is not significantly affected as a result of development of the Project.

This chapter provides an overview of key potential impacts to human health that may arise as a result of Project development. The mitigation and management measures that TNG will implement to avoid and/or reduce impacts are summarised. At the end of the chapter, a statement of residual impact is made detailing the extent to which the proposed mitigation and management measures will ensure that the NT EPA's objective for this environmental factor is met.

This chapter is only intended to identify significant events that may affect employees, contractors or members of the community; it is not intended to identify all Worksafe related risks and mitigating measures specific to the Processing Facility operation. These items are addressed outside of the scope of the EIS.

The content of this chapter has been developed specifically to address section 3.1 of the EIS TOR (Appendix A).

7.12.2 Existing Environment

The Project is proposed to be located in a designated industrial precinct within the Greater Darwin area, proximal to residential, recreational and other industrial areas. It is situated on Channel Island Road, Whickham, adjacent to the Adelaide-Darwin Railway.

The site is situated within the Middle Arm peninsula of Darwin Harbour and consists of terrestrial vegetation, mangrove communities and disturbed areas from historic extractive industry activities.

The regional setting of the Project is addressed in chapter 3 and elements of the surrounding environment addressed throughout the Environmental Factors in chapter 7.

The Project will utilise a range of hydrocarbons, gases, liquid and solid reagents and consumables; as well as production of end products, some of which are classified as hazardous or as dangerous goods.

Under the *Work Health and Safety (National Uniform Legislation) Act 2011* the site will require licensing as a Major Hazard Facility; a number of materials on site will exceed thresholds established under Schedule 15 of the *Work Health and Safety (National Uniform Legislation) Regulations 2011*.

The climatic conditions at the Project Site provide potential risks to human health with regard to heat, sun exposure and potential exposure to severe weather events.

The Project Site also supports habitat in which biting insects occur and has potential to support populations of vertebrate fauna that could pose biting risk.

7.12.3 Potential Impacts and Risks

Development of the Darwin Processing Facility has the potential to impact human health, particularly given the location of the Project. Table 7-87 uses the Source – Pathway – Receptor model to identify potential high level impacts to human health. The individual pathways are detailed in the chapters below.

Table 7-87: Potential pathways for human health impacts

Source	Pathway	Receptor
Operational Activities	Release of hazardous materials due to vehicle accident.	Project employees and contractors.
	Release of hazardous materials due to rail accident.	
	Release of hazardous materials within the Project area.	
	Explosion from hazardous materials or pressurised vessels on site.	General community.
	Fire resulting from Project activities.	
	Bioaccumulation risk from wastewater discharge	
Environmental Factors	Environmental exposure of workers (e.g. climatic conditions)	Project employees and contractors.
	Animal attacks and biting insects.	

7.12.3.1 Release of hazardous materials due to vehicle or rail accident

Development of the Project will necessitate the transport of dangerous goods and hazardous materials via road or rail to the site, which has an associated level of risk of accident resulting in injury and/or harm to employees, contractors or the general public.

TNG will engage third-party specialist transport companies to undertake road and rail operations. This will ensure suitably experienced and equipped contractors are undertaking the activity, with established protocols in place.

In the case of rail, specialised containers will be utilised for product transport to reduce the risk of release to the environment. Trains will be scheduled to minimise the risk of collision. For road transport, designated transport routes will be determined to ensure local residential roads are avoided.

Requirements of the *Australia Dangerous Goods Code for Transport by Road and Rail* will be adhered to.

In the unlikely event of release of a hazardous material due to vehicle or rail accident, the Emergency Response Plan (ERP) (Appendix AA) will be enacted. Emergency services will be notified, attempt will be made to contain spills or fire where possible and NT EPA and NT Worksafe will be notified, as per statutory requirements.

Given the regulation surrounding movement of hazardous materials and dangerous goods, the use of experienced contractors to undertake the activities and avoidance of local residential areas, it is considered that development of the Project will not significantly increase the current level of risk experienced.

7.12.3.2 Release of hazardous materials within Project area

Impacts to employee health can occur through inappropriate storage and handling of hazardous materials.

TNG intend to design and construct best practice storage facilities for hazardous materials in accordance with Australian Standards, the *Australian Dangerous Goods Code* (with particular consideration given to compatibility requirements) and Material Safety Data Sheets.

A number of products proposed for use on site retain inhalation or skin irritation risks. Training in safe handling of materials and appropriate Personal Protective Equipment (PPE) will be provided for all applicable employees.

Where a spill occurs, spill response procedures will be executed. TNG will ensure appropriate spill response equipment is available for each hazardous material type stored on site and suitable training is provided.

Given the hazardous nature of some products used in the Processing Facility, the risk to health of employees and contractors as a result of a release of material within the Project area is considered a moderate risk that will require management.

It is not anticipated that release of hazardous materials will become a public health issue under normal operating conditions, as most spills will be contained within the site, which is not accessible to the public. In the unlikely event of a catastrophic spill migrating off site into the Elizabeth River, community health and amenity may be impacted through altered water quality and bioaccumulation of toxicants within food sources from the river. The issues associated impacts to marine environmental quality are addressed in chapter 7-7.

7.12.3.3 Explosion from hazardous materials or pressurised vessels on site

Being a chemical processing facility, hazardous materials and pressurised vessels will be utilised on the site. Stringent design and management measures will be enforced for storage and use of such items through building permits and licensing requirements.

In the unlikely event of an explosion on site, it is not expected that direct impacts will occur outside of the site boundary as the site is a 507 ha land parcel, with a buffer zone between active areas and adjacent industrial operations. Residential areas will be at least 2.4 km from the Project, once Weddell is developed; direct explosion impacts are not projected to occur at this distance.

TNG is however cognisant that secondary impacts from a chemical or pressurised vessel explosion could affect employees, adjacent industrial operations and residents / general community in the vicinity of the site. Impacts may occur through tremors from the explosion, toxic gas plumes, release of hazardous materials to the Elizabeth River or inconveniences from local roads being blocked off during the initial response phase.

A significant explosion is considered to be a very rare but potentially significant risk event. An explosion is not anticipated to occur at the Facility; nevertheless, TNG will implement strict mitigation to avoid such incidents.

7.12.3.4 Fire resulting from Project activities

The Project requires the use of 'hot work' as part of ongoing operations. Equipment utilised on site, along with the existence of flammable materials, can result in a fire risk for the Project.

Fire occurrences at the facility have a risk of resulting in injury or harm to employees and will require implementation of management measures. Given the distance to residential areas, it is not considered that a Facility fire would have a human health effect on the general community; however, it is acknowledged that fire instigated from the site does pose a risk of facilitating an off-site wildfire.

Currently, the instance of fire at the site is high; particularly as a result of abandoned/stolen vehicle fires. Fire protection controls for the Facility, including installation of fire hydrants, operation of a dedicated fire truck, use of sprinkler systems, fire hose reels, fire extinguishers and maintenance of a firebreak around operational areas, will decrease uncontrolled fire occurrence on the site and, therefore, reduce fire impacts on adjacent areas.

7.12.3.5 Bioaccumulation Risk from wastewater discharge

The Project requires discharge of treated process wastewater into the East Arm Estuary. Chapters 7-7, 7-8 and 7-9 provide detail on this activity and assess the risks to marine environmental quality, benthic habitat and communities and marine fauna.

TNG is cognizant that the Darwin Harbour system is utilised for a range of activities, including recreational fishing and collection of filter-feeding bivalves from the river. Recreational fishing is the essence of the NT and anecdotal information suggests that the Larrakia people, especially, congregate on occasion to collect bivalves as part of their culture.

Should wastewater be released above criteria, risks of impacts on human health through consumption of marine species may occur. Management of the marine environmental quality will indirectly address this risk. Mitigation measures are detailed in chapter 7-7 and the Marine Environmental Quality Monitoring and Management Plan (Appendix R).

7.12.3.6 Environmental exposure of workers

The NT environment can be extreme and consideration needs to be given to the risk of exposure to environmental elements for workers at the Darwin Processing Facility. Impacts could result from:

- Heat and sun exposure;
- Cyclonic events;
- Flooding.

Sunburn and heat stress are foreseeable risks in a climate such as in Darwin. The risks of exposure will, however, be reduced due to a significant proportion of the work areas within the Processing Facility being enclosed and, therefore, protected from the sun. Adequate ventilation will be incorporated into the design of buildings to reduce heat stress risks. It is not anticipated that the Project will result in undue risks to human health from this element.

Northern Australia is subject to cyclonic activity during November to April each year. Prediction of cyclones has significantly improved with technological advances and the implementation of emergency procedures preceding arrival of cyclones is well understood within the community.

TNG will construct the Processing Facility in accordance with relevant Building Codes to account for cyclonic activity. A Cyclone Response Plan will also be developed that will incorporate shut down/evacuation procedures during cyclone warnings. It is not expected that human health impacts resulting from cyclones will increase as a result of the Project development.

Consequent to the location of the Project being adjacent to Elizabeth River, portions of the site are subject to storm surge and inundation. TNG has situated the Processing Facility above the storm surge level and will install adequate structures to mitigate flood risk to the operational areas. Given these measures, it is not anticipated that flood impacts at the site will significantly detriment human health.

7.12.3.7 Animal bites

Several animals identified or anticipated within the Project area have capability for human interactions and inflicting bites. These are mainly snake, crocodiles and free roaming dogs (including feral dogs and dingoes). Arachnids are not considered to pose an undue risk.

Staff awareness, management protocols to reduce opportunity for attacks and response procedures in the instance of injury from animal attacks will be implemented. It is not anticipated that these risks will be any greater as a result of the Project.

7.12.3.8 Biting insects

The NT coast has extensive areas of mangrove lined estuaries and freshwater floodplains, with much of the coastal zone being largely in its natural state. In general, development activities occurring on coastal floodplains in the NT will encounter human health issues associated with biting insects.

The local environment of the Middle Arm leads to the expectation that potentially significant biting insect issues may occur in the Project area. The main insects causing these issues are biting midges and mosquitoes.

The extensive mangrove areas surrounding the Project site are potential sources of the mangrove biting midge *Culicoides ornatus*. This is the most significant biting midge in the coastal areas of northern Australia and is expected to occur in very high seasonal numbers, particularly between August to November, when populations are at their peak.

Mosquitoes breed in standing water which can be created by, for example, rainfall in any ponding areas or water holding receptacles. In general, seasons with higher levels of rainfall experience higher numbers of mosquitoes than lower rainfall years (Whelan & Hurk 2003). Development can be rapid, and numbers of adult biting mosquitoes can be expected to reach peaks within three weeks of heavy rainfall (Whelan & Hurk 2003).

The presence of tidal areas (such as poorly or restricted draining upper tidal areas) and natural or man-made depressions (e.g. vehicle tracks) allows for the expectation that seasonally raised numbers of the northern salt marsh mosquito *Aedes vigilax* may be present. *A. vigilax* is an aggressive biter both at night and at daytime in shaded areas. Other mosquito species (e.g. *Culex annulirostris*, *C. sitiens*, *Anopheles* spp., *Coquillettidia xanthogaster*, *Verrallina funerea*) may also occur at the site, with higher numbers expected in the wet season.

The potential human health issues associated with biting insects on site include:

- unbearable nuisance caused by biting insects in very high numbers;
- painful bites, intense itching, infection and scarring (following scratching); and
- transmission of viruses.

Establishment of management protocols for the Project is essential in reducing the nuisance and human health risks associated with biting insects.

7.12.4 Mitigation and Management

The mitigation measures outlined in Table 7-88 will be implemented to reduce the risk of impacts to human health as a result of Project activities. More detail is provided in the management plans and procedures developed through the EMP (Appendix D), the ERP (Appendix AA), and Biting Insects Management Plan (BIMP) (Appendix BB).

Table 7-88: Human health - potential impacts and mitigation measures

Pathway	Mitigation hierarchy	Mitigation measure
Release of hazardous materials through road or rail accident	Avoid	- Engage specialist third party contractors to conduct road and rail transport requirements for the Project. - Ensure all vehicles are licensed and carry appropriate equipment to respond to a spill, including PPE. - Apply <i>Australia Dangerous Goods Code (ADG Code) for Transport by Road and Rail</i> requirements to all transport activities. - Ensure loads are appropriately secured prior to leaving the site. - Establish designated transport routes to avoid local residential areas. - Establish collaborative relationships with local emergency services, ensuring they are aware of the Project activities, including transport of materials via road and rail. - Identify all major incidents and hazards that could result from Project operations. - Conduct and document a safety assessment in relation to the operation of the facility, which involves a comprehensive and systematic investigation and analysis of all aspects of risks to health and safety that could occur in the operation of the Major Hazard Facility. - Implement control measures that eliminate or minimise the risk of a major incident occurring at the Project. - Establish a Safety Management System (SMS) for the operation of the Project. - Prepare a Safety Case for the Facility that demonstrates that the Project SMS will control risks arising from major incidents and hazards that could cause a significant impact. The Safety Case must demonstrate the adequacy of the measures to be implemented by the operator to control risks associated with the occurrence of major incidents.
Release of hazardous materials within the Project area	Avoid/Minimise	Management of hazardous materials on site is addressed in chapter 7-2. Specific to human health, the following will also be implemented: - Staff will be provided with sufficient training to competently and safely handle hazardous materials. - Appropriate PPE will be provided to all staff working with hazardous materials on site. - Change management protocols will be established to ensure requirements of any new materials brought to site are understood and additional measures can be implemented, where required. <i>Australian Dangerous Goods Code</i> requirements for storage compatibility will be adhered to. - Spill response procedures and equipment will be available and understood by employees and contractors at the site.

Pathway	Mitigation hierarchy	Mitigation measure
Explosion on site.	Avoid	- Design and construction of the Facility in accordance with Australian and International Standards, Building Codes and Licence requirements. - Control of emission of flammable vapours, gases and mists (e.g. through the use of enclosed container and transfer systems, vapour recovery connections, sufficient ventilation). - Elimination of ignition sources from hazardous areas. - Installation of leak detection systems. - Storing the minimum required quantities of flammable / explosive materials. - Control of 'hot work' through an established permitting system. - Good housekeeping practices on site. - Implement the ERP, as required.
Fire resulting from Project activities	Avoid/Minimise	- Implement the ERP (Appendix AA), as required. - Implement the FMP (Appendix K). - Ensure fire response equipment (e.g. fire breaks, extinguishers, fire reels) is available, operational and maintained. Fire extinguishers to be used in accordance with <i>Australian Standard 1841.1-2007 (Portable Fire Extinguishers – General Requirements)</i>. - Fire hydrants will be connected on a ring main throughout the Facility, designed as per <i>Australia Standard 2419.1-2005 (Fire Hydrant Installations)</i>. Fire water will be sourced from the fire water surge tank. - A foam injection and deluge system will be required for the solvent extraction mixer settling units where the organic solution is used. The foam deluge system shall be designed as per <i>Australian Standard 2118.3-2010 (Automatic Fire Sprinkler Systems – Deluge Systems)</i>. - Use of firewalls between high risk units where appropriate. - Personnel trained in the use of fire response equipment. 'Hot work' permit system in operation. Where there is a perceived high risk (e.g. on Total Fire Ban days), ensure trained personnel are on standby when hot work is carried out on site. - Deliberate lighting of fires on site to be prohibited.
Bioaccumulation of metals within marine species consumed by community members	Avoid/Minimise	Management of wastewater discharge quality, and therefore the impact on marine species potentially consumed by community members, is addressed in chapter 7-7.
Personnel exposure to climatic elements	Minimise	- All personnel (including contractors and office workers) will be trained in the risks associated with climate exposure, the signs and symptoms of over-exposure to heat and its effects (e.g. dehydration) and what to do in case of an emergency. First-aid facilities will be equipped to provide at least an initial response to incidents of this type. - Drinking water will be available across the site at clearly signposted locations. - To reduce sun exposure appropriate PPE (e.g. long sleeved shirts, trousers, hats and/or helmets) and sunscreen will be made available and their use made compulsory. - Develop and implement Cyclone Response Plan.

Pathway	Mitigation hierarchy	Mitigation measure
Animal bites and biting insects	Avoid/Minimise	• Site induction and personnel training to address potential risks associated with biting animals, how to avoid them and what to do in case of a bite or emergency. • Personnel provided PPE to provide protection from biting animals and deter biting insects e.g. boots, gloves, long sleeves, trousers. • Implement BIMP (Appendix BB).

7.12.5 Monitoring and Reporting

The BIMP (Appendix BB), EMP (Appendix D) and associated sub-plans detail objectives, monitoring procedures and performance indicators, as well as corrective actions and reporting requirements. The sub-plans and procedures are reported through the EMP. The measures are outlined in Table 7-89 below.

Table 7-89: Other inspections and reporting for human health

Relevant Plan	Procedure (if relevant)	Monitoring/Inspections	Reporting
EMP (Appendix D)	Hazardous Material Management (EP-13 in EMP Appendix D)	Daily inspection to ensure site is cleared of waste, all POL/chemicals have been stored and disposed of correctly, and all spills have been identified and dealt with (see Daily Inspection Checklist). Regular inspection of any bunds to check integrity and detect leaks and spills (see Weekly Inspection Checklist). Regular inspection of stormwater drains for any sediment capture.	Incidents are to be reported and records maintained/retained. Keep waste tracking/disposal records for all HAZMAT in Daily Site Diary.
ERP (Appendix AA)	Vehicle Incident	-	ERC to immediately notify NT WorkSafe, preserve area (if required) and provide written notification within 48 hours if the incident results in either: • Death of a person; • Serious injury or illness; or • Dangerous incident.
	Hazardous substances spill	-	Undertake and/or manage investigations into spill incident, which is to be provided to the ERC within 24 hours of the incident occurring. Review and implement recommendations.
	Flood	Monitor weather forecasts and surface water monitoring stations. Monitor surface water management infrastructure performance and integrity.	-
FMP (Appendix K)	NA	Daily inspections to identify any potential fire hazards (see Daily Inspection Checklist) Regularly check integrity of all bunds and containers that store fuels and chemicals	Incidents are to be reported and records retained (Incident, Accident and Near Miss Report). Investigate incidents and implement preventative actions as required.
BIMP (Appendix BB)	Appendix A, C, D	Conducting regular (at least weekly) site inspections, especially during the wet season, to identify existing or potential	Report infestations internally, which will be recorded in the Biting Insect Register.

Relevant Plan	Procedure (if relevant)	Monitoring/Inspections	Reporting
		standing water bodies and implementing immediate actions to eradicate or remedy such areas where possible.	Significant infestations of biting insects and/or sickness due to biting insects to be reported to NT Medical Entomology Branch.
		Existing or potential ponding areas must be reported to the Environmental Manager.	Record infestation treatments in the Chemical Treatment Register.
		Monitor on-site works to ensure activities such as ground disturbance do not lead to the creation of newly ponded areas.	
		Erosion and wash-down practices must be inspected and cleared from sediment and debris that may be forming standing water pools.	
MEQMMP (Appendix R)		Refer to Table 7-49	Annual Report and Performance Review

7.12.6 Statement of Residual Impacts

In consideration of the outcomes of the EIA and proposed management measures, TNG considers that the EPA's objective for human health can be achieved with the implementation of appropriate mitigation activities.

Some residual risk remains after the implementation of mitigation measures, such as:

- Risk of vehicle / rail accident;
- Bioaccumulation risk in the unforeseen event of a hazardous material spill to the marine environment;
- Biting insect nuisances.

These are considered very rare occurrences or lower level risks (in the case of biting insects). It is expected these risks will be acceptable to TNG and the NT community.

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**ENVIRONMENTAL
OFFSETS**

8. ENVIRONMENTAL OFFSETS

The term ‘environmental offsets’ refers to measures that compensate for the residual adverse impacts of an action on Matters of National Environmental Significance (MNES) protected by the EPBC Act. Offsets provide environmental benefits to counterbalance the impacts that remain after avoidance and mitigation measures. These remaining, unavoidable impacts are termed ‘residual impacts’.

For assessments under the EPBC Act, offsets are only required if residual impacts are significant, as defined in *Significant Impact Guidelines 1.1 – Matters of National Environmental Significance* and *Significant impact guidelines 1.2 – Actions on, or Impacting Upon, Commonwealth Land and Actions by Commonwealth Agencies*. The significant impact guidelines provide overarching guidance on determining whether an action is likely to have a significant impact on a MNES.

The MNES protected under national environment law include:

- listed threatened species and communities;
- listed migratory species;
- Ramsar wetlands of international importance;
- Commonwealth marine environment;
- World heritage properties;
- national heritage places;
- the Great Barrier Reef Marine Park;
- nuclear actions; and
- a water resource, in relation to coal seam gas development and large coal mining development.

The Project was referred by the Proponent to DoEE for consideration under the EPBC Act and determined to be a controlled action. The controlling provisions included the likely significant impact on:

- listed threatened species and communities (sections 18 & 18A)
- listed migratory species (sections 20 & 20A)

8.1 CONSIDERATION OF OFFSET PRINCIPLES

The following information informs the assessment and decision-making process in relation to the requirement for environmental offsets. Specifically, Table 8-1 outlines the principles that apply to offsets.

Table 8-1: Consideration of offset principles

Offset Principle	Consideration
Environmental offsets will only be considered after avoidance and mitigation options have been pursued.	Avoidance and mitigation measures are described in chapter 7.
Environmental offsets are not appropriate for all projects	Applies when environmental values cannot be offset or when residual impacts are not significant. TNG considers the latter is applicable for this assessment.
Environmental offsets will be cost-effective, as well as relevant and proportionate to the significance of the environmental value being impacted.	No offsets are proposed.
Environmental offsets will be based on sound environmental information and knowledge.	TNG considers that the information provided in the EIS is based on sound environmental information and knowledge including a large number of database searches, field observations and technical reports.
Environmental offsets will be applied within a framework of adaptive management.	No offsets are proposed.
Environmental offsets will be focussed on longer term strategic outcomes.	No offsets are proposed.

8.2 ASSESSMENT OF SIGNIFICANT RESIDUAL IMPACTS

Table 8-2 provides an assessment of the residual impacts of the Darwin Processing Facility based on the residual impact significance model. The key considerations in formulating this assessment are the following outcomes of impact evaluation:

- No impact on any flora or ecological communities listed as Threatened under the EPBC Act;
- Some impact on flora listed under the TPWC Act but no impact likely to lead to listing under the EPBC Act;
- Some loss of habitat (fragmented) for Threatened fauna but no impact likely to lead to an increase in the threat level in currently listed species;
- Risk of spread of existing weed infestations or introduction of new weed species is manageable;
- Risk to water quality in the Elizabeth River is manageable;
- Risk to downstream water quality and benthic habitat in the Port of Darwin Wetland is manageable;
- No risk to other groundwater users or to important sources of groundwater; and
- No direct impact on the Commonwealth marine environment.

Table 8-2: Offset calculation table

Environmental Impact	Mitigation			Significant residual impact	Offset Calculation Methodology					
	Avoid and minimise	Rehabilitation type	Likely rehabilitation success		Type	Risk	Likely offset success	Time Lag	Offset Quantification	
Terrestrial flora and vegetation										
Loss of native vegetation cover	Develop and implement an internal Ground Disturbance Permit system.	Recover topsoil and utilise the seed bank to conduct rehabilitation of disturbed areas.	Very High. Fresh topsoil generally results in high rates of recruitment.	No significant residual impact.	N/A	N/A	N/A	N/A	N/A	
Decrease of populations of conservation significant flora	Prior to commencement of construction, review project envelope to reduce or eliminate, where possible, direct impacts on the following species: <i>Cycas armstrongii</i> (VU, TPWC Act) <i>Tricoryne elatior</i> (NT, TPWC Act) <i>Polymeria pusila</i> (DD) <i>Buchnera</i> sp. ciliate bracts (DD) To reduce the potential for indirect impacts, provide signage and fencing to protect populations of these species that occur adjacent or almost adjacent to active areas.			No impact on any flora or ecological communities listed under the EPBC Act.	N/A	N/A	N/A	N/A	N/A	
				Some impact on flora listed under the TPWC Act but no impact to any flora or vegetation that would lead to listing under the EPBC Act.						

Environmental Impact	Mitigation				Significant residual impact	Offset Calculation Methodology				
	Avoid and minimise	Rehabilitation type	Likely rehabilitation success			Type	Risk	Likely offset success	Time Lag	Offset Quantification
Spread of existing weed infestations or introduction of new weed species	Review existing weed mapping and signpost areas of significant weed infestations. Educate mine personnel on the identifying and managing the key weed species. Develop and implement weed hygiene procedures whereby vehicles and equipment coming to site are free of weed seeds. Use the Ground Disturbance Permit system to assess the risk of spreading weeds when undertaking land clearing.	Routinely undertake site inspections and implement weed control measures (physical removal, chemical controls) as required. Immediately rehabilitate any disturbed areas that are not required for infrastructure, where possible.	Multiple methods available for weed control. Methods to remediate/treat weed infestations common across industry and have been shown to be successful in controlling weeds spread or introduced at the Project.		No significant residual impact. Risk of spread of existing weed infestations or introduction of new weed species is manageable.	N/A	N/A	N/A	N/A	N/A
Increase in level of dust deposition on vegetation arising from construction and operational activities, including vehicle movements and	Key dust sources in the operations phase have been identified and will take place inside sheds. Specialised containers will be used on trains and trucks will be covered to prevent dust during loading and unloading.	N/A	N/A		No significant residual impact. The residual impacts from dust generation are minor, will be monitored and can be mitigated with	N/A	N/A	N/A	N/A	N/A

Environmental Impact	Mitigation			Significant residual impact	Offset Calculation Methodology				
	Avoid and minimise	Rehabilitation type	Likely rehabilitation success		Type	Risk	Likely offset success	Time Lag	Offset Quantification
material transport.	Where roads remain unsealed, water trucks will be used to suppress wheel generated dust from access roads. The Processing Facility will have dust suppression measures fitted, such as water sprays. A photo and condition monitoring program will be developed and implemented for vegetation. The program will be based on the likely risk (e.g. high traffic areas) and the value of adjoining vegetation (e.g. sensitive and significant).			appropriate management measures.					
Altered fire regimes resulting in loss or reduced health and condition of native vegetation	Site personnel will be trained in fire protection. The site will be equipped with fire extinguishers and other fire prevention measures. A hot work permit system will be implemented.	N/A	N/A	No significant residual impact. While a fire may result in significant impacts, the likelihood of fire can be mitigated to an acceptable level through	N/A	N/A	N/A	N/A	N/A

Environmental Impact	Mitigation			Significant residual impact	Offset Calculation Methodology				
	Avoid and minimise	Rehabilitation type	Likely rehabilitation success		Type	Risk	Likely offset success	Time Lag	Offset Quantification
	Grassy weeds will be eliminated from the site. Uncontrolled public access will be prevented.			appropriate management measures.					
Terrestrial Fauna									
Reduction and/or fragmentation of fauna habitat through clearing	Develop and implement an internal Ground Disturbance Permit system.	Undertake rehabilitation which aims to establish vegetation units that provide fauna habitat and reduce fragmentation.	Very High. Fresh topsoil generally results in high rates of recruitment.	No significant residual impact Some loss of habitat (already fragmented) for Threatened fauna but no impact likely	N/A	N/A	N/A	N/A	N/A
Impacts on fauna of conservation significance	Undertake pre-clearing trapping and translocation targeting the possible presence of northern quoll and black footed tree rat. Develop and implement a Biodiversity Management Plan (see draft Appendix L).	Incorporate habitat requirements for key fauna into rehabilitation planning, where practical.	Re-establishment of native vegetation is achievable.	to lead to an increase in the threat level in currently listed species. Equal or higher quality habitat is available in the local area and regionally the reduction in habitat	N/A	N/A	N/A	N/A	N/A

Environmental Impact	Mitigation			Significant residual impact	Offset Calculation Methodology				
	Avoid and minimise	Rehabilitation type	Likely rehabilitation success		Type	Risk	Likely offset success	Time Lag	Offset Quantification
	Undertake terrestrial mammal and avifauna monitoring during operations. Use fauna sensitive fencing around infrastructure.			does not exceed 0.01%. A fauna corridor along the western edge of the site is maintained.					
Vehicle strike	Maintain a speed limit of ≤40 km/h for vehicles on internal roads. Erect warning signs in any locations where fauna are regularly sighted. Ensure employee and contractor awareness of local fauna and encourage reporting of sightings and any incidents of vehicle strike. The use of buses for employee transport to reduce vehicle movements associated with the Project.	N/A	N/A	No significant residual impact. The residual impacts from vehicle strike are minor and can be mitigated with appropriate management measures.	N/A	N/A	N/A	N/A	N/A

Environmental Impact	Mitigation			Significant residual impact	Offset Calculation Methodology				
	Avoid and minimise	Rehabilitation type	Likely rehabilitation success		Type	Risk	Likely offset success	Time Lag	Offset Quantification
Increase in the abundance of introduced fauna	Ensure all putrescible waste produced at the Facility is securely stored until removed from site. Monitor sightings of feral fauna and undertake control measures in consultation with stakeholders.	N/A	N/A	No significant residual impact The residual impacts from an increase in the abundance of introduced fauna are minor and can be mitigated with appropriate management measures.	N/A	N/A	N/A	N/A	N/A
Lighting, noise, vibrations and human movement altering natural behaviour.	All light sources will be aimed towards work areas and away from surrounding habitat, using light shields as necessary to minimise light spill. Implement the Noise Management Procedure (EP-21) within the EMP (Appendix D).	Undertake rehabilitation that aims to establish vegetation that will act as a buffer between the Processing Facility and the remnant habitat.	Very High. Fresh topsoil generally results in high rates of recruitment.	No significant residual impact The residual impacts from site lighting, noise and vibration are minor and can be mitigated with appropriate management measures.	N/A	N/A	N/A	N/A	N/A
Altered fire regimes resulting in loss or reduced health and	Site personnel will be trained in fire protection.	N/A	N/A	No significant residual impact.	N/A	N/A	N/A	N/A	N/A

Environmental Impact		Mitigation			Significant residual impact	Offset Calculation Methodology				
		Avoid and minimise	Rehabilitation type	Likely rehabilitation success		Type	Risk	Likely offset success	Time Lag	Offset Quantification
condition of remnant fauna habitat.		The site will be equipped with fire extinguishers and other fire prevention measures.			While a fire may result in significant impacts, the likelihood of fire can be mitigated to an acceptable level with appropriate management measures.					
		A hot work permit system will be implemented.								
		Grassy weeds will be eliminated from the site.								
		Uncontrolled public access will be prevented.			Under the proposed measures it is likely the incidence of fire will decrease from the current frequency.					
		A Fire Management Plan will be implemented for the Project.								
Marine flora, fauna and marine environmental quality										
Changes in marine habitat quality from the ocean outfall	Design of the Wastewater Treatment Plant to criteria that	N/A		N/A	No significant residual impact	N/A	N/A	N/A	N/A	N/A
	meets the ANZG (2018) 95% SPL default guideline values				The residual impacts from the Treated Wastewater Ocean Outfall can be mitigated with appropriate					

Environmental Impact	Mitigation			Significant residual impact	Offset Calculation Methodology				
	Avoid and minimise	Rehabilitation type	Likely rehabilitation success		Type	Risk	Likely offset success	Time Lag	Offset Quantification
	- do not result in an accumulation of contaminants over time - discharge only during ebb tides to ensure maximum dilutions are achieved and marine environmental impacts do not arise upstream during flood tides Selection of a wastewater ocean outfall locations that ensures an appropriate level of ecological protection can be achieved Monitoring water quality parameters at the ocean outfall Updating predictive numerical modelling of water quality associated with the outfall using monitoring data			management measures.					

Environmental Impact	Mitigation			Significant residual impact	Offset Calculation Methodology				
	Avoid and minimise	Rehabilitation type	Likely rehabilitation success		Type	Risk	Likely offset success	Time Lag	Offset Quantification
Contaminated groundwater and/or stormwater runoff from the onshore Processing Facility	Construct containment areas compliant with appropriate standards well clear of any waterway or drainage system Educate workforce on reporting and management of spillages. Actively manage all spillages and recover contaminated material. Construct bunding and pipelines with spill protection Erosion protection measures (bunding, spoon drains, silt fencing and sediment ponds) will be installed to contain any erosion. Rehabilitation of disturbed areas not required for infrastructure Undertake regular inspections	Undertake rehabilitation that aims to establish vegetation that will stabilise disturbed areas, prevent erosion and create a buffer between the Processing Facility and the marine environment. Remediation of contaminated soils in accordance with applicable regulations.	Very High. Fresh topsoil generally results in high rates of recruitment. Methods for remediation of contaminated sites common across industry and have shown to be successful.	No significant residual impact The residual impacts are minor and can be mitigated with appropriate management measures.	N/A	N/A	N/A	N/A	N/A

Environmental Impact	Mitigation			Significant residual impact	Offset Calculation Methodology				
	Avoid and minimise	Rehabilitation type	Likely rehabilitation success		Type	Risk	Likely offset success	Time Lag	Offset Quantification
Exposure to non-process waste (litter)	Litter that is generated from the Project during both construction and operation phases will be managed in accordance with a Waste Management Plan and compliance with the requirements of the <i>Marine Pollution Act</i> (NT) and the <i>Waste Management and Pollution Control Act</i> .	N/A	N/A	No significant residual impact The residual impacts are minor and can be mitigated with appropriate management measures.	N/A	N/A	N/A	N/A	N/A
Benthic Habitat and Communities (BHC)									
Disturbance from outfall pipeline installation	Develop and implement an internal Ground Disturbance Permit system. Clearing to prioritise use of areas already disturbed. Proposed disturbance envelope for pipeline corridor occurs predominantly over soft-bottom bare substrate minimising impacts to small sections of mixed BHC.	NA	NA	No significant residual impact. No impact on any flora or ecological communities listed under the EPBC Act.	N/A	N/A	N/A	N/A	N/A

Environmental Impact	Mitigation			Significant residual impact	Offset Calculation Methodology				
	Avoid and minimise	Rehabilitation type	Likely rehabilitation success		Type	Risk	Likely offset success	Time Lag	Offset Quantification
	Hydrographic survey of pipeline corridor Detailed high resolution BHC validation mapping survey of pipeline corridor is required to ensure avoidance of higher value BHC.								
Changes in marine habitat quality from the ocean outfall	Design of the Wastewater Treatment Plant to criteria that - meets the ANZG (2018) 95% SPL default guideline values - do not result in an accumulation of contaminants over time - discharge only during ebb tides to ensure maximum dilutions are achieved and marine environmental impacts do not arise upstream during flood tides	N/A	N/A	No significant residual impact The residual impacts from the Treated Wastewater Ocean Outfall can be mitigated with appropriate management measures.	N/A	N/A	N/A	N/A	N/A

Environmental Impact	Mitigation			Significant residual impact	Offset Calculation Methodology				
	Avoid and minimise	Rehabilitation type	Likely rehabilitation success		Type	Risk	Likely offset success	Time Lag	Offset Quantification
	Selection of a wastewater ocean outfall location that ensures an appropriate level of ecological protection can be achieved Monitoring water quality parameters at the ocean outfall Updating predictive numerical modelling of water quality associated with the outfall using monitoring data								
Contaminated groundwater and/or stormwater runoff from the onshore Processing Facility	Construct containment areas compliant with appropriate standards well clear of any waterway or drainage system Educate workforce on reporting and management of spillages. Actively manage all spillages and recover contaminated material.	Undertake rehabilitation that aims to establish vegetation that will stabilise disturbed areas, prevent erosion, create a buffer between the Processing Facility and the marine environment and increase the	Very High. Fresh topsoil generally results in high rates of recruitment. Methods for remediation of contaminated sites common across industry and have shown to be successful.	No significant residual impact The residual impacts are minor and can be mitigated with appropriate management measures.	N/A	N/A	N/A	N/A	N/A

Environmental Impact	Mitigation			Significant residual impact	Offset Calculation Methodology				
	Avoid and minimise	Rehabilitation type	Likely rehabilitation success		Type	Risk	Likely offset success	Time Lag	Offset Quantification
	Construct bunding and pipelines with spill protection	infiltration of stormwater.							
	Erosion protection measures (bunding, spoon drains, silt fencing and sediment ponds) will be installed to contain any erosion.	Remediation of contaminated soils in accordance with applicable regulations.							
	Rehabilitation of disturbed areas not required for infrastructure								
	Undertake regular inspections								
	Remediate contaminated soils in accordance with applicable regulations.								
Disturbance of Acid Sulfate Soils	Disturbance of ASS/PASS to be avoided where possible	Disturbed ASS/PASS to be treated, neutralised and disposed or used in compliance with the ASS Management Plan	Methods available for treatment of ASS. Methods to remediate/treat ASS/PASS common across industry and have been shown to be successful in neutralising	No significant residual impact	N/A	N/A	N/A	N/A	N/A
	Excavated ASS/PASS to be treated during construction to prevent acidic fluids leaching into surface water or groundwater.			The residual impacts are minor and can be mitigated with appropriate management measures.					

Environmental Impact	Mitigation			Significant residual impact	Offset Calculation Methodology				
	Avoid and minimise	Rehabilitation type	Likely rehabilitation success		Type	Risk	Likely offset success	Time Lag	Offset Quantification
	Preparation of compliant treatment pads. The area will be fully contained/constructed such that drainage/runoff water from the pad is directed to an appropriate receptacle for testing and treatment (if required).		ASS/PASS and preventing leaching.						
Terrestrial Environmental Quality									
Exposure to contaminants of potential concern from fly-tipped waste	Removal of fly-tipped waste from the site using accredited waste specialists. Inspection of remnant fly-tipped waste for the presence of asbestos and removal, transport and disposal of asbestos using licensed specialists.	N/A	N/A	No significant residual impact The residual impacts are minor and can be mitigated with appropriate management measures.	N/A	N/A	N/A	N/A	N/A
Exposure of Acid Sulfate Soils and Potential Acid Sulfate Soils (ASS/PASS)	Disturbance of ASS/PASS to be avoided where possible Excavated ASS/PASS to be treated during construction to prevent acidic fluids leaching	Disturbed ASS/PASS to be treated, neutralised and disposed or used in compliance with the	Methods available for treatment of ASS. Methods to remediate/treat ASS/PASS common across industry and	No significant residual impact The residual impacts are minor and can be mitigated with	N/A	N/A	N/A	N/A	N/A

Environmental Impact	Mitigation				Significant residual impact	Offset Calculation Methodology				
	Avoid and minimise	Rehabilitation type	Likely rehabilitation success			Type	Risk	Likely offset success	Time Lag	Offset Quantification
	into surface water or groundwater. Preparation of compliant treatment pads. The area will be fully contained/constructed such that drainage/runoff water from the pad is directed to an appropriate receptacle for testing and treatment (if required).	ASS Management Plan	have been shown to be successful in neutralising ASS/PASS and preventing leaching.		appropriate management measures.					
Soil erosion resulting in disturbance of ASS	Implementation of the Erosion and Sediment Control Plan to avoid erosion Vegetation clearing to be undertaken in stages and in dry season conditions wherever possible. Erosion protection measures (bundling, spoon drains, silt fencing and sediment ponds) will be installed to contain any erosion.	Undertake rehabilitation that aims to establish vegetation that will stabilise disturbed areas and prevent erosion.	Very High. Fresh topsoil generally results in high rates of recruitment.		No significant residual impact The residual impacts are minor and can be mitigated with appropriate management measures.	N/A	N/A	N/A	N/A	N/A

Environmental Impact	Mitigation			Significant residual impact	Offset Calculation Methodology				
	Avoid and minimise	Rehabilitation type	Likely rehabilitation success		Type	Risk	Likely offset success	Time Lag	Offset Quantification
	Rehabilitation of disturbed areas not required for infrastructure								
Contamination from hazardous materials used in the construction and operations phases	Construct containment areas compliant with appropriate standards well clear of any waterway or drainage system Educate workforce on reporting and management of spillages. Actively manage all spillages and recover contaminated material. Construct bunding and pipelines with spill protection Undertake regular inspections	Remediation of contaminated soils in accordance with applicable regulations.	Methods for remediation of contaminated sites common across industry and have shown to be successful.	No significant residual impact The residual impacts are minor and can be mitigated with appropriate management measures.	N/A	N/A	N/A	N/A	N/A
Hydrological and Hydrogeological Processes									
Flooding	The Project layout has given consideration to the 1 in 100 AEP and 1 in 1,000 AEP event	N/A	N/A	No significant residual impact The residual impacts are minor and can	N/A	N/A	N/A	N/A	N/A

Environmental Impact	Mitigation			Significant residual impact	Offset Calculation Methodology				
	Avoid and minimise	Rehabilitation type	Likely rehabilitation success		Type	Risk	Likely offset success	Time Lag	Offset Quantification
	inundation levels and is above those levels. A bund around the outside of the operational Project area will provide a measure of further protections against an event exceeding a 1 in 1,000 year AEP event.			be mitigated with appropriate management measures.					
Alteration of surface hydrology	Sediment ponds, bunding and armoured outfalls will form aspects of the stormwater management system around the outside of the operational areas of the Project Stormwater within the Development Envelope will be directed to the wastewater treatment plant prior to discharge from the site.	N/A	N/A	No significant residual impact The residual impacts are minor and can be mitigated with appropriate management measures.	N/A	N/A	N/A	N/A	N/A
Temporary or permanent alteration of groundwater flows and/or	No abstraction of groundwater Revegetation of disturbed areas to increase infiltration	Undertake rehabilitation that aims to establish vegetation that will stabilise disturbed areas, prevent	Very High. Fresh topsoil generally results in high rates of recruitment.	No significant residual impact The residual impacts are minor and can be mitigated with	N/A	N/A	N/A	N/A	N/A

Environmental Impact	Mitigation			Significant residual impact	Offset Calculation Methodology				
	Avoid and minimise	Rehabilitation type	Likely rehabilitation success		Type	Risk	Likely offset success	Time Lag	Offset Quantification
groundwater levels	rates surrounding the Development Envelope.	erosion, create a buffer between the Processing Facility and the marine environment and increase the infiltration of stormwater.		appropriate management measures.					
Air Quality and Greenhouse Gases									
Significant greenhouse gas contribution	Greenhouse gas emissions will contribute to 6.2% of the NT total, which equates to 0.18% of the National total. Minimisation strategies will be implemented to reduce Project contributions. No offsets are proposed.	N/A	N/A	No significant residual impact The residual impacts to the National greenhouse gas contribution are minimal. Mitigation with appropriate management measures will be undertaken to reduce the Project impact.	N/A	N/A	N/A	N/A	N/A

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**ECOLOGICALLY
SUSTAINABLE
DEVELOPMENT**

9. ECOLOGICALLY SUSTAINABLE DEVELOPMENT

In 1983, the United Nations moved to recognise the impact of development of the biosphere, resulting from increased concern that continued economic growth was not sustainable. Following this, the 1987 report by the World Commission on Environment and Development, entitled *Our Common Future* (Brundtland et al. 1987), posited that environmental problems are a global concern and that policies for sustainable development are in the interest of all nations. Brundtland et al. (1987) defined sustainable development as “*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*”.

Within Australia, the concept of Ecologically Sustainable Development (**ESD**) has been incorporated into the National Strategy for Ecologically Sustainable Development (ESDSC 1992) and endorsed by the Council of Australian Governments. The goal of the National Strategy is to achieve “*Development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends*”.

In the Northern Territory, ESD is defined as “*Using, conserving and enhancing the communities’ resources so that ecological processes, on which life depends, are maintained, and the total quality of life now and in the future can be increased. ESD is development that aims to meet the needs of Australians today, while conserving our ecosystems for the benefit of future generations*”.

The principles of ESD are incorporated into many acts of parliament, including the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999*, and the Northern Territory *Environment Protection Authority Act (2007)*. The EPBC Act outlines five key principles of ESD, while the NT adopts principles that mirror those of the EPBC, but with the addition of the Public Participation Principle.

The key principles of ESD are central to the Project. Table 9-1 outlines how the planning and design phases of the Project have incorporated the principles and objective of the ESD.

Table 9-1: The principles of ecologically sustainable development, as outlined in the EPBC Act (DEWHA 2010b)

Principle	Measures Taken
The Integration Principle – Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.	The Integration Principle outlines that economic development without due regard to the environmental cost or social development may have negative impacts in the long-term. TNG has adopted an integrated approach to planning, ensuring that all three components of sustainable development (economic development, social development and environmental protection) are considered together. A range of technical studies have been conducted into the potential environmental and social impacts of the Project and, in turn, are informing the planning and design of the Project. These studies include: • Flora, Vegetation and Fauna; • Air Quality; • Climate Change; • Heritage; • Hydrogeology; • Hydrology; • Noise; • Social; • Soils; and • Traffic.

Principle	Measures Taken
	The outcomes of these studies, the potential impacts and avoidance, mitigation and management measures, are summarised in the relevant chapters of the EIS.
The Precautionary Principle – If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation	The application of the Precautionary Principle is triggered by two conditions: the threat of serious or irreversible environmental damage and scientific uncertainty as to the environmental damage. By its very nature, the EIS is precautionary action in that it assesses the potential for serious or irreversible change and uses technical reports to reduce scientific uncertainty regarding the likelihood of such damage. TNG has taken the following actions to fulfil the requirements of the precautionary principle: • A significance-based approach was used to assess the potential impacts of the Project, informed by technical studies and stakeholder engagement. Such an approach assumes that identified impacts will occur and that the proposed mitigation measures will be implemented effectively. • A risk-based approach was used to determine key risks that incorporate uncertain threats to the environment. This approach includes an assessment of the likelihood of harm and the measures taken to avoid, mitigate or manage the risk. • A compliance assessment method was applied to protect relevant environmental values. Such an approach relies on statutory guidelines based on both scientific knowledge and community values. Modelled emissions and discharges from infrastructure and operations are incorporated into the planning of the Project in order to achieve compliance with statutory limits. • Measures to avoid, mitigate or manage the threat of damage to the environment or social development will be implemented at all stages of construction, operation and closure.
The Intergenerational Principle – The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations	Careful management of the environmental impacts of the Project will ensure that the integrity of the environment is maintained for future generations. The Project will use a range of avoidance, mitigation and management measures to achieve this. All potential impacts have been modelled for the full life of the project, resulting in future generations receiving no additional environmental or social impacts than current generations. Domestic production of vanadium pentoxide will increase the viability of domestic manufacturing of vanadium redox batteries, which would in turn improve Australia's ability to provide renewable energy. Provision of renewable energy plant aligns with the NTG's commitment to produce 50% renewable energy by 2030 for electricity supplied to NT households and businesses, helping to reduce global greenhouse gas emissions and allowing the health of the environment to be maintained for future generations. The Project has a planned life of 40 years, resulting in a suite of jobs being provided for the Darwin community for many years. In addition, the Project will provide opportunities for apprenticeships, up-skilling of workers and on the job training, contributing to the skill base present in the Darwin community. Throughout the life of the Project, measures will be investigated and implemented to reduce resource requirements for the Facility; ensuring it operates as efficiently as possible to protect long term resource availability for future generations.
The Biodiversity Principle – The conservation of biological diversity and ecological integrity	Biological diversity is comprised of genetic diversity (within taxa), species diversity and ecosystem diversity. The planning and design of the project has been informed by in-depth terrestrial and aquatic biodiversity studies. The Project has been planned to maintain biological diversity at the site by minimising land clearing where practicable and maintaining habitat connectivity with surrounding vegetation. In

Principle	Measures Taken
should be a fundamental consideration in decision-making.	addition, the highly diverse and sensitive mangrove habitat will be largely avoided during construction and operations. The specific measures used to maintain biological diversity and ecological integrity are outlined in relevant chapters of the EIS.
The Valuation Principle – Improved valuation, pricing and incentive mechanisms should be promoted.	The Valuation Principle that endeavours to reduce environmental cost externalities by applying a ‘polluter pays’ framework is largely the responsibility of the government, by implementing policies that develop pricing and incentive mechanisms. However, the content of the EIS and all subsequent environmental reporting, will inform governments and contribute the development of such policies.
The Public Participation Principle – Decisions and actions relating to ecologically sustainable development should provide for broad community involvement on issues which affect them.	The Public Participation Principle seeks to promote broad consultation and collaboration from the community on issues of ESD that relate to them. Throughout the planning and design of the project, TNG has undertaken stakeholder engagement to inform and involve the Darwin community with the Project, and the potential environmental impacts. The approach and results to stakeholder engagement activities are outlined in Chapter 5. TNG will continue stakeholder engagement throughout the life of the Project.



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CONCLUDING STATEMENT

10. CONCLUDING STATEMENT

The Environmental Factors were assessed in accordance to the NT EPA objectives, with the purpose to identify, avoid or mitigate risks relating to the land, water, sea, air or people and communities. The proposed mitigation measures mentioned within this document (chapter 7) have resulted in reducing the risk and impact to the Environmental Factors. Without these mitigation measures the impacts to flora and fauna, terrestrial environmental quality and marine quality could be determined to have the highest impacts originating from the Project. Adhering to the mitigation measures, the Project is considered to meet the objectives of the EPA.

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REFERENCES

11. REFERENCES

CHAPTER 1 REFERENCES

Northern Territory Environmental Protection Authority 2019, *Draft General Guidance for Proponents Preparing an Environmental Impact Statement*, Northern Territory Government. Available from: <https://ntepa.nt.gov.au/about-ntepa/for-your-comment/comments-closed/guidance-proponents-preparing-eis>

CHAPTER 2 REFERENCES

No references

CHAPTER 3 REFERENCES

Bureau of Meteorology 2019, *Climate statistics*, Australian Government. Available from: http://www.bom.gov.au/climate/averages/tables/cw_014015.shtml

Department of Environment and Natural Resources 2000, *Land Resources of the Elizabeth, Darwin and Blackmore Rivers – Greater Darwin Area, Northern Territory*, Northern Territory Government. Available from: http://www.ntlis.nt.gov.au/metadata/export_data?type=html&metadata_id=2DBC8771203606B6E040CD9B0F274EFE

Department of Infrastructure, Planning and Logistics 2018, *Northern Territory Planning Scheme*, Northern Territory Government. Available from: <https://nt.gov.au/property/building-and-development/nt-planning-scheme/northern-territory-planning-scheme>

Department of Lands, Planning and the Environment 2015, *Darwin Regional Land Use Plan 2015*, Northern Territory Government. Available from: <https://dlpe.nt.gov.au/darwin-regional-land-use-plan-2015> [April 2019].

Department of the Environment 2008, *Rangelands 2008 – Taking the Pulse*, Land and Water Australia, Commonwealth of Australia. Available from: <https://environment.gov.au/land/publications/acris-rangelands-2008-taking-pulse>

Thackway, R, & Creswell, ID 1995, *An Interim Biogeographic Regionalisation for Australia: a framework for setting priorities in the national reserves system cooperative program*, Version 4.0. Australian Nature Conservation Agency, Canberra. Available from: <http://environment.gov.au/land/nrs/publications/ibra-framework-setting-priorities-nrs-cooperative-program>

Wood, BG, Fogarty, P J, & Day, KJ 1985, *The Land Systems of the Darwin Region: Conservation Commission of the Northern Territory Technical Report Number 24*, Conservation Commission of the Northern Territory, Northern Territory Government. Available from: <https://www.territorystories.nt.gov.au/jspui/handle/10070/227809>

CHAPTER 4 REFERENCES

Department of Health 2014a, *Code of practice for on-site wastewater management*, Northern Territory Government. Available from: https://nt.gov.au/_data/assets/pdf_file/0008/228833/code-of-practice-onsite-wastewater-management.pdf

Engineers Australia 2010, 'Infrastructure Report Card 2010 Australia', Available from: https://issuu.com/engineersaustralia/docs/entire_report_final

Land Development Corporation 2016, 'Middle Arm Industrial Precinct', Available from: <https://www.landdevcorp.com.au/industrial-commercial/middle-arm-industrial-precinct/>

National Environment Protection Council 2013, *The National Environment Protection (Assessment of Site Contamination) Measure*, Australian Government. Available from: <http://nepc.gov.au/nepms/assessment-site-contamination>

Northern Territory Government 2017, *Northern Territory Roadmap to Renewables*, Northern Territory Government. Available from: <https://roadmaprenewables.nt.gov.au/?a=460760>

The Economist 2018, *Vanadium is the latest beneficiary of the battery craze*. Available from: <https://www.economist.com/business/2018/07/21/vanadium-is-the-latest-beneficiary-of-the-battery-craze>

United States Geological Survey 2019a, 'Mineral Commodity Summaries', Available from: <https://prd-wret.s3-us-west-2.amazonaws.com/assets/palladium/production/atoms/files/mcs-2019-titan.pdf>

United States Geological Survey 2019b, 'Mineral Commodity Summaries', Available online: <https://prd-wret.s3-us-west-2.amazonaws.com/assets/palladium/production/atoms/files/mcs-2019-vanad.pdf>

CHAPTER 5 REFERENCES

Commonwealth of Australia 2018, *Charter: National Water Quality Management Strategy*, Department of Agriculture and Water Resources. Available from: <https://www.waterquality.gov.au/sites/default/files/documents/nwqms-charter.pdf>

Department of Sustainability, Environment, Water, Population and Communities 2012a, 'Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy', Available from: http://www.environment.gov.au/system/files/resources/12630bb4-2c10-4c8e-815f-2d7862bf87e7/files/offsets-policy_2.pdf

Department of Sustainability, Environment, Water, Population and Communities 2011a, *Survey Guidelines for Australia's Threatened Fish*, Australian Government. Available from: <http://www.environment.gov.au/system/files/resources/6c9817ee-517b-4c13-9d8c-e66a61514f53/files/survey-guidelines-fish.pdf>

Department of Sustainability, Environment, Water, Population and Communities 2011b, *Survey Guidelines for Australia's Threatened Mammals*, Australian Government. Available from : <http://www.environment.gov.au/system/files/resources/b1c6b237-12d9-4071-a26e-ee816caa2b39/files/survey-guidelines-mammals.pdf>

Department of the Environment 2013, *Matters of National Environmental Significance Significant Impact Guidelines 1.1, Environment Protection and Biodiversity Conservation Act 1999*, Commonwealth of Australia. Available from: http://www.environment.gov.au/system/files/resources/42f84df4-720b-4dcf-b262-48679a3aba58/files/nes-guidelines_1.pdf

Department of the Environment and Energy 2017, *EPBC Act Policy Statement 3.21: Industry Guidelines for Avoiding, Assessing and Mitigating Impacts on EPBC Act Listed Migratory Shorebird Species*, Commonwealth of Australia. Available from: <http://www.environment.gov.au/system/files/resources/67d7eab4-95a5-4c13-a35e-e74cca47c376/files/bio4190517-shorebirds-guidelines.pdf>

Department of the Environment, Water, Heritage and the Arts 2010a, *Survey Guidelines for Australia's Threatened Birds*, Commonwealth of Australia. Available from: <http://www.environment.gov.au/system/files/resources/107052eb-2041-45b9-9296-b5f514493ae0/files/survey-guidelines-birds-april-2017.pdf>

Northern Territory Department of Natural Resources, Environment, The Arts and Sport 2010, *Water Quality Objectives for the Darwin Harbour Region: Background Document*, Northern Territory Government. Available from: https://denr.nt.gov.au/_data/assets/pdf_file/0003/254856/WQGO_for_DH_Feb_2010_final.pdf

Northern Territory Environmental Protection Authority 2013a, *Guidelines for Assessment of Impacts on Terrestrial Biodiversity*, Northern Territory Government. Available from: https://ntepa.nt.gov.au/_data/assets/pdf_file/0004/287428/guideline_assessment_terrestrial_biodiversity.pdf

Northern Territory Environmental Protection Authority 2013b, *Guidelines for the Preparation of an Economic and Social Impact Assessment*, Northern Territory Government. Available from: https://ntepa.nt.gov.au/_data/assets/pdf_file/0006/287430/guideline_assessment_economic_social_impact.pdf

Northern Territory Environmental Protection Authority 2013c, *Guidelines on Environmental Offsets and Associated Approval Conditions*, Northern Territory Government. Available from: https://ntepa.nt.gov.au/_data/assets/pdf_file/0007/287431/guideline_assessment_environmental_offsets.pdf

Northern Territory Environmental Protection Authority 2013d, *Guidelines for the Siting, Design and Management of Solid Waste Disposal Sites In the Northern Territory*, Northern Territory Government. Available from: https://ntepa.nt.gov.au/_data/assets/pdf_file/0006/284685/siting_design_landfills.pdf

Northern Territory Environmental Protection Authority 2013e, *Guidelines on Conceptual Site Models*, Northern Territory Government. Available from: https://ntepa.nt.gov.au/_data/assets/pdf_file/0004/284674/guideline_pollution_conceptual_site_models.pdf

Northern Territory Environmental Protection Authority 2013f, *Guidelines on Mixing Zones*, Northern Territory Government. Available from: https://ntepa.nt.gov.au/_data/assets/pdf_file/0011/284681/guidelines_mixing_zones.pdf

Northern Territory Environmental Protection Authority 2014, *Noise guidelines for development sites in the Northern Territory*, Northern Territory Government. Available: https://ntepa.nt.gov.au/_data/assets/pdf_file/0005/284684/noise_guidelines_for_development_sites.pdf

Northern Territory Environmental Protection Authority 2015a, *Guideline for the Preparation of an Environmental Management Plan*, Northern Territory Government. Available from: https://ntepa.nt.gov.au/_data/assets/pdf_file/0006/284883/guideline_prep_emp.pdf

Northern Territory Environmental Protection Authority 2015b, *Guidelines to Prevent Pollution from Building Sites*, Northern Territory Government. Available from: https://ntepa.nt.gov.au/_data/assets/pdf_file/0010/284680/guideline_prevent_pollution_building_sites.pdf

Northern Territory Environmental Protection Authority 2016a, *Guideline for Reporting on Environmental Monitoring*, Northern Territory Government. Available from: https://ntepa.nt.gov.au/_data/assets/pdf_file/0006/284856/guideline_reporting_env_monitoring.pdf

Northern Territory Environmental Protection Authority 2017a, *Guideline: Recommended Land Use Separation Distances*, Northern Territory Government. Available from: https://ntepa.nt.gov.au/_data/assets/pdf_file/0006/453192/guideline_recommended_land_separation_distances_oct.pdf

Northern Territory Environmental Protection Authority 2017b, *Northern Territory Contaminated Land Guideline*, Northern Territory Government. https://ntepa.nt.gov.au/_data/assets/pdf_file/0020/434540/guideline_contaminated_land.pdf

Northern Territory Environmental Protection Authority 2018a, *Guidance on Adaptive Management*, Northern Territory Government. Available from: https://ntepa.nt.gov.au/_data/assets/pdf_file/0003/622092/guideline_adaptive_management.pdf

Northern Territory Environmental Protection Authority 2018b, *Opportunities and Timeframes for Community Engagement in the Environmental Impact Assessment Process*, Northern Territory Government. Available from: https://ntepa.nt.gov.au/_data/assets/pdf_file/0006/546792/guideline_opportunities_timeframes_community_engagement_eia_process.pdf

Northern Territory Environmental Protection Authority 2018c, *NT EPA Environmental Factors and Objectives*, Northern Territory Government. Available from: https://ntepa.nt.gov.au/_data/assets/pdf_file/0005/546791/guideline_environmental_factors_objectives.pdf

Northern Territory Environmental Protection Authority 2018d, *Northern Territory Noise Management Framework Guideline*, Northern Territory Government. Available from: https://ntepa.nt.gov.au/_data/assets/pdf_file/0004/566356/noise_management_framework_guideline.pdf

Northern Territory Environmental Protection Authority 2019, *Draft General Guidance for Proponents Preparing an Environmental Impact Statement*, Northern Territory Government. Available from: <https://ntepa.nt.gov.au/about-ntepa/for-your-comment/comments-closed/guidance-proponents-preparing-eis>

Northern Territory Government 2019, *Strike*, Department of Primary Industry and Resources. Available from: <http://strike.nt.gov.au/wss.html;jsessionid=5th94x3fq5911g400c8at478x>

CHAPTER 7.1 REFERENCES

Northern Territory Environmental Protection Authority 2016b, *Terms of Reference for the Preparation of an Environmental Impact Statement: Darwin Refinery, TNG Limited*, Northern Territory Government. Available from: https://ntepa.nt.gov.au/_data/assets/pdf_file/0007/286747/terms_reference_darwin_refinery.pdf

Northern Territory Environmental Protection Authority 2018c, *NT EPA Environmental Factors and Objectives*, Northern Territory Government. Available from: https://ntepa.nt.gov.au/_data/assets/pdf_file/0005/546791/guideline_environmental_factors_objectives.pdf

CHAPTER 7.2 REFERENCES

Department of Health 2009, *Guidelines for the Assessment Remediation and Management of Asbestos Contaminated Sites in Western Australia*, Western Australian Government. Available from: <https://ww2.health.wa.gov.au/~media/Files/Corporate/general%20documents/Asbestos/PDF/Guidelines-Asbestos-Contaminated%20Sites-May2009.pdf>

Department of Natural Resources, Environment, The Arts and Sport 2008, *Greater Darwin Region: Acid sulfate soils Middle Arm*, Northern Territory Government. Available from: file:///C:/Users/user/Desktop/Middle-Arm_50k_Acid-Sulfate-Soils.pdf

Golder Associates 2019a, 'Preliminary Site Investigation and Shallow Soil Baseline Assessment, Proposed TNG Refinery Lot 1817 Hundred of Ayers, Darwin NT', prepared for TNG Limited.

Hays, J 1967, 'Land surfaces and laterites in the north of the Northern Territory' in JN Jennings & JA Mabbutt, (eds), *Landform studies from Australia and New Guinea*, pp. 182-210. Australian National University Press, Canberra, ACT.

National Environment Protection Council 2013, *The National Environment Protection (Assessment of Site Contamination) Measure*, Australian Government. Available from: <http://nepc.gov.au/nepms/assessment-site-contamination>

Pietsch, BA 1986, *1:100 000 geological map series explanatory notes: Bynoe 5072, Northern Territory Geological Survey*, Department of Mines and Energy, Darwin, Northern Territory Government.

Stuart-Smith, PG, Wills, K, Crick, IH & Needham, RS 1980, 'Evolution of the Pine Creek geosyncline', in J Ferguson & AB Goleby (eds), *Proceedings of the International Uranium Symposium on the Pine Creek Geosyncline (Uranium in the Pine Creek Geosyncline)* pp. 101-140. International Atomic Energy Agency, Vienna.

Wood, BG, Fogarty, P J, & Day, KJ 1985, *The Land Systems of the Darwin Region: Conservation Commission of the Northern Territory Technical Report Number 24*, Conservation Commission of the Northern Territory, Northern Territory Government. Available from: <https://www.territorystories.nt.gov.au/jspui/handle/10070/227809>

CHAPTER 7.3 REFERENCES

Brocklehurst, PS, & Edmeades, BF 1996, *Mangrove Survey of Darwin Harbour, Northern Territory, Australia Technical Report No. R96/7*. Department of Lands, Planning and the Environment, Northern Territory Government.

Department of Environment and Natural Resources 2000, *Land Resources of the Elizabeth, Darwin and Blackmore Rivers – Greater Darwin Area, Northern Territory*, Northern Territory Government. Available from: http://www.ntlis.nt.gov.au/metadata/export_data?type=html&metadata_id=2DBC771203606B6E040CD9B0F274EFE

Department of Environment and Natural Resources 2019, *Technical Report: Land Clearing Guidelines*, Northern Territory Government. Available from: https://nt.gov.au/data/assets/pdf_file/0007/236815/land-clearing-guidelines-2019.pdf

Department of Land Resource Management 2016, *Typhonium praetermissum Threatened species distribution in the Greater Darwin Region*, Northern Territory Government. Available from: https://nt.gov.au/data/assets/pdf_file/0019/405541/typhonium-praetermissum-mapped-distribution.pdf

Department of Land Resource Management 2019, *Typhonium praetermissum Threatened species distribution in the Greater Darwin Region*, Northern Territory Government. Available from: <file:///C:/Users/user/Downloads/Mapped%20Distribution%20Typhonium%20praetermissum%20V3.2%20Sept%202019.pdf>

Fogarty, PJ, Lynch, B, & Wood, BG 1984, *Land Resources of The Elizabeth, Darwin and Blackmore Rivers. Report Number 15/84d*. Northern Territory Government, Land Conservation Unit, Conservation Commission of the Northern Territory, Northern Territory Government. Available from: <http://hdl.handle.net/10070/229286>.

Russell-Smith, J 1991, 'Classification, species richness, and environmental relations of monsoon rain forest in northern Australia', *Journal of Vegetation Science*, vol. 2, no. 2, pp. 259-278. Available from: JSTOR.

Wilson, BA, Brocklehurst, PS, Clark, MJ, & Dickinson, KJM 1990, *Vegetation Survey of the Northern Territory, Australia. Explanatory notes to accompany 1:1 000 000 Map Sheets*, Northern Territory Conservation Commission, Darwin.

CHAPTER 7.4 REFERENCES

- BirdLife International 2016, *The IUCN Red List of Threatened Species 2016: Burhinus grallarius*. Available from: <https://www.iucnredlist.org/species/22693600/93415183>
- Brown, GP, Phillips, BL, & Shine, R 2011, 'The ecological impact of invasive cane toads on tropical snakes: field data do not support laboratory-based predictions', *Ecology*, vol. 92, no. 2, pp. 422-431. Available from: NCBI.
- Close, DH, & Newman, OMG 1984, 'The decline of the Eastern Curlew in south-eastern Australia', *Emu*, vol. 84, pp. 38-40. Available from: Taylor & Francis Online.
- Cogger, HG 2014, *Reptiles and amphibians of Australia*, CSIRO Publishing, Collingwood.
- Department of the Environment 2015, *Wildlife Conservation Plan for Migratory Shorebirds*, Australian Government. Available from: <http://www.environment.gov.au/system/files/resources/9995c620-45c9-4574-af8e-a7cfb9571deb/files/wildlife-conservation-plan-migratory-shorebirds.pdf>
- Department of the Environment and Energy 2018, *Species Profile and Threats Database*, Australian Government. Available from: <http://www.environment.gov.au/sprat>
- Fukuda, Y, Webb, G, Manolis, C, Delaney, R, Letnic, M, Lindner, G, & Whitehead, P 2011, 'Recovery of saltwater crocodiles following unregulated hunting in tidal rivers of the Northern Territory, Australia', *The Journal of Wildlife Management*, vol. 75, pp. 1253–1266. Available from: ResearchGate.
- Higgins, PJ, & Davies, SJF (eds) 1996, *Handbook of Australian, New Zealand and Antarctic birds, Volume 3: Snipe to Pigeons*, Oxford University Press, Melbourne.
- Hill, BM, & Ward, SJ 2010, *National Recovery Plan for the Northern Quoll Dasyurus hallucatus*, Department of Natural Resources, Environment, The Arts and Sport, Northern Territory Government. Available from: <https://www.environment.gov.au/system/files/resources/8744fe3f-3a94-431f-906c-975719d42f4f/files/northern-quoll.pdf>
- Marchant, S, & Higgins, PJ (eds) 1993, *Handbook of Australian, New Zealand and Antarctic Birds. Volume 2: Raptors to Lapwings*, Oxford University Press, Melbourne.
- Menkhorst, P, & Knight, F 2009, *A Field Guide to the Mammals of Australia*, 2nd Ed, Oxford University Press, Melbourne.
- Morcombe, MK 2010, *Field Guide to Australian Birds*, Steve Parish Publishing, Archerfield.
- Pavey, C, & Ward, S 2012, *Threatened Species of the Northern Territory: Common Brushtailed Possum, Trichosurus vulpecula*, Department of Environment and Natural Resources, Northern Territory Government. Available from: https://nt.gov.au/_data/assets/pdf_file/0019/205525/common-brushtail-possum.pdf
- Pizzey, G, & Knight, F 2012, *The Field Guide to the Birds of Australia*, Harper Collins Publishers, Sydney.
- Price, O, Rankmore, B, Milne, D, Brock, C, Tynan, C, Kean, L, & Roeger, L 2005, 'Regional patterns of mammal abundance and their relationship to landscape variables in eucalypt woodlands near Darwin, northern Australia', *Wildlife Research*, vol. 32, pp. 435-446. Available from: CSIRO.
- Simpson, K 1993, *Field Guide to the Birds of Australia: the most complete one-volume book of identification*, Viking O'Neil, Hawthorn.

Threatened Species Scientific Committee 2016a, *Conservation Advice Calidris tenuirostris Great knot. Commonwealth of Australia, Canberra*, Department of the Environment. Available from: <http://www.environment.gov.au/biodiversity/threatened/species/pubs/862-conservation-advice-05052016.pdf>

Threatened Species Scientific Committee 2016b, *Conservation Advice Calidris canutus Red knot. Commonwealth of Australia, Canberra*, Department of the Environment. Available from: <http://www.environment.gov.au/biodiversity/threatened/species/pubs/855-conservation-advice-05052016.pdf>

Threatened Species Scientific Committee 2016c, *Conservation Advice Charadrius mongolus Lesser sand plover. Commonwealth of Australia, Canberra*, Department of the Environment. Available from: <http://www.environment.gov.au/biodiversity/threatened/species/pubs/879-conservation-advice-05052016.pdf>

Threatened Species Scientific Committee 2016d, *Conservation Advice Charadrius leschenaultii Greater sand plover. Commonwealth of Australia, Canberra*, Department of the Environment. Available from: <http://www.environment.gov.au/biodiversity/threatened/species/pubs/877-conservation-advice-05052016.pdf>

URS 2001, 'Public Environmental Report: Blackmore River (East) Aquaculture Project Middle Arm, Darwin Harbour, Northern Territory', prepared for Phelps/Panizza Holdings. Available from: https://ntepa.nt.gov.au/_data/assets/pdf_file/0004/286438/perfull.pdf

van der Ree, R., 1999. Barbed wire fencing as a hazard for wildlife. *Victorian Naturalist*, 116(6), pp.210-217.

Van Dyck, S, & Strahan, R 2008, *The Mammals of Australia*, 3rd ed, New Holland Publishers, Sydney.

Ward, S, Woinarski, J, Griffiths, T, & McKay, L 2012a, *Threatened Species of the Northern Territory: Yellow-spotted Monitor, Varanus panoptes*, Department of Environment and Natural Resources. Available from: https://nt.gov.au/_data/assets/pdf_file/0006/206466/floodplain-monitor.pdf

CHAPTER 7.5 REFERENCES

Advisian 2019, 'TNG Darwin Processing Facility Hydrology and Coastal Assessment', prepared for TNG Limited.

Cardno 2014, 'Elizabeth and Blackmore River Catchments: Flood study', prepared for Department of Lands, Planning and the Environment. Available from: https://denr.nt.gov.au/_data/assets/pdf_file/0003/254865/Eliz1.pdf

Golder Associates 2019b, 'Hydrogeological Study – TNG Darwin Process Facility', prepared for TNG Limited.

Pietsch, BA 1986, *1:100 000 geological map series explanatory notes: Bynoe 5072, Northern Territory Geological Survey*, Department of Mines and Energy, Darwin, Northern Territory Government.

CHAPTER 7.6 REFERENCES

ANZG 2000, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, Australian Government. Available from: <https://www.waterquality.gov.au/anz-guidelines/resources/previous-guidelines/anzecc-armcanz-2000>

ANZG 2018, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, Australian Government. Available from: <https://www.waterquality.gov.au/anz-guidelines>

Aquatic Health Unit 2010, *Water Quality Objectives for the Darwin Harbour Region*, Available from: https://denr.nt.gov.au/_data/assets/pdf_file/0003/254856/WQGO_for_DH_Feb_2010_final.pdf

Department of Health 2014b, *Contaminated sites ground and surface water chemical screening guidelines*, Western Australian Government. Available from: <https://ww2.health.wa.gov.au/~media/Files/Corporate/general%20documents/Environmental%20health/Ground%20and%20Surface%20Chemical%20Water%20Screening%20Guidelines.ashx>

Department of Water and Environmental Regulation 2014, *Assessment and management of contaminated sites – Contaminated sites guidelines*, Western Australian Government. Available from: https://www.der.wa.gov.au/images/documents/your-environment/contaminated-sites/guidelines/Assessment_and_management_of_contaminated_sites.pdf

Golder Associates 2019a, 'Preliminary Site Investigation and Shallow Soil Baseline Assessment, Proposed TNG Refinery Lot 1817 Hundred of Ayers, Darwin NT', prepared for TNG Limited.

Golder Associates 2019b, 'Hydrogeological Study – TNG Darwin Process Facility', prepared for TNG Limited.

National Environmental Protection (Assessment of Site Contamination) Measure 1999 (Cth), Australian Government. Available from: <https://www.legislation.gov.au/Details/F2013C00288>

National Environmental Protection (Assessment of Site Contamination) Measure 2013 (Cth), Guideline on Investigation Levels for soil and groundwater – Schedule B1, Australian Government. Available from: <http://nepc.gov.au/system/files/resources/93ae0e77-e697-e494-656f-afaaf9fb4277/files/schedule-b1-guideline-investigation-levels-soil-and-groundwater-sep10.pdf>.

National Health and Medical Research Council 2008, *Guidelines for Managing Risk in Recreational Water*, Australian Government. Available from: <https://www.nhmrc.gov.au/about-us/publications/guidelines-managing-risks-recreational-water>

CHAPTER 7.7 REFERENCES

ANZG 2018, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, Australian Government. Available from: <https://www.waterquality.gov.au/anz-guidelines>

Bureau of Meteorology 2019, *Climate statistics*, Australian Government. Available from: http://www.bom.gov.au/climate/averages/tables/cw_014015.shtml

Cardno 2014, 'Elizabeth and Blackmore River Catchments: Flood study', prepared for Department of Lands, Planning and the Environment. Available from: https://denr.nt.gov.au/_data/assets/pdf_file/0003/254865/Eliz1.pdf

ANZG 2000, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, Australian Government. Available from: <https://www.waterquality.gov.au/anz-guidelines/resources/previous-guidelines/anzecc-armcanz-2000>

Baird 2019a, 'TNG Darwin Processing Facility Outfall: Hydrodynamic Modelling Report', prepared for TNG Limited.

Baird 2019b, 'TNG Darwin Processing Facility Outfall: Pollutant Outfall Modelling Report', prepared for TNG Limited.

Department of Land Resource Management 2014, *Darwin Harbour Water Quality Protection Plan*, Northern Territory Government. Available from: https://denr.nt.gov.au/_data/assets/pdf_file/0011/254855/Water-Quality-Protection-Plan-Feb2014-web.pdf

Department of Natural Resources, Environment, The Arts and Sport 2010, *Water Quality Objectives for the Darwin Harbour Region – Background Document*, Northern Territory Government. Available from: https://denr.nt.gov.au/_data/assets/pdf_file/0003/254856/WQGO_for_DH_Feb_2010_final.pdf

Northern Territory Environmental Protection Authority 2018c, *NT EPA Environmental Factors and Objectives*, Northern Territory Government. Available from: https://ntepa.nt.gov.au/_data/assets/pdf_file/0005/546791/guideline_environmental_factors_objectives.pdf

O2 Marine 2019a, 'Darwin Industrial Processing Facility: Marine Environmental Quality Site Investigation', prepared for TNG Limited.

O2 Marine 2019b, 'Darwin Industrial Processing Facility: Marine Environmental Quality Monitoring and Management Plan', prepared for TNG Limited.

Padovan, AV 2003, *Darwin Harbour water and sediment quality in Darwin Harbour Region: current knowledge and future needs*, Department of Infrastructure, Planning and Environment, Darwin, Northern Territory. pp. 5–18.

Skinner, L, Townsend, S & Fortune, J 2009, *The impact of urban land-use on total pollutant loads entering Darwin Harbour: Report 06/2008D*, Department of Natural Resources, Environment, The Arts and Sport. Available from: https://denr.nt.gov.au/_data/assets/pdf_file/0005/253760/pollutant_loads_report_200905.pdf

URS 2011a, *Marine Water and Sediment Quality Assessment*, prepared for Northern Territory Department of Lands and Planning.

CHAPTER 7.8 REFERENCES

- Mount R, Bricher, P & Newton J 2007, *National intertidal/subtidal benthic (NISB): Habitat classification scheme*, National Heritage Trust, Australian Government. Available from: <https://ozcoasts.org.au/wp-content/uploads/2018/05/pn21267.pdf>
- Wolstenholme J, Dinesen ZD & Alderslade P 1997, 'Hard corals of the Darwin region, Northern Territory, Australia' in JR Hanley, G Caswell, D Megirian & HK Larson (eds), *Proceedings of the Sixth International Marine Biological Workshop: The Marine Flora and Fauna of Darwin Harbour, Northern Territory, Australia*, Museums and Art Galleries of the Northern Territory and the Australian Marine Sciences Association, Darwin, Australia. pp. 381-398. Available from: <https://pdfs.semanticscholar.org/0638/2c74f82b33cb84a2465c9fdc8bf8c816575f.pdf>
- BMT WBM 2010, 'East Arm, Elizabeth River, Blackmore River and Middle Arm Marine Habitat Survey', unpublished report for iX Survey.
- Brocklehurst, PS, & Edmeades, BF 1996, *Mangrove Survey of Darwin Harbour, Northern Territory, Australia Technical Report No. R96/7*. Department of Lands, Planning and the Environment, Northern Territory Government.
- Department of Environment and Energy 2019, *The Directory of Important Wetlands in Australia (the Directory)*, Australian Government. Available from: <https://www.environment.gov.au/water/wetlands/australian-wetlands-database/directory-important-wetlands>
- Department of Land Resource Management 2013, *The Mangrove Communities of Darwin Harbour: Biomass Update*, Department of Land Resource Management, Northern Territory Government. Available from: https://www.territorystories.nt.gov.au/bitstream/10070/213495/4/Biomass_Update_-_Report_Darwin_Mangroves.pdf
- Department of Natural Resources, Environment, The Arts and Sport 2019, *Sites of Conservation Significance: Darwin Harbour*, Northern Territory Government. Available from: <https://nt.gov.au/environment/environmental-data-maps/important-biodiversity-conservation-sites/conservation-significance-list>
- Geo Oceans 2011a, 'Ichthys Gas Field Development Project – Benthic Habitat Mapping of the Darwin Region : Supplement to the draft Environmental Impact Statement', prepared for Inpex.
- Halpern, BS, Walbridge, S, Selkoe, KA, Kappel, CV, Micheli, F, D'Agrosa, C, Bruno, JF, Casey, KS, Ebert, C, Fox, HE, Fujita, R, Heinemann, D, Lenihan, HS, Madin, EMP, Perry, MT, Selig, ERS, Steneck, MR & Watson, R 2008, 'A Global Map of Human Impact on Marine Ecosystems', *Science*, vol. 319, pp. 948-952. Available from: NCBI.
- Metcalf 1999, *Mangrove Litter Production: Darwin Harbour Northern Territory*, PhD thesis, Northern Territory University.
- Northern Territory Environmental Protection Authority 2018c, *NT EPA Environmental Factors and Objectives*, Northern Territory Government. Available from: https://ntepa.nt.gov.au/data/assets/pdf_file/0005/546791/guideline_environmental_factors_objectives.pdf
- O2 Marine 2019c, 'Darwin Industrial Processing Facility: Benthic Habitat and Communities Site Investigation', prepared for TNG Limited.

Semeniuk, V 1985, 'Mangrove Environment of Port Darwin, Northern Territory: The Physical Framework and Habitats', *Journal of the Royal Society of Western Australia*, vol.67, no. 3 and 4, pp.81-97. Available from: ResearchGate.

Semeniuk, V 1993, 'The Mangrove systems of Western Australia', *Journal of the Royal Society of Western Australia*, vol. 76, pp.99-122.

Smit, N, Penny, S & Griffiths, T 2012, *Assessment of marine biodiversity and habitat mapping in the Weddell region, Darwin Harbour*, Department of Lands, Planning and Environment. Available from: <http://data.imas.utas.edu.au/attachments/2e754ed7-caab-4640-a133-5ead9e077edb/Weddell%20Marine%20Biodiversity%20and%20habitats%202012%20optimised.pdf>

URS 2010, *Ichthys Gas Field Development Project – Nearshore Marine Ecology and Benthic Communities Study*, Department of Natural Resources, Environmental, the Arts and Sport, Northern Territory Government. Available from: <https://www.inpex.com.au/media/1731/draft-eis-technical-appendices-appendix-8-nearshore-marine-ecology-and-benthic-communities-study.pdf>

Wang, XH, Sidhu, H & Williams, D 2011, 'Modelling of three dimensional tidal dynamics in Darwin Harbour, Australia', *The ANZIAM Journal*, vol. 52, pp. Available from: Semantic Scholar

Wightman, G 2006, *Mangroves of the Northern Territory, Australia. Identification and Traditional Use. Northern Territory Botanical Bulletin No. 3*, Department of Natural Resources, Environment and the Arts and Greening Australia, Northern Territory Government.

CHAPTER 7.9 REFERENCES

ANZG 2018, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, Australian Government. Available from: <https://www.waterquality.gov.au/anz-guidelines>

Cardno 2013, 'Turtle and Dugong Monitoring Program Baseline Report: Ichthys Nearshore Environmental Monitoring Program', prepared for INPEX.

Chatto, R & Baker, B 2008, *The distribution and status of marine turtle nesting in the northern territory*, Department of Natural Resources, Environment, the Arts and Sport. Available from: https://dtsc.nt.gov.au/_data/assets/pdf_file/0006/279915/marine_turtle_nesting.pdf

Commonwealth of Australia 2012, *Species group report card – cetaceans. Supporting the marine bioregional plan for the North Marine Region*, Department of Sustainability, Environment, Water, Population and Communities. Available from: <http://www.environment.gov.au/system/files/pages/1670366b-988b-4201-94a1-1f29175a4d65/files/north-west-report-card-cetaceans.pdf>

Department of Sustainability, Environment, Water, Population and Communities 2012b, *Marine bioregional plan for the North Marine Region*, Australian Government. Available from: <https://www.environment.gov.au/system/files/pages/0fcb6106-b4e3-4f9f-8d06-f6f94bea196b/files/north-marine-plan.pdf>

Department of Sustainability, Environment, Water, Population and Communities 2012c, *Species group report card – dugong: North Marine Region*, Australian Government. Available from: <https://www.environment.gov.au/system/files/pages/0fcb6106-b4e3-4f9f-8d06-f6f94bea196b/files/north-report-card-dugong.pdf>

Department of Sustainability, Environment, Water, Population and Communities 2012d, *Species group report card – dolphins: North Marine Region*, Australian Government. Available from: <https://www.environment.gov.au/system/files/pages/0fcb6106-b4e3-4f9f-8d06-f6f94bea196b/files/north-marine-plan.pdf>

Department of Sustainability, Environment, Water, Population and Communities 2012e, *Species group report card – bony fishes: North Marine Region*, Australian Government. Available from: <https://www.environment.gov.au/system/files/pages/1670366b-988b-4201-94a1-1f29175a4d65/files/north-west-report-card-bonyfishes.pdf>

Department of Sustainability, Environment, Water, Population and Communities 2012f, *Species group report card – sawfishes and river sharks: North Marine Region*, Australian Government. Available from: <https://www.environment.gov.au/system/files/pages/0fcb6106-b4e3-4f9f-8d06-f6f94bea196b/files/north-report-card-sawfishes.pdf>

Department of Sustainability, Environment, Water, Population and Communities 2012g, *Species group report card – marine reptiles: North Marine Region*, Australian Government. Available from: <http://www.environment.gov.au/system/files/pages/a73fb726-8572-4d64-9e33-1d320dd6109c/files/south-west-report-card-reptiles.pdf>

Flora and Fauna Division 2019, 'Darwin Region Coastal Dolphin Monitoring Program: Progress Report – October 2018 surveys', Department of Environment and Natural Resources, Northern Territory Government. Available from:

<https://www.territorystories.nt.gov.au/jspui/bitstream/10070/305351/1/Darwin%20Region%20Coastal%20Dolphin%20Monitoring%20Program%20-%20October%202017%20-%20REV0.pdf>

Geo oceans 2011b, 'Ichthys gas field development project: Benthic habitat mapping of the Darwin region – methods of data collection, collation and map production', prepared for INPEX.

GHD 2011, 'Ichthys gas field development project: summary report of dolphin surveys in the Middle Arm and West Arm of Darwin Harbour- January to March 2011', prepared for INPEX.

O2 Marine 2019d, 'Darwin Industrial Processing Facility: Marine Fauna Desktop Assessment', prepared for TNG Limited.

Palmer, C 2010, *Darwin Harbour Coastal Dolphin Project*, Department of Natural Resources, Environment, the Arts and Sport. Available from: https://denr.nt.gov.au/_data/assets/pdf_file/0007/255157/InterimReport_DarwinHarbourDolphins_2008-to-2010_PALMER.pdf

Pollock, K & Brooks, L 2015, 'The Darwin dolphin monitoring program. Abundance, apparent survival, movements and habitat use of humpback, bottlenose and snubfins in the Darwin area', prepared for Statplan consulting PTY LTD.

Smit, N, Penny, S & Griffiths, T 2012, *Assessment of marine biodiversity and habitat mapping in the Weddell region, Darwin Harbour*, Department of Lands, Planning and Environment. Available from: <http://data.imas.utas.edu.au/attachments/2e754ed7-caab-4640-a133-5ead9e077edb/Weddell%20Marine%20Biodiversity%20and%20habitats%202012%20optimised.pdf>

URS 2011b, 'Ichthys Gas Field Development Project. Potential effects of underwater blasting, piledriving and dredging on sensitive marine fauna in Darwin Harbour', prepared for INPEX.

CHAPTER 7.10 REFERENCES

Aurora Environmental 2019, 'Darwin Processing Facility - Climate Change Impact Assessment', prepared for TNG Limited.

Commonwealth of Australia 2017, *2017 Review of Climate Change Policies*, Department of the Environment and Energy. Available from: <https://www.environment.gov.au/system/files/resources/18690271-59ac-43c8-ae1-92d930141f54/files/2017-review-of-climate-change-policies.pdf>

Department of Environment and Energy 2019, *The Directory of Important Wetlands in Australia (the Directory)*, Australian Government. Available from: <https://www.environment.gov.au/water/wetlands/australian-wetlands-database/directory-important-wetlands>

New South Wales Environmental Protection Authority 2016, *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*, New South Wales Government. Available from: <https://www.epa.nsw.gov.au/-/media/epa/corporate-site/resources/air/approved-methods-for-modelling-and-assessment-of-air-pollutants-in-nsw-160666.pdf>

Northern Territory Government 2018, *Climate Change – Mitigation and Adaptation opportunities in the Northern Territory, Discussion Paper*, Northern Territory Government. Available from: <https://haveyoursay.nt.gov.au/climatechange>

Vipac Engineers and Scientists 2019a, 'Darwin Magnetite Concentrate Processing Facility - Air Quality Assessment', prepared for TNG Limited.

CHAPTER 7.11 REFERENCES

Australian Bureau of Statistics 2018, Australian demographic statistics 2018, cat. no. 3218.0. Available from: <https://www.abs.gov.au/>

Elton Consulting 2019, 'Darwin Processing Facility – Socio-economic Impact Assessment', prepared for TNG Limited.

Tonkin Consulting 2019a, Proposed Magnetite Processing Facility – Traffic Impact Assessment', prepared for TNG Limited.

Vipac Engineers and Scientists 2019b, 'Darwin Magnetite Concentrate Processing Facility – Noise Impact Assessment', prepared for TNG Limited.

CHAPTER 7.12 REFERENCES

Whelan, P & Hurk, A 2003, 'Medically important insects in the Northern Territory and how disasters may affect them', *The Northern Territory Disease Control Bulletin*, vol. 10, no. 1, pp. 27-38. Available from: <https://digitallibrary.health.nt.gov.au/prodjspui/handle/10137/206>

CHAPTER 8 REFERENCES

ANZG 2018, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, Australian Government.
Available from: <https://www.waterquality.gov.au/anz-guidelines>

CHAPTER 9 REFERENCES

Brundtland, GH, Khalid, M, Agnelli, S, Al-Athel, S & Chidzero, B (eds) 1987, *Our common future*, Oxford University Press.

Department of the Environment, Water, Heritage and the Arts 2010b, *Guidelines for Section 516A reporting - Environment Protection and Biodiversity Conservation Act 1999*, Available online: <http://www.environment.gov.au/resource/guidelines-section-516a-reporting-environment-protection-and-biodiversity-conservation-act>

Ecologically Sustainable Development Steering Committee 1992, *National Strategy for Ecologically Sustainable Development*, Department of the Environment and Energy. Available from: <https://www.environment.gov.au/about-us/esd/publications/national-esd-strategy>

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DRAFT ENVIRONMENTAL IMPACT
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