

ENVIRONMENTAL IMPACT MONITORING PROGRAM

Ichthys On-Shore LNG Facilities

Bladin Point

Prepared for:
JKC Australia LNG Pty Ltd

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EXECUTIVE SUMMARY

The Ichthys Onshore Liquefied Natural Gas (LNG) Processing Plant is located on Bladin Point in Darwin Harbour, Northern Territory.

The Ichthys Onshore LNG Facilities - Construction Environmental Management Plan (INPEX Operations Australia Pty Ltd, 2016) (L092-AH-PLN-10001) (CEMP) was prepared for the development of the Ichthys Onshore LNG Processing Plant at Bladin Point and its supporting infrastructure, and details the environmental protection management measures and controls necessary to avoid, reduce or mitigate the potential environmental impacts during the construction, pre-commissioning (including hydrotesting), commissioning and demobilisation phases of the Project.

The Environmental Impact Monitoring Program (EIMP) details the monitoring of surface water, groundwater, mangrove community health, sediment quality, sedimentation and erosion, bio-indicators, air quality (dust), airborne noise, weeds and flora and fauna. It has been developed to monitor for impacts on the environment during the works covered by the CEMP.

The objectives of this revision of this EIMP are to:

- Incorporate the proposed amendments as outlined in the Annual Environmental Monitoring Report;*
- Provide information relating to Site conditions that can inform the environmental monitoring programs;*
- Provide a robust environmental dataset against which environmental performance can be assessed against environmental objectives and targets set out in the CEMP; and*
- Define the process by which future changes to the monitoring program will be determined, under an adaptive management framework, as portions of the monitoring program become redundant when activities and their locations change or cease, or as risk pathways are closed, or as a result of safety requirements as Bladin Point becomes a Major Hazard Facility.*

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Appendix C	Selected Conceptual Site Models Diagrams

ABBREVIATIONS

Abbreviation	Description
ADWG	Australian Drinking Water Guidelines
AEMR	Annual Environmental Monitoring Report
AGL	Above Ground Level
AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment Conservation Council
ANZECC Guidelines	Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000)
AOC	Accidentally Oil Contaminated
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
AS	Australian Standard
AS/NZS	Australian and New Zealand Standard
ASS	Acid Sulfate Soil
BOM	Australian Bureau of Meteorology
BPMC	Bladin Point Mangrove Community
BTEXN	Benzene, toluene, ethylbenzene, xylene, naphthalene
°C	Degrees Celsius
CEMP	Construction Environmental Management Plan (INPEX document L092-AH-PLN-10001)
cm	Centimetre
CSMC	Control Site Mangrove Community
CoC	Chain of Custody
COC	Continuously Oil Contaminated
Cth	Commonwealth
dB(A)	A-weighted Decibel
DLPE	Department of Lands, Planning and the Environment
DO	Dissolved Oxygen
EC	Electrical Conductivity
EIMP	Environmental Impact Monitoring Program
EIS	Environmental Impact Statement
EPA7 (as amended)	Environment Protection Approval 7 (as amended)
EPC	Engineering Procurement and Construction
ESCP	Erosion and Sediment Control Plan
FSANZ	Food Standards Australia New Zealand
g	Gram
GDA	Geocentric Datum of Australia
GEL	Generally Expected Level

Abbreviation	Description
GEP	Gas Export Pipeline
GIIP	Good International Industry Practice
GPS	Global Positioning System
ha	Hectare
IEC	International Electrotechnical Commission
IECA	International Erosion Control Association
IFC	International Finance Corporation
ISO	International Organisation for Standardisation
ISQG	Interim Sediment Quality Guideline
Jetty	Product Loading Jetty
km	Kilometre
L	Litre
L _{Aeq}	Equivalent continuous A-weighted sound pressure level
LNG	Liquefied Natural Gas
LOR	Limit of Reporting
LPG	Liquefied Petroleum Gas
m	Metre
m ²	Square metre
m ³	Cubic metre
mg	Milligram
mg/L	Milligram per litre
mL	Millilitre
mm	Millimetre
MHF	Major Hazard Facility
MNES	Matters of National Environmental Significance
MOF	Module Offloading Facility
Mt/a	Million tonnes per annum
NATA	National Association of Testing Authorities
NCW	Non-contaminated water
NEMP	Nearshore Environmental Monitoring Plan
NEPM	National Environment Protection Measure
NHMRC	National Health and Medical Research Council
NMT	Noise Monitoring Terminals
NOAA	National Oceanic and Atmospheric Administration
NRETAS	Department of Natural Resources, Environment, the Arts and Sport
NSR	Noise sensitive receptor
NSW	New South Wales
NT	Northern Territory

Abbreviation	Description
NT EPA	Northern Territory Environment Protection Authority
NTU	Nephelometric Turbidity Units
OECD	Organisation for Economic Cooperation and Development
ORP	Oxidation Reduction Potential
PAH	Polycyclic aromatic hydrocarbons
PASS	Potential Acid Sulfate Soil
pH	Acid/ alkaline value
PM ₁₀	Particulate matter of 10 micrometres or less in size
PM _{2.5}	Particulate matter of 2.5 micrometres or less in size
QA/QC	Quality Assurance/Quality Control
RTK	Real Time Kinematic
SPL	Sound Pressure Level
STR	Supplementary Technical Report
SWL	Standing water level
T0	Commencement of rain event
T1	Ten minutes after commencement of the rain event
T2	Twenty minutes after commencement of the rain event
TDS	Total Dissolved Solids
TOC	Top of casing
TOF	Temporary Office Facilities
TPH	Total Petroleum Hydrocarbons
TRH	Total Recoverable Hydrocarbons
TSS	Total Suspended Solids
µg	Microgram
µg/L	Microgram per litre
µm	Micrometres
WDL	Waste Discharge Licence
WONS	Weeds of National Significance
WQOs	Water Quality Objectives

1. INTRODUCTION

1.1 Background

INPEX Operations Australia Pty Ltd (Company), on behalf of Ichthys LNG Pty Ltd and the upstream Ichthys joint venture participants, is developing the Ichthys gas and condensate field (the Ichthys Field) in the Browse Basin, around 450 kilometres (km) north north-east of Broome in Western Australia (**Figure 1-1**). JKC Australia LNG Pty Ltd (Contractor), the joint venture between JGC Corporation, Kellogg Brown and Root Pty Ltd (KBR) and Chiyoda Corporation, has been appointed by Company as the engineering, procurement and construction (EPC) Contractor for development of the following:

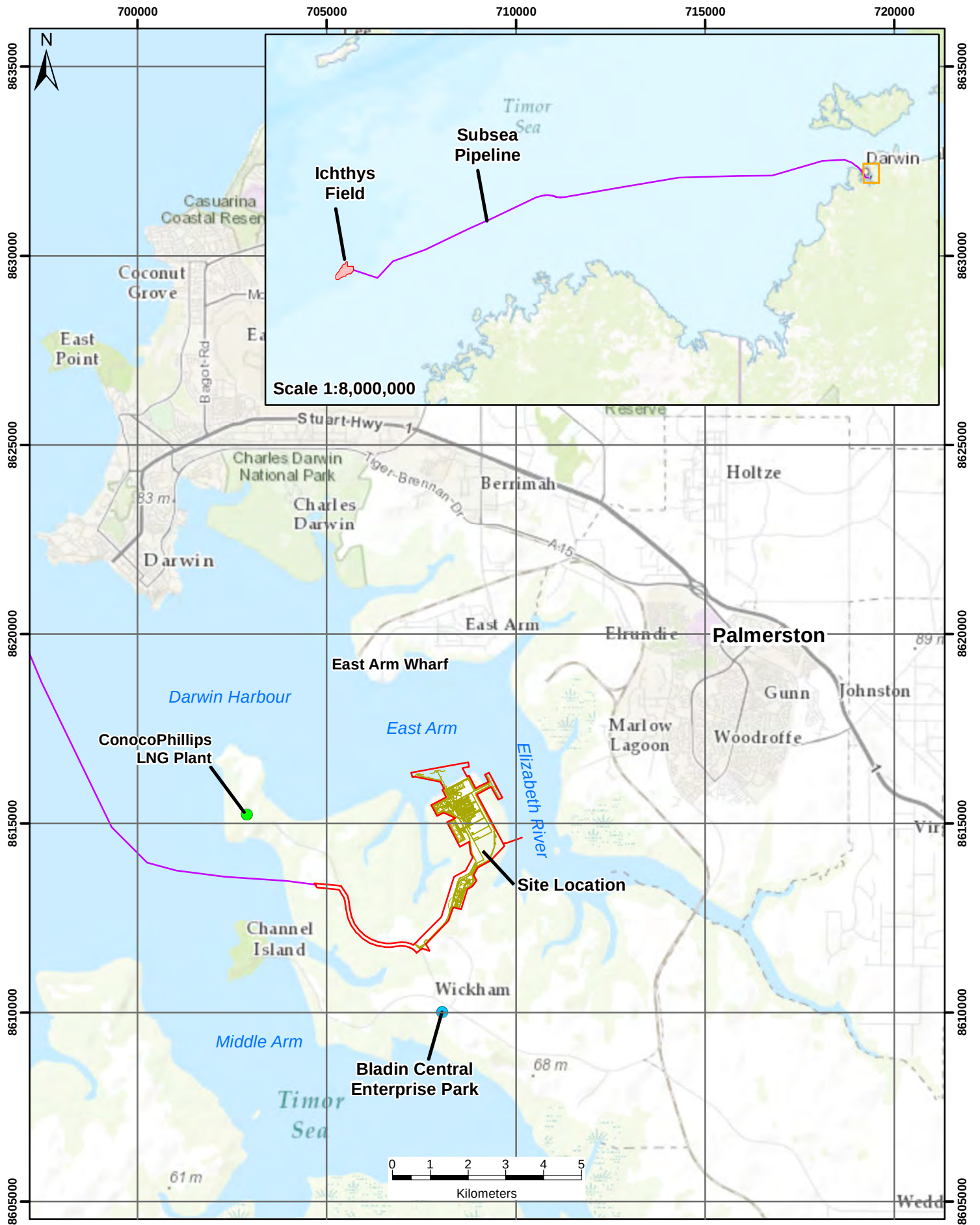
- Ichthys Onshore Liquefied Natural Gas (LNG) Facilities and its supporting infrastructure at Bladin Point; and
- Manigurr-ma Village at Howard Springs.

For the purposes of this document, the Project is defined to include the onshore facilities located at Bladin Point ('the Site'), including the product loading jetty (Jetty), module offloading facility (MOF) and the Gas Export Pipeline (GEP) terminating at the beach valve enclosure (**Figure 1-2**).

The *Ichthys Onshore LNG Facilities - Construction Environmental Management Plan* (INPEX Operations Australia Pty Ltd, 2016) (CEMP) was prepared for the Site following development approval (Northern Territory [NT] Government Development Permit DP12/0065B) to address the site-specific environmental risks associated with the Project. The CEMP details the environmental protection management measures and controls necessary to avoid, reduce or mitigate environmental impacts during the construction, pre-commissioning (including hydrotesting), commissioning and demobilisation phases of the Project.

An *Environmental Impact Monitoring Program* (AEC Environmental Pty Ltd, 2015a) (L290-AH-PLN-10013) (EIMP [Rev 6]) was prepared to meet Condition 22 of the Environment Protection Approval for the Project (EPA7) (as amended) and established the monitoring framework for the detection of potential impacts associated with the construction of the Project. EIMP (Rev 6) was approved by the Northern Territory Environment Protection Authority (NT EPA) on 2 April 2015 and implemented from 1 May 2015.

This EIMP was prepared following the assessment of monitoring data collected in 2013, 2014, 2015 and the first ten months of 2016, and introduces further refinement in the methods and monitoring locations, and trigger values for various aspects of the monitoring program, as it relates to the remaining scope of work. Whilst previous revisions primarily targeted construction activities undertaken at Site, with a particular focus on earthworks and facility construction and hydrotesting, the Project is now transitioning into the pre-commissioning and commissioning phases, and ultimately the removal of temporary facilities and demobilisation. These activities will often occur in parallel along with ongoing construction works and it is anticipated that a single EIMP revision is needed to apply to these phases going forward. This has necessitated the revision of EIMP (Rev 6). The changes to this EIMP have been summarised in **Appendix A**.



Legend

- Site Boundary
- ConocoPhillips LNG Plant
- Subsea Pipeline
- Bladin Central Enterprise Park
- Construction Footprint
- Ichthys Field

Project Location

Figure
1-1

INPEX
Bladin Point

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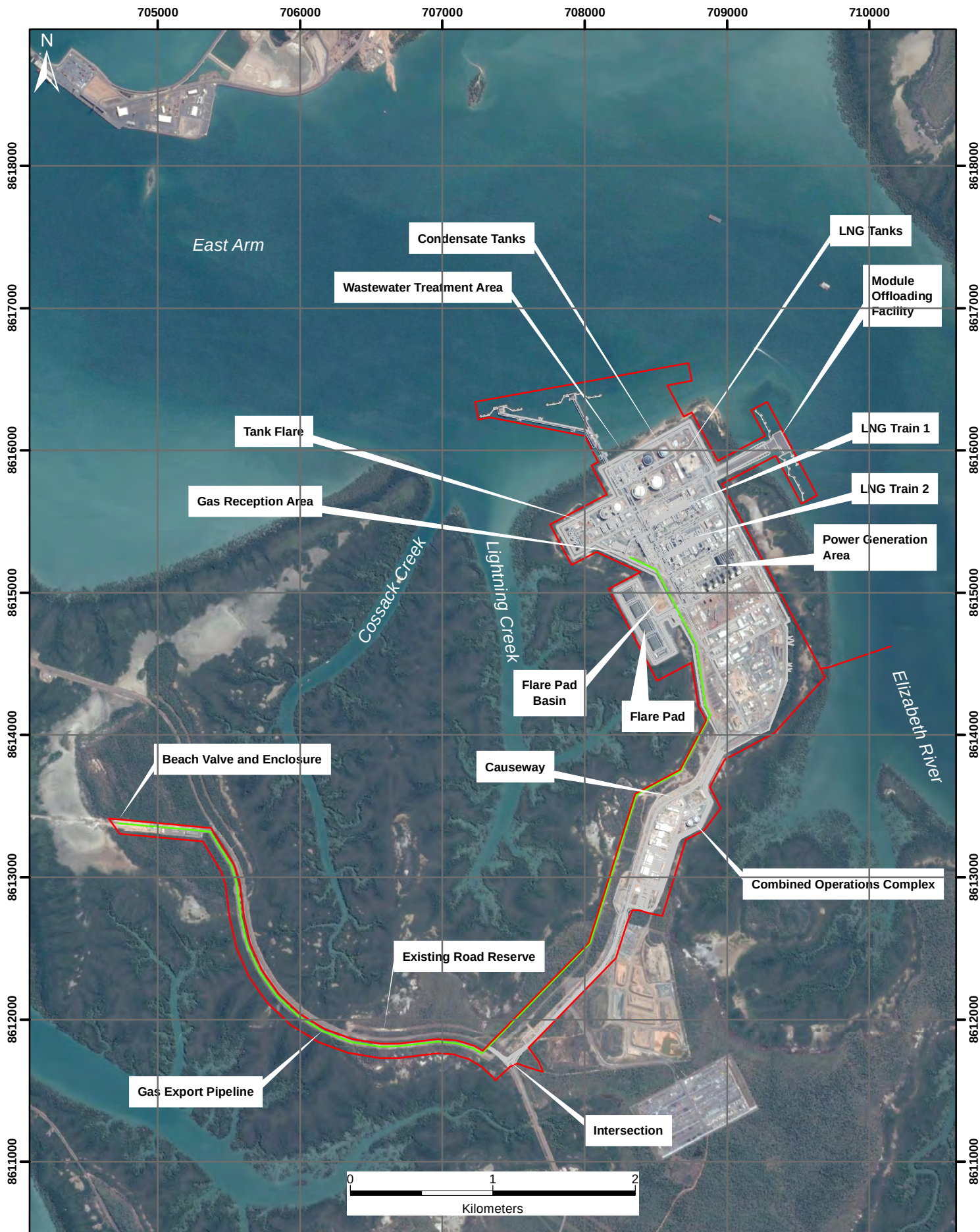
Date: 30/08/2016

Author: malcolm.nunn

Map Scale: 1:130,000

Revision: A

Coordinate System: GDA 1994 MGA Zone 52



— Site Boundary — Construction Footprint
— Gas Export Pipeline

Bladin Point Site

Figure 1-2

INPEX
Bladin Point

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Date: 30/08/2016

Author: malcolm.nunn

Map Scale: 1:35,000

Revision: A

Coordinate System: GDA 1994 MGA Zone 52

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R:\Projects\2008\INPEX\GIS\Maps\BP_EIMP\9FIG_1_02_SiteFootprint_160830.mxd

1.2 Objectives

The objectives of the EIMP are to:

- Incorporate the proposed amendments as outlined in the Annual Environmental Monitoring Report;
- Provide information relating to Site conditions that can inform the environmental monitoring programs;
- Provide a robust environmental dataset against which environmental performance can be assessed against environmental objectives and targets set out in the CEMP; and
- Define the process by which future changes to the monitoring program will be determined, under an adaptive management framework, as portions of the monitoring program become redundant when activities and their locations change or cease, or as risk pathways are closed, or as a result of safety requirements as Bladin Point becomes a Major Hazard Facility (MHF).

1.3 Scope and Methods

1.3.1 Scope

In accordance with the EPA7 (as amended), the scope of the monitoring program that is set out in the EIMP is to assess potential impacts of Project activities in the receiving environment. The impact monitoring is based on identified environmental risk pathways, as identified in **Appendix B**, and is aligned with the CEMP using an outcome-focused, risk-based approach ranking the potential environmental consequences resulting from Project activities. The EIMP excludes monitoring specifically associated with discharges from outfalls and the Extractive Minerals Area which are subject to separate licence conditions.

The EIMP documents the monitoring requirements for the following management plans:

- Surface water monitoring;
- Groundwater quality monitoring;
- Mangrove community health, sediment, and bio-indicator monitoring;
- Air quality (dust) monitoring;
- Airborne noise monitoring;
- Flora and fauna monitoring; and
- Weed monitoring.

Spill response monitoring is carried out as part of the adaptive management strategy process on the Project (see Table 6-57, mitigation measure 6.14.22 in the CEMP). Adaptive response monitoring is generally undertaken by increasing the frequency or analytical parameters in the surface water, groundwater and mangrove community health, sediment and bio-indicator monitoring programs depending on the specific needs related to a spill event and feeds into the adaptive management strategy to apply appropriate management actions and mitigate impacts.

This EIMP is inclusive of all monitoring for anticipated activities to be undertaken during the remaining phases of the Project, including:

- Construction;
- Pre-commissioning (including hydrotesting);
- Commissioning; and
- Demobilisation (including reinstatement where applicable).

1.3.2 Monitoring Approach

An overview of the methodologies (including the proposed amendments in this EIMP Rev 9) that will be used to monitor the potential environmental impacts of the Project is presented in **Table 1-1**. The monitoring outlined in this table is indicative of the existing program and the adaptive monitoring process outlined in **Chapter 5** and **13**.

Table 1-1 Environmental Impact Monitoring Program

Monitoring Program	Frequency	Monitoring Rationale and Methodology
Surface water	During stormwater overtopping events	Four surface water auto-sampler units are located at drainage outfalls at strategic locations in the drainage structures to monitor over-topping events. Samples are collected for laboratory analysis. In situ analysis is undertaken using pre-calibrated water quality meters.
	Monthly	Determination of impacts of surface water discharge in the marine receiving environment through sampling locations in the receiving environment upstream and downstream of the point of discharge and at reference sites ¹ . Samples are collected for laboratory analysis to supplement in situ analysis of key parameters. In situ analysis is undertaken using pre-calibrated water quality meters.
Groundwater	Continuous and monthly	In situ analysis of groundwater pH and conductivity using data loggers across the bore network. Groundwater elevations are also monitored continuously. The telemetered program will cease when the Site becomes a MHF. Groundwater sampling will then be undertaken on a monthly basis using an intrinsically safe method (e.g. bailing). In situ analysis is undertaken using calibrated meters.
Mangrove community health, sediment quality, sedimentation and erosion and bio-indicators	Quarterly	An assessment is made of the vitality of mangrove communities through comparison of baseline and reference site data on canopy cover, tree condition and benthic community health. Photographs of mangrove condition are collected from standard reference points at monitoring sites. Cores are taken to investigate the presence and thickness of veneers of different material overlying the mangrove substrates. Elevation of marker stakes is also measured to determine the effects, if any, on ground surface elevation. Sediment samples are collected from the top 1 to 5 cm of sediment within intertidal areas using a sterile scoop. If potential impacts are observed (e.g. discoloured surface sediments might indicate acid leachate is occurring), a sample is collected for determination of pore water quality, acid soluble metals and/or acid volatile sulfides to determine the level of risk posed by the sediment. Bio-indicators were sampled on an annual and bi-annual basis. In response to elevated metal concentrations detected in June 2014, bio-indicators (<i>Telescopium telescopium</i>) have been sampled on a quarterly basis from September 2014 onwards. Data is assessed for trends and against reference sites. Mud whelk distribution along transects is recorded with GPS coordinates.
	Annually	Sediment depth is monitored by relative elevation of sediments measured by surveyed benchmarks.
Air quality (dust)	Continuous sampling and gravimetric determination	Dust is collected in dust deposition gauges. Particulate matter of 10 micrometres or less in size (PM₁₀) and 2.5 micrometres in size (PM_{2.5}) are measured through near-forward light scattering samplers (E-Samplers). Dust mass determination is undertaken.

Monitoring Program	Frequency	Monitoring Rationale and Methodology
Airborne noise monitoring	Continuously throughout the construction program	Assessment of sound levels dB (A) and comparison to baseline data. Permanent sound monitors have been deployed which continuously record sound. Audio recordings are examined when a noise exceedance is recorded or a noise complaint is received.
Flora and fauna monitoring	As required	Visual assessment of clearance against the clearance permit. Clearing limits are collected using a Global Positioning System.
	Daily	Documentation of all native fauna injuries and deaths in registers.
Weed monitoring	Quarterly	Visual survey to review onsite weed management efficacy. Weed locations are captured by GPS and newly identified weed locations incorporated into the weed inventory.

¹ A reference site is defined in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Australian and New Zealand and Environment Conservation Council [ANZECC] and the Agriculture and Resource Management Council of Australia and New Zealand [ARMCANZ]) (Section 3.1.4) as a location nearby that is uninfluenced or not as influenced by the disturbance being assessed.

1.4 Document Structure

The structure of the EIMP is set out in **Table 1-2**.

Table 1-2 Structure of the EIMP

Chapter/Appendix	Description
Executive Summary	Summary of the content of this EIMP
1 Introduction	Background and the purpose of the monitoring program review
2 Legislative Framework	Legislative and approvals framework for the monitoring program
3 Project and Site Description	Overview of the Project and Site where monitoring is undertaken
4 Reporting and Risk Assessment Framework	Overview of the reporting processes and risk assessment framework applying to the monitoring program
5 Adaptive Management	Defines the process by which future changes to the monitoring program will be determined, under an adaptive management framework, as portions of the monitoring program become redundant when activities and their locations change or cease, or as risk pathways are closed, or as a result of safety requirements as Bladin Point becomes a MHF.
6 Surface Water	Surface water monitoring program that will be undertaken
7 Groundwater	Groundwater quality monitoring program that will be undertaken
8 Mangrove Community Health, Sediments and Bio-indicators	Mangrove community health, sediment and bio-indicator monitoring program that will be undertaken
9 Air Quality	Dust monitoring program that will be undertaken
10 Airborne Noise	Airborne noise monitoring program that will be undertaken
11 Flora and Fauna	Flora and fauna monitoring program that will be undertaken
12 Weeds	Weed and pest monitoring program that will be undertaken
13 Major Hazard Facility and Separable Portions	The provisions around MHF components and separable portions are outlined in this section
14 References	Reference list of all the sources referred to in this EIMP
A Summary of Proposed Updates to the EIMP	Comparison of changes in this revision of the EIMP with reference to EIMP (Rev 6)
B Source-Pathway-Receptor Conceptual Site Model	Outline of the source-pathway-receptors structure to be used in assessments to facilitate the retirement of redundant monitoring scope
C Selected Conceptual Site Model Diagrams	Provides three examples of conceptual site models, in this instance, for spills on Site

2. LEGISLATIVE AND APPROVAL FRAMEWORK

2.1 Regulations and Legislative Requirements

The key environmental legislation governing the construction phase of the Project comprises the following Acts:

- *Environment Protection Authority Act (EPA Act) (NT)*;
- *Environmental Assessment Act (EA Act) (NT)*;
- *Environment Protection and Biodiversity Conservation Act (EPBC Act) (Cwlth)*;
- *Heritage Act (NT)*
- *Mining Management Act (MM Act) (NT)*;
- *Northern Territory Environment Protection Authority Act (NT)*.
- *Planning Act (NT)*;
- *Public and Environmental Health Act (PEH act) (NT)*;
- *Waste Management and Pollution Control Act (WMPC Act) (NT)*;
- *Water Act (NT)*; and
- *Work Health and Safety (National Uniform Legislation) Act (NT)*.

The environmental assessments and approvals required under these Acts support the legal framework that will govern delivery of the Project.

2.1.1 Environmental Approvals

The key environmental approvals required for the Project are described below.

2.1.2 Environmental Assessment Act Decision

The *Assessment Report 65: Environmental Assessment Report and Recommendations* (NRETAS, 2011) documents the findings of the environmental assessment completed under the EA Act.

2.1.3 EPBC Act Approval

Commonwealth Government Approval Decision EPBC 4208/2008 issued for the Project includes a number of conditions requiring the preparation of management plans to minimise impacts on the Commonwealth marine environment, listed threatened species and listed migratory species.

2.1.4 Development Permits (Planning Act)

The Minister for Lands and Planning issued the Project with a development permit (DP12/0065 [as amended]) for the use and development of the land for the purpose of the LNG processing plant.

Development permit DP13/0501, for the use and development of the land for the purpose of the GEP, has also been issued by the NT EPA.

2.1.5 Environment Protection Approval (WMPC Act)

The EPA7 (as amended) was issued for constructing, installing and carrying out works in relation to premises for processing hydrocarbons so as to produce, store and dispatch LNG or methanol pursuant to the WMPC Act.

3. PROJECT AND SITE DESCRIPTION

3.1 Overview of Project and Associated Activities

The Project's onshore development area comprises the Bladin Point Area and the isthmus where the operations complex, Site access road connected to Wickham Point Road and the GEP are located (Figure 1-2).

It should be noted that the EIMP network encompasses those areas required to ensure coverage for air, noise, surface water, groundwater, mangrove, weeds and flora and fauna spatial datasets. This is important to support impact assessment and identification of potential impacts to the wider receiving environment. As offshore pipeline activities in Darwin Harbour are not within the scope of the EPA7 (as amended), the potential impacts of these activities are not monitored as part of the EIMP.

The CEMP details the environmental protection management measures and controls necessary to avoid, reduce or mitigate the potential environmental impacts during the construction of the onshore LNG facilities. The monitoring program detailed in this EIMP is designed to detect environmental impacts from the construction, pre-commissioning, commissioning and demobilisation activities outlined in Table 2-3 of the CEMP.

3.2 Site Description

3.2.1 Site Location

The Site is located at Bladin Point on Middle Arm Peninsula in Darwin Harbour, approximately 16 kilometres (km) south-east of the City of Darwin and occupies an area of 406 hectares (ha). The Site is located at NT Portion 07002, 144 Wickham Point Road, Wickham NT 0822; Section 1901 and Section 1896, Hundred of Ayers, Wickham NT 0822; and 1000 Channel Island Road, Wickham NT 0822. The Site is zoned as development under the *Northern Territory Planning Scheme* (Department of Lands, Planning and the Environment, no date).

The Site is situated approximately 4 km to the south-west of a residential area of Palmerston and approximately 2.5 km south-east of East Arm Peninsula which is developed with light industry, warehouses and a cement manufacture plant). Two small uninhabited islands are located within the East Arm channel 2.5 km and 3 km north-west and west north-west respectively from the Site. The existing Darwin Liquefied Natural Gas plant is located approximately 2 km to the west of the Site.

Extensive archaeological investigations have been conducted throughout the area. In addition to the aboriginal sites identified on Bladin Point, the investigations also identified seven World War II sites. A search of the NT EPA contaminated site website (March 2016) did not identify any land classified as potentially contaminated or contaminated at or in the vicinity of the Site (NT EPA, 2016).

3.2.2 Climate

The Site is located within tropical northern Australia and is subject to two distinct weather seasons, namely the wet and dry season. The wet season generally occurs from October to April, in accordance with the way the Bureau of Meteorology (BOM) calculates its statistics, and also how the NT EPA applies wet season controls, and is characterised by warm and humid weather. The monsoonal rainfall period generally occurs between December and March and is characterised by higher than average rainfall and an increased potential for cyclone development. The dry season occurs between May and September and is typically characterised by dry days and cooler day-time temperatures (BOM, 2016).

Meteorological data for the Site is sourced from the Project's onsite weather station and supplemented, where required, with data from the BOM weather station at Darwin Airport (site number 014015). Typically, November is the hottest month in the Darwin region with an average temperature of 25.3°C minimum to 33.3°C maximum while July is typically the coolest month with an average of 19.3°C minimum to 30.6°C maximum (BOM, 2016). The region receives an average annual rainfall of 1,727.8 millimetres (mm), with an average 94 days of rain (BOM, 2016).

During the wet season, Darwin is dominated by westerly and west north-west winds (BOM, 2016). Dry season winds vary from the south-east through to the north (BOM, 2016). The strongest winds and heaviest rainfall are associated with the passage of tropical cyclones, which can occur in the region at any time during the period November to April. Tropical cyclones cause most damage within a distance of 50 km inland from the coast. Strong winds and storm surges can be of concern to coastal developments and flood damage can also result from associated heavy rains.

3.2.3 Regional and Local Geology

Bladin Point is a low-lying peninsula which is separated from the mainland by a mudflat dominated by deeply weathered lateritic regolith formed on labile Cretaceous marine sediments. The dominant soils covering over half the area on the undulating terrain are shallow to moderately deep, very gravely massive earth (surface lateritic gravel). The residual soils are typically lateritic clay, silts and sand with ferricrete layers often close to the surface or outcropping.

The Cretaceous material is underlain by Early Proterozoic and highly folded rocks of the Finnis River Group's Burrell Creek Formation (Phyllite). The Burrell Creek Formation is dominated by finer-grained lutitic rocks, predominantly claystone and siltstone. Younger Lower Cretaceous rocks of the Darwin Formation which overlay the Proterozoic rocks are exposed at the shoreline of Bladin Point. Quaternary marine deposits are present at the Site overlapping the older formations (Stuart-Smith *et al*, 1980; Nott, 1994).

3.2.4 Soils and Morphology

Land unit surveys of the Blackmore and Elizabeth River catchments (Fogarty *et al*, 1984) describe soil morphology at 25 locations in or adjacent to the Site. Underlying rocks outcrop on crests and moderately deep to deep soils occur on deep weathered Cretaceous sediments in the undulating terrain. Estuarine mangrove, tidal flat and dune facies were deposited during the Quaternary fringe at Bladin Point.

The dominant soils (>50% of the area) on the undulating terrain were described as shallow (<0.25 metres [m]) to moderately deep (0.25 to <0.5 m), very gravely, massive earths. The soils were classified as Rudosols and Brown Kandosols in Australian Soil Classification System (Isbell, 1996). Soils in drainage lines and estuarine frontage are very poorly drained (Hydrosols) and subject to regular or seasonal inundation and waterlogging. The risk of erosion is moderate to high due to the intense monsoonal rainfall environment and the structureless nature of soils.

The Cretaceous land surface in the Darwin region can exhibit elevated background concentrations of metals in the near surface, in common with many deep weathered landscapes in Australia (Naidu *et al*, 1996). In the context of the Bladin Point development, elevated background concentrations of metals (such as arsenic) may be a factor in accurately assessing future onsite and offsite contamination. In soils, metals are bound tightly to iron and aluminium sesquioxides in the natural environment and the bioavailable fraction tends to be very low in high pH environments (Ng *et al*, 2003).

The majority of the Site was characterised as Hotham soils. However it should be noted that prior to construction, ground improvement activities were carried out onsite which involved soil mixing to increase the stability of the Site pre-construction. Subsequently, this EIMP does not draw distinctions between the Hotham soil groups and classifies them as a whole.

3.2.5 Hydrology and Surface Water Quality

Bladin Point is surrounded on three sides by water: to the east is the Elizabeth River, to the north the East Arm of Darwin Harbour and to the west is Lightning Creek. Rainfall during the wet season forms ephemeral overland streams that discharge into the surrounding water bodies. Surface water historically flowed from the high point along the centre of the Peninsula to the east, north and west. Construction works have modified the topography of the Site but have maintained the general discharge to the north, east and south through specifically constructed discharge points. The main access road for the Site has been constructed through a salt flat located at the isthmus between Bladin Point and the mainland.

As a necessary part of the Site development, the pre-development natural drainage systems of Bladin Point have been largely replaced by engineered systems. Stormwater runoff is drained from the Site through designated drainage swales, usually via the regulating reservoir and eventually into Darwin Harbour. Runoff from several catchments is collected into various detention basins located at the Site.

The *Wet Season 2015/2016 Erosion and Sediment Control Plan (ESCP)* (CDM Smith, 2015), for the Site shows several drainage systems which have been constructed on Site to control stormwater runoff. The plans go through a process of review during development before being endorsed by Certified Professionals in Erosion and Sediment Control. The surface water drainage network at the Site is managed in accordance with International Erosion Control Association (IECA) best practice guidance (IECA, 2008).

The water quality of Darwin Harbour is regarded as '*slightly modified*' in accordance with the *Water Quality Objectives for the Darwin Harbour Region – Background Document* (Darwin Harbour WQOs) (NRETAS, 2010a). The Darwin Harbour WQOs provide that:

Hydrodynamic modelling, supported by water quality studies, indicate that significant tidal movement in the Harbour does not, on a time scale of weeks or even months, transport diffuse and point source nutrients out of the Harbour, but rather assists in their dispersal within the Harbour precinct.

From the above it is considered that the impacts of urban and point source discharge are likely to be localised and remain within the confines of Darwin Harbour.

3.2.6 Hydrogeology

In the Darwin region, there are generally two separate groundwater aquifers; a shallow unconfined aquifer in the laterite subsoil layer (typically <10 m) and a deep aquifer confined to rocks of Proterozoic age, such as dolomite (typically >40 m). The direction of groundwater flow is controlled by area topography and is from high to low areas of elevation.

As indicated in Haig and Townsend (2003), aquifer recharge in the Darwin Harbour catchment occurs during wet seasons as a result of direct infiltration of water into the regional aquifer(s) from December to May. Although in some years, recharge can begin as early as October and end as late as June.

The uppermost aquifer on Site occurs within the clayey sand/gravel horizons of the Cretaceous Darwin Formation and within weathered laterite material of the Proterozoic Burrell Creek Formation.

The groundwater surface of the uppermost aquifer within the Site generally follows the topography in that it is elevated along the central parts of the Site and is lowest at the coastal edges of the Site. The groundwater flow generally occurs radially away from the central part of the Site towards the coastal areas (URS Australia Pty Ltd, 2009) and the isthmus area which separates the Operations Complex and civil work areas.

Previous investigations conducted on Site (Appendix 18, *Ichthys Project Environmental Impact Statement* [INPEX Browse, Ltd, 2010] [EIS]) considered it likely that unconfined to semi-confined conditions exist in the uppermost aquifer. The seasonal groundwater level increases up to 7 m generally confirms the potential for a seasonal semi-confined aquifer regime. In addition, groundwater levels in the bores located adjacent to coastal areas were influenced by marine tides.

The influence of Site activities including the alteration of topography, surface and soil characteristics due to vegetation clearing, bulk earthworks and ground improvement is likely to have modified groundwater behaviour from its natural state. The decrease in surface water infiltration in ground improvement areas and the potential for increased infiltration from the installation of erosion and sediment controls may also affect groundwater levels. Furthermore ground improvement works are also likely to have influenced groundwater flows and paths from the Site and potential groundwater retention. However, as discussed in the *Hydrogeological Conceptual Site Model* (L290-AH-REP-10476) (AEC Environmental Pty Ltd, 2014a) (Site Model), no significant changes to the seasonal groundwater water levels at the Site have been noted.

3.2.7 Groundwater Quality

Groundwater quality assessment has previously been undertaken on the aquifers in the Darwin rural area (URS Australia Pty Ltd, 2009). Regionally, the aquifer included in the Cretaceous rock/sediments (which is also present beneath the Site, Cretaceous Darwin Member of the Bathurst Island formation) was reported to have typically acidic conditions. Radke *et al* (1998) stated that:

Darwin rural groundwaters have a wide range of pH (4.1 to 7.6), within which acidity is the main problem. ...Groundwater in the Cretaceous sediments in the recharge areas is acidic (usually <5) and very corrosive. ...The overlying Cretaceous sediments are also utilised for groundwater supplies, but only out of necessity because of lower yields and higher acidity. ...Water quality from areas of immediate recharge through Cretaceous sediments can be summarised as low hardness (usually <10mg/L), acidic (approx. pH 5 at the borehead) and very corrosive (Jolly, 1983).

Within the Darwin region, naturally acidic groundwater with the presence of dissolved metals has a wide distribution. The groundwater quality has been confirmed locally through investigations at the Site (URS Australia Pty Ltd, 2009).

Groundwater quality data was collected from 14 groundwater wells for the 2008 (dry season) and 2009 (wet season) groundwater quality baseline study (INPEX Browse, Ltd, 2010). From this data, the existing groundwater prior to construction activities was characterised as being acidic to neutral in pH, varying between pH 4.6 and 6.3 while salinity ranged from fresh to saline, with most groundwater wells being brackish to saline. Elevated concentrations of aluminium, cadmium, copper, manganese, nickel and zinc were measured and low concentrations of some nutrients were detected.

Currently declared beneficial uses for groundwater within the region are agriculture, environment, public water supply and rural stock and domestic (*Declaration of Beneficial Uses and Objectives – Elizabeth-Howard Rivers Region Groundwater* [Department of Land Resource Management, 2010]). A site-specific beneficial use assessment was undertaken as part of the *Annual Environmental Monitoring Report – Environmental Impact Monitoring Program* (AEC Environmental Pty Ltd, 2014b) AEMR (2014). This assessment determined that, for the Site, the only applicable beneficial use related to the environment, i.e. maintaining the health of aquatic ecosystems.

3.2.8 Mangrove Communities

Bladin Point is considered to be part of the Darwin Coastal Bioregion. The flora of Bladin Point is dominated by woodland and monsoon vine forest with fringing patches of mixed low woodland species and *Melaleuca* forest. The woodland community includes *Eucalyptus miniata* (Darwin woollybutt) and *E. tetrodonta* (Darwin stringybark) with mixed mid-storey species including *Cycas armstrongii* (NRETAS, 2011), which is listed as vulnerable under the *Territory Parks and Wildlife Conservation Act* (NT) (TPWC Act). Clearing was undertaken as part of the approved development permit.

Bladin Point is fringed by an extensive mangrove community, typical of the majority of the shoreline of Darwin Harbour. The intertidal areas of Darwin Harbour contain over 27,000 ha of mangroves, which constitutes 44% of the mangrove community in the Darwin Coastal Bioregion and 5% of the total mangrove area of the Northern Territory (NRETAS, 2011). Darwin Harbour contains 36 mangrove species, six of which are common: *Rhizophora stylosa*, *Ceriops tagal*, *Sonneratia alba*, *Bruguiera exaristata*, *Avicennia marina* and *Camptostemon schultzei* (Brocklehurst *et al.*, 1996).

The structural features of mangrove communities in Darwin Harbour are similar to those in many other parts of the world, showing pronounced shoreline zonation with species arranged in nearly mono-specific bands, often parallel to the coast (Snedaker, 1982). Each mangrove zone or assemblage tends to develop at a particular topographic elevation (or regime of tidal inundation) but the pattern of zonation may alter with local geomorphic variation such that assemblages may resemble patches or strips, rather than extensive bands (Metcalf, 2007). The mangrove communities surrounding Bladin Point are typical of the mangrove communities within Darwin Harbour with distinct zones and fringes of transition. These are the *Sonneratia* or seaward zone, the *Rhizophora* or tidal creek zone, the *Ceriops* or tidal flat zone and the hinterland margin zone.

4. REPORTING AND RISK ASSESSMENT FRAMEWORK

The Project uses a systematic risk assessment process to identify activities that have the potential to result in adverse impacts on environmental aspects. By developing mitigation measures and controls to reduce the risks identified, 'Residual Risks' can be reduced to as low as reasonably practicable.

The risk assessment process used within this EIMP aligns with the CEMP and was used to inform the conceptual site model provided in **Appendix B**. For illustrative purposes, the source and receptor pathways for accidentally oil contaminated (AOC), continuously oil contaminated (COC) and the non-contaminated water (NCW) systems are shown in **Appendix C**. Various reporting is undertaken in support of the EIMP and these deliverables are described further below.

4.1 ESDAT Database Management and Exceedance Notifications

The EIMP sampling is completed by the end of a calendar month, samples are analysed and laboratory certificates released within one to two weeks of month end. Monitoring results are entered into the ESDAT database within 48 hours of receipt from the analytical laboratory. Following a quality assurance/quality control (QA/QC) check (involving an ESDAT screen, followed by liaison with the laboratory and confirmation/resolution of any apparent outlier results), the data are compared against trigger values. Any identified exceedances are entered into a register which is then used in the risk assessment workshop.

4.2 Monthly Risk Assessment Workshop

A workshop is held during each month at which the previous month's results from all the monitoring programs are subject to a risk assessment to identify the potential sources of any exceedances.

For the groundwater and surface water parameters, the assessment of seasonality on trigger value exceedances is carried out by applying the 80th percentile statistical analysis process as endorsed by ANZECC (2000a). Under these guidelines, using a minimum of 24 months of data, it is possible to use this technique to account for seasonal trends in surface and groundwater analyte concentrations encountered for the Project.

The 80th percentile for each analyte is calculated from the data of the corresponding month of the previous two years (or more if available) and adding a month either side, to create the dataset for the calculation which is sensitive to early and late historical seasonal changes. By tracking the 80th percentile for relevant analytes at each monitoring location, it is then possible to establish whether concentrations are within the seasonal variations.

Following this, the concentrations that are therefore 'genuine' exceedances can then be identified and any potential impacts examined. After calculating the 80th percentile, the analyte concentration for any given month will therefore occur within one of the following scenarios:

- It is below the EIMP specified trigger value and no further action is required; or
- It exceeds the trigger value, but the concentration is within the seasonal variation as calculated by the 80th percentile treatment and therefore no further action is required; or
- It exceeds both the trigger value and the seasonal variation and requires further investigation.

A multiple lines of evidence approach is used to assess the exceedances requiring further investigation, and whether it can be attributed to a construction activity, spill or discharge source. The stepwise processes for determining if an exceedance constitutes a non-compliance and environmental event is defined in the trigger exceedance mitigation measures in the CEMP for surface water, groundwater, mangroves, dust and noise.

The key components of the multiple line of evidence assessment are:

- Exclusion of invalid data e.g. from equipment malfunctions;
- Comparison of data at impact sites and reference sites, and at up gradient and down gradient locations. For example, if exceedances are detected at both reference and impact sites in a specific month, this is deemed not attributable to Site activities and discharges;
- Assessment of climatic conditions, groundwater levels and when required, Piper and Turner plots for ASS assessment purposes;
- Comparison of any intra-annual (i.e. seasonal) and inter-annual trends in concentrations. If the exceedances are within the expected statistical seasonal and inter-annual trends they are attributed to natural and/or seasonal variation;
- Spatial distribution using isopleth maps to determine where the exceedances occurred; and
- Comparison of the Site activities in the monthly construction registers against the credible risk pathways and the locations in the receiving environment where the specific exceedances were recorded.

In the week following the completion of each workshop, a summary of the key outcomes of the risk assessment is provided to Company to notify of any potential non-compliances, and any such non-compliances are entered into MYOSH.

4.3 Monthly Factual Reports and Quarterly Interpretative Reports

Monthly factual reports and quarterly interpretive reports are prepared. Monthly reports include the outcomes of any risk assessment workshops and the quarterly reports provide interpretation of the previous three months of data collected.

4.4 Annual Environmental Monitoring Report

Annual reporting provides a summary of the data obtained through the reporting year, which runs from 1 May to 30 April in the following year. The AEMR captures all monitoring information relating to the EIMP and satisfies the requirements of Condition 29 of EPA7 (as amended). The report provides a detailed assessment of the monitoring results using multiple lines of evidence to assess if there are trends in the dataset that can be attributed to construction activities, spills or discharges. The report provides a strategic assessment of the structural changes which need to be made for future monitoring within the Site, by setting out key findings and/or recommendations necessary to achieve the monitoring program and management objectives.

Assessment of the monitoring requirements on an annual basis allows for refinement of the monitoring program to be made as the Project proceeds towards the operations phase.

The Annual Environmental Monitoring Report is provided to the NT EPA on 31 July each year.

4.5 Event Reporting

Subcontractors are required to immediately notify the Project Environmental Manager or their delegate of any environmental event.¹ Contractor will then provide immediate verbal notification to Company Environmental Representative (within business hours) or the Company Duty Manager (outside of normal business hours).

Prior to undertaking the monthly sampling events, MYOSH is screened to identify relevant spills. Where an event has occurred in proximity to a groundwater, surface water or mangrove monitoring location or within an identified risk pathway, the analyte list is checked for relevant contaminants of concern. Separately, MYOSH is also screened when results are available as a check of outlier results and whether they may be attributed to a reported event. Events may occur where data are lost due to equipment malfunctions and these will be reported using the online event reporting database.

¹ Environmental event is the collective term for an incident and near miss (hazard event). Incident is defined as an unplanned event, action or occurrence that causes or has potential to cause harm or impact on the environment, reputation, social or cultural heritage, or legal compliance. Hazard event (near miss) is a set of conditions or circumstances that has potential to cause harm or impact on the environment, reputation, social or cultural heritage, or legal compliance. A non-conformance is a failure to comply with a condition, commitment or requirement of an environmental plan, procedure or approval.

5. ADAPTIVE MONITORING

The adaptive monitoring that is described in this chapter is defined as the framework that will facilitate changes in the monitoring program that may result from changes in the scope of work or from the observed environmental impacts. The Project is entering a period where different parts of the Site are transitioning from construction to commissioning, and the temporary plant and equipment will be demobilised. As Project activities change in nature and location, risk pathways on Site and the potential for environmental harm will change accordingly.

The remaining phases of the Project currently include:

- Construction;
- Pre-commissioning (including hydrotesting);
- Commissioning; and
- Demobilisation.

Circumstances under which modifications to the monitoring program could be made include:

- Cessation of specific Site activities in a given location, or altogether, resulting in the removal of an impact pathway and/or risk source;
- Changes in regulatory requirements;
- Reduction in the scale of an activity, resulting in redundancy in monitoring locations or programs;
- Changes in the hazard classification of the Site (or parts of the Site) related to the use of live hydrocarbons or MHF status, resulting in restrictions on the types of equipment being used and safety considerations; and
- Changes required to address continual breaches of a trigger, as part of adaptive monitoring.

Proposed changes to the monitoring programs, be they reductions in the monitoring scope, or an expansion/extension of a monitoring program, will not proceed if the objectives of the program will not be met, i.e. to monitor for potential environmental impacts associated with Site activities. Any change to a monitoring program within this EIMP will be subject to an evaluation of the risk source(s), source-pathway-receptor relationship, evaluation of the available monitoring dataset and a comprehensive multiple lines of evidence assessment.

An example of where a program was expanded was when the frequency of metals sampling events in mud whelks was modified from annually to biannually to quarterly, in response to elevated metals concentrations that were detected in June 2014. An example of where it is proposed to reduce a monitoring program is the decommissioning of the marine buoys and ceasing the continuous data collection, based on the removal of the risk source (e.g. piling activities) and potential duplication with the monthly monitoring program in the receiving marine environment.

In adopting this adaptive monitoring approach to the EIMP and the individual monitoring programs themselves (surface water, groundwater, air quality, airborne noise, mangrove community health, sediments and bio-indicators, flora and fauna, and weeds) this will provide a feedback loop whereby the monitoring programs can be informed by the on-going monitoring data and results.

6. SURFACE WATER

6.1 Summary of Compliance Requirements

Surface water monitoring undertaken in accordance with this EIMP will meet the compliance requirements set out in the following legislation, policies, guidelines and approval requirements associated with the Project.

6.1.1 Approval Requirements

Condition 8 of the EPA7 (as amended) approval for the Project requires that the Approval Holder must do all things reasonable and practicable to ensure the Project does not adversely affect the Declared Beneficial Uses and Objectives, including those applying to the Darwin Harbour region.

The CEMP sets out the objectives, targets and indicators that apply to the surface water monitoring program and these have been incorporated into the program.

6.1.2 Policies and Guidelines

6.1.2.1 Darwin Harbour Water Quality Objectives (WQOs)

The Darwin Harbour WQOs (NRETAS, 2010a) were developed to provide preliminary physico-chemical stressors against which various attributes of the health and condition of waterways can be measured and reported. The Darwin Harbour WQOs identify:

- Water quality issues and management goals;
- Environmental values or uses of waterways in various parts of the catchment;
- Priority water quality indicators to be monitored;
- Water types (freshwater, estuary systems, marine or groundwater) to which the objectives will apply;
- A rationale for determining water types in the context of seasonal variation experienced in the region; and
- Marine, freshwater and estuarine WQOs for various waterways in the Darwin Harbour catchment based on local water quality data and relevant national water quality guidelines.

The Darwin Harbour WQOs cover a broad range of water types. In respect of estuaries, the water types are divided into 'upper estuary', 'mid estuary' and 'outer estuary'. The Site is located within the 'upper estuary' category. This is described in the Darwin Harbour WQOs as '*...the upper most reaches of the estuary where hypersaline conditions may persist for short periods during the dry season and significant freshwater pulses prevail during the wet season where stratification may occur*'. In relation to toxicants, the Darwin Harbour WQOs stipulate that the ANZECC Guidelines should be used.

6.1.2.2 Australian and New Zealand Guidelines for Fresh and Marine Water Quality

The ANZECC Guidelines are used as a tool for assessing water quality and provide trigger values that protect the designated environmental values of water resources and against which performance can be measured. The ANZECC Guideline trigger values for marine water receiving environments have been adopted for the Project.

The ANZECC Guidelines set out three grades of guideline trigger values for toxicants: high, moderate and low reliability trigger values. The use of the appropriate grade depends on the data available and hence the confidence or reliability of the final figures (Warne, 1998).

The ANZECC Guidelines provide that the different grades were derived as follows:

- High reliability guideline trigger values – derived from multiple-species data or chronic 'no observable effect concentration' data, using the risk-based statistical distribution method;
- Moderate reliability guideline trigger values – reflect a lower confidence in extrapolation methods and were derived with acute toxicity data. It was then necessary to convert the figure from that calculation to a chronic protection figure by application of either calculated or default acute to chronic ratios; and
- Low reliability guideline trigger values – derived in the absence of a dataset of sufficient quantity, using larger assessment factors to account for greater uncertainty. These are considered as interim or indicative working levels subject to more test data becoming available. Low reliability figures should not be used as default guidelines, although it is reasonable to use them in the risk-based decision scheme to determine if conditions at the Site increase or decrease the potential risk.

The ANZECC Guidelines go on to provide that the trigger values derived using the statistical distribution method (i.e. the high and moderate reliability trigger values) were calculated at four different species protection levels (99%, 95%, 90% and 80%). The species protection level signifies the percentage of species in the receiving environment ecosystem that may be expected to be protected. The 95% species protection level trigger values apply to ecosystems classified as 'slightly-moderately disturbed', and it is noted that the Darwin Harbour WQOs have also been set at this level.

The ANZECC Guidelines also recommend that in the absence of local biological effects data, high or moderate reliability trigger values with a 95% species protection level should be adopted. Where there is no high or moderate reliability trigger value available, the adoption of a low reliability trigger value is recommended as an interim working level until such time that site-specific trigger values can be developed. For those chemicals that have the potential to bio-accumulate the decision scheme in the ANZECC Guidelines recommends the 99% species protection trigger values are applied and this has been adopted in the EIMP for benzene, naphthalene, cadmium and mercury.

It has not been possible to derive trigger values for every chemical. Section 8.3.4.5 of the ANZECC Guidelines provides some preliminary guidance for deriving preliminary working levels for such chemicals according to international guidance (Organisation for Economic Cooperation and Development [OECD], 1992; OECD, 1995). One such approach endorsed internationally is the one adopted by the National Institute for Public Health and the Environment in the Netherlands, which has developed 'Dutch Intervention Values' for total recoverable hydrocarbon (TRH) fractions.

6.2 Updates to the Environmental Impact Monitoring Program

6.2.1 Alignment of Receiving Environment Trigger Values with the CEMP

The following surface water trigger values from EIMP (Rev 6) have been modified to align with the CEMP:

- Dissolved oxygen (DO) – the upper limit of 100% saturation will be removed while the lower limit of 80% saturation will be retained;
- Chlorine – measurement of chlorine only applies when wastewater has been shock dosed with chlorine and does not include potable water treatment;
- Aluminium – will be changed from 55 µg/L to 24 µg/L;
- Arsenic (III) and arsenic (V) – will be removed as monitoring parameters. Total filtered arsenic will be included as a monitoring parameter with a trigger value of 2.3 µg/L;
- Chromium (III) – will be changed from 27.4 µg/L to 10.0 µg/L;
- Manganese – will be changed from 80 µg/L to 390 µg/L;
- Nickel – will be changed from 70 µg/L to 7 µg/L;
- Toluene - 110 ug/L (changed from LOR to 99% species protection level); and

- Total recoverable hydrocarbons – will be the TRH limit of reporting (LOR) at offshore surface water receiving environment monitoring locations, noting that the onsite trigger value of 600 µg/L will remain the same.

For stressors, the ANZECC Guidelines outline that for biological indicators, and for physical and chemical stressors where no biological or ecological effects data are available, the preferred approach to deriving guideline trigger values is from local reference data. The Project has already adopted the Darwin Harbour WQOs for physico-chemical class indicators based on the 80th and/or 20th percentiles of data from reference sites for the Darwin Harbour region. As such there are no other Site-specific trigger values for the Project.

The chlorine trigger level has also changed in the CEMP. The justification for this was that, although the trigger level for chlorine in the ANZECC Guidelines is 3 µg/L, in practice, common standard instruments for in situ testing of chlorine are only capable of detecting chlorine at 20 µg/L for water that has no turbidity or total suspended solids (TSS) influence. Analysis of chlorine at a laboratory is not considered to be reliable due to the rapid rate of decay of chlorine over time. Therefore, it was proposed (and approved) that the trigger level be changed to 20 µg/L, which is the detection limit of the instrument.

A new marine aluminium high reliability trigger value of 24 µg/L (Golding et. al, 2014) and a manganese high reliability trigger value of 390 µg/L (J. Stauber and R. Van Dam, *pers. comm.*, 23 March 2015) has been adopted. The chromium (III) trigger value has been corrected from an errata from the ANZECC Guidelines, while the nickel trigger value has been corrected to align with the CEMP and the 99% protection level marine trigger value in the ANZECC Guidelines.

Arsenic speciation undertaken for the surface water monitoring program will be replaced with the monitoring and analysis of total filtered arsenic. The arsenic (III) trigger value of 2.3 µg/L derived from the ANZECC Guidelines will be applied to the total filtered arsenic results. The arsenic (III) trigger value is more stringent than the trigger value for arsenic (V) and as total filtered arsenic is primarily comprised of the sum of the arsenic (III) and arsenic (V) concentrations, this represents a conservative approach.

The toluene trigger value was changed to the 99% protection marine trigger value to align with the current impact assessment approach for BTEXN in the CEMP.

For TRH, advice from analytical laboratories regarding the LOR for total petroleum hydrocarbons (TPH)/TRH for receiving environment surface waters outside of the Site boundary shows significant variability, depending on the method used and the chain length of the hydrocarbons analysed as well as interference, and will range between 100 to 500 µg/L.

The application of trigger values is inherently conservative (Markich et al., 2001). For example, metal guideline values (typically expressed as the inorganic metal concentration) may be up to an order of magnitude lower than levels that are toxic to sensitive test organisms.

6.2.2 Cessation of Continuous Monitoring at Marine Buoys

The objective of the continuous monitoring at the marine buoys was to assess potential surface water impacts associated with the construction of the MOF, temporary Wastewater Treatment Works (WWTP) and the Jetty in the nearshore areas around the Site. Construction in these areas, and in particular piling activities, had the potential to result in the deterioration of aquatic environmental health including a decline in water quality through the introduction of nutrients, metals, hydrocarbons and altered physico-chemical conditions.

The continuous marine buoy and monthly surface water monitoring program includes the monitoring of the same set of physico-chemical parameters, including; salinity, DO, temperature, pH, turbidity and conductivity. In addition to this, the monthly monitoring program also assesses TDS and other contaminants of concern including nutrients, hydrocarbons and metals.

Construction associated with the MOF, WWTP and the Jetty was completed by October 2015. Given the cessation of construction activities and the removal of the potential risk sources (e.g. piling) within the nearshore areas, an assessment was undertaken in AEMR (2016) to determine whether continuous monitoring using marine buoys was still necessary.

Following the assessment in AEMR (2016) and comparison of the continuous data collected at marine buoys and the monthly surface water monitoring results, it was recommended that the marine buoys be removed from the surface water monitoring program. This proposed change is justified by the cessation of the construction activities at the MOF, WWTP and Jetty and the subsequent removal of the construction risk sources in Darwin Harbour, in particular piling (which can result in disturbance of the substrate and increasing TSS).

It was demonstrated in AEMR (2016) that there was a good correlation between the monthly surface water monitoring results and the continuous marine buoy results. This provided confirmation of the longer term trends that had been identified in the monthly monitoring program (dating back to October 2012) and also supported the conclusion that monthly surface water monitoring was sufficient to identify any impacts that could arise from Site activities and/or discharges.

In accordance with the recommendation, the marine buoys will be decommissioned, the collection of continuous physico-chemical data will cease and results from the monthly surface water monitoring program will be used to evaluate any potential impacts of Site activities and/or discharges in the receiving environment. This will be done in accordance with the process outlined in **Chapter 5**.

6.2.3 Refinement of Monitoring Locations and Monitoring Frequencies

6.2.3.1 Auto-Samplers

Four auto-samplers (SWAS01 to SWAS04) were installed on Site in November 2015 (**Figure 6-1**). The locations of the auto-samplers were dependent on the Site's drainage at the time of installation and therefore differ slightly from the locations listed in EIMP (Rev 6) and will be retained at these sites, other than SWAS01 and SWAS02.

Chapter 13 provides information on the considerations that need to be taken into account as the Bladin Point site becomes a MHF, for example, the requirement to use intrinsically safe equipment. The auto-samplers are not intrinsically safe and are a potential ignition source and explosive risk, therefore SWAS01 and SWAS02 will need to be moved to non-hazardous locations due to safety considerations. This will be done in accordance with the process outlined in **Chapter 5**.

6.2.3.2 Surface Water Locations

Four new offsite surface water monitoring locations were established (BPSW34, BPSW35, CSSW03 and CSSW04) (**Figure 6-2**). These locations were identified as indicative in the EIMP (Rev 6) and the final locations are provided in this EIMP.

The GEP surface water monitoring program comprises assessment of offsite water quality through the monthly collection of grab samples from two impact sites located in tidal creeks to the south-west of the GEP corridor (BPSW34 and BPSW35). The monthly marine surface water monitoring program commenced in August 2014 to assess the potential surface water impacts associated with the construction of the GEP in the nearshore waters downstream of the GEP corridor. Construction in these areas, and in particular ASS excavations, associated deep soil mixing and vegetation clearing had the potential to result in the deterioration of aquatic environmental health including a decline in water quality through the introduction of nutrients, metals, hydrocarbons and altered physico-chemical conditions.

The monthly surface water monitoring program includes the monitoring of physico-chemical parameters, including; salinity, DO, temperature, pH, turbidity and conductivity. In addition to this, the monthly monitoring program also assesses TDS and other contaminants of concern including nutrients, hydrocarbons and metals.

The construction of the GEP and reinstatement works are now complete. Given that the works are complete, and its progression into the commissioning phase, an assessment of the potential risk sources and monitoring requirements was undertaken in AEMR (2016).

Following the assessment and analysis of the GEP surface water monitoring program results in AEMR (2016), it was recommended that the monitoring frequency be changed from monthly to quarterly. This proposed change is justified by the cessation of the construction activities on the GEP and the subsequent modification of the risk sources, in particular ASS excavations, deep soil mixing and vegetation clearing.

The quarterly monitoring frequency is deemed sufficient to monitor potential surface water impacts that may arise as a result of ASS mobilisation and subsequent groundwater expression following groundwater recharge in the wet season. In addition, quarterly monitoring is deemed adequate to monitor any potential impacts related to potential, increased nutrient loads from the mulch that has been applied during the reinstatement works.

It was further recommended that quarterly GEP surface water monitoring should continue at BPSW34 and BPSW35 until the end of the 2016/17 wet season (i.e. April 2017). If impacts along the GEP arise (e.g. ASS mobilisation through the groundwater expression pathway) these will start to manifest in the 2016 dry season because of groundwater transit times (the last ASS treatment activities were recorded in August 2015) and as the groundwater recedes in the affected areas and causes potential oxidation of ASS. Monitoring through the 2016/17 wet season will provide further evidence on whether the patterns are due to natural variation or impacts arising from the construction and commissioning of the GEP. Following evidence that no adverse impacts have occurred these monitoring sites will be removed from the EIMP. The projected date for their removal is the second quarter of 2017 subject to the provisions in **Chapter 5**.

6.2.4 Adjustment of Monitoring Equipment

The EIMP (Rev 6) specifies that the auto-samplers will undertake in situ analysis for physico-chemical parameters including temperature, DO, oxidation reduction potential (ORP), electrical conductivity (EC), salinity and turbidity. Due to equipment limitations, the installed auto-samplers cannot analyse for temperature, salinity, DO and ORP. Therefore, the auto-samplers will collect data on the following:

- Turbidity and EC will be measured by in situ probes;
- Salinity values will be calculated by applying a conversion factor to the EC values; and
- pH values will be determined as part of the laboratory analysis of the water samples collected by the auto-samplers.

This will be done in accordance with the process outlined in **Chapter 5**. Laboratory analysis of samples will continue as normal.

6.3 Surface Water Trigger Values

6.3.1 Onsite Basins

The CEMP sets out surface water quality trigger values that apply to monitoring undertaken for actively discharged stormwater at Site. These are set out in **Table 6-1**.

Table 6-1 Surface Water Discharge Quality Trigger Values

Parameter	Detection Method	Trigger Value	Reference
pH	In situ	6 and 8.5	Water quality objectives for the Darwin Harbour region-background document (NRETAS 2010) – upper estuary trigger values.
Turbidity	In situ	Greater than 75 NTU for stormwater (Project adopted value)	The guidelines in <i>Best practice erosion and sediment control</i> (IECA 2008) specify a discharge trigger value of 50 mg/L TSS. Given the need for a real-time measurement of suspended sediment for Site management, a value of 75 NTU has been used. A number of correlations have been attempted between TSS and NTU across the Site and in the receiving environment with no clear correlation evident. Therefore, the 75 NTU will continue to be used as the best practice guideline.
Oil and grease	Visual	Visual sheen or detectable odour	Good international industry practice.
Iron floc and scum	Visual	No visible matter	
Floating matter/litter	Visual		

6.3.2 Darwin Harbour Receiving Environment

Tables 8 and 9 of the Darwin Harbour WQOs set out WQOs for upper estuary waters for a number of priority water quality indicators. For toxicants, the Darwin Harbour WQOs provide that the ANZECC Guidelines should be used and as such, the relevant trigger values from the Darwin Harbour WQOs and ANZECC Guidelines that have been adopted for the Project are set out in **Table 6-2**. The Darwin Harbour receiving environment trigger values are used to evaluate the quality of water flowing through the drainage system and captured by the auto samplers. The auto-samplers were installed to collect samples of water discharging through the erosion and sediment controls. As per the CEMP, they are not compliance points for stormwater discharge and provide further information on water quality during overtopping events.

Table 6-2 Surface Water Quality Receiving Environment Trigger Values

Parameter	Detection Method	Trigger Value ¹	Reference
DO saturation	In situ	Lower limit 80%	Water quality objectives for the Darwin Harbour region - background document (NRETAS 2010) – upper estuary trigger values.
pH	In situ	6 lower limit; 8.5 upper limit	
TSS	Laboratory	10 mg/L	
Turbidity	In situ	20 NTU	Australian and New Zealand guidelines for fresh and marine water quality – Volume 1 The Guidelines (ANZECC 2000a) – Section 3 Aquatic ecosystems.
Temperature	In situ	+/- 3°C of ambient at reference sites	<i>Environmental, Health, and Safety General Guidelines</i> (IFC 2007).
Ammonia	Laboratory	20 µg/L	Water quality objectives for the Darwin Harbour region-background document (NRETAS 2010) – upper estuary trigger values.
Total nitrogen	Laboratory	300 µg/L	
Total phosphorus	Laboratory	30 µg/L	
Oxides of nitrogen	Laboratory	20 µg/L	
Filterable reactive phosphorus (FRP)	Laboratory	10 µg/L	
Chlorophyll-a	Laboratory	4 µg/L	
Aluminium	Laboratory	24 µg/L	<i>Derivation of a water quality guideline for aluminium in marine waters</i> (Golding et al. 2015).
Filtered total arsenic	Laboratory	2.3 µg/L	Australian and New Zealand Guidelines for fresh and marine water quality – Volume 2 Aquatic Ecosystems – Rationale and Background Information (ANZECC 2000a) – Section 8.3.7 Detailed descriptions of chemicals.
Cadmium	Laboratory	0.7 µg/L	
Chromium (III)	Laboratory	10.0 µg/L	
Chromium (VI)	Laboratory	4.4 µg/L	
Cobalt	Laboratory	1 µg/L	Australian and New Zealand guidelines for fresh and marine water quality – Volume 1 The Guidelines (ANZECC 2000a) – Section 3 Aquatic ecosystems.
Copper	Laboratory	1.3 µg/L	
Lead	Laboratory	4.4 µg/L	
Manganese	Laboratory	390 µg/L	
Mercury (inorganic)	Laboratory	0.1 µg/L	Australian and New Zealand Guidelines for fresh and marine water quality – Volume 2 Aquatic Ecosystems – Rationale and Background Information (ANZECC 2000a) – Section 8.3.7 Detailed descriptions of chemicals.
Nickel	Laboratory	7 µg/L	
Silver	Laboratory	1.4 µg/L	
Vanadium	Laboratory	100 µg/L	Australian and New Zealand guidelines for fresh and marine water quality – Volume 1

Parameter	Detection Method	Trigger Value ¹	Reference
Zinc	Laboratory	15 µg/L	The Guidelines (ANZECC 2000a) – Section 3 Aquatic ecosystems.
Benzene	Laboratory	500 µg/L	
Ethylbenzene	Laboratory	5 µg/L	Australian and New Zealand Guidelines for fresh and marine water quality – Volume 2 Aquatic Ecosystems – Rationale and Background Information (ANZECC 2000a) – Section 8.3.7 Detailed descriptions of chemicals.
Toluene	Laboratory	110 µg/L	
Xylenes	Laboratory	75 µg/L	
Naphthalene	Laboratory	50 µg/L	Australian and New Zealand guidelines for fresh and marine water quality – Volume 1 The Guidelines (ANZECC 2000a) – Section 3 Aquatic ecosystems.
Total Petroleum Hydrocarbon (TPH)/ Total Recoverable Hydrocarbon (TRH)	Laboratory	LOR	Advice from analytical laboratories regarding the LOR for TPH/TRH for receiving environment surface waters outside of the Site Project boundary shows significant variability, depending on the method used and the chain length of the hydrocarbons analysed and will range between 100 to 500 µg/L.
<i>Escherichia coli</i> (<i>E. coli</i>)	Laboratory	No single sample greater than 200 <i>E. coli</i> per 100 mL	Water quality objectives for the Darwin Harbour region-background document (NRETAS 2010) – upper estuary trigger values.
Enterococci	Laboratory	50 enterococci per 100 mL	

¹ The shaded cells represent a change between the EIMP (Rev 6) and this EIMP. In some cases, the change may relate to the description of the parameter or the trigger value that applies. In some cases, additional parameters are monitored.

6.4 Monitoring Sites

Surface water sampling locations as from the EIMP approval date are outlined in **Table 6-3** and **Figure 6-1** and **Figure 6-2**.

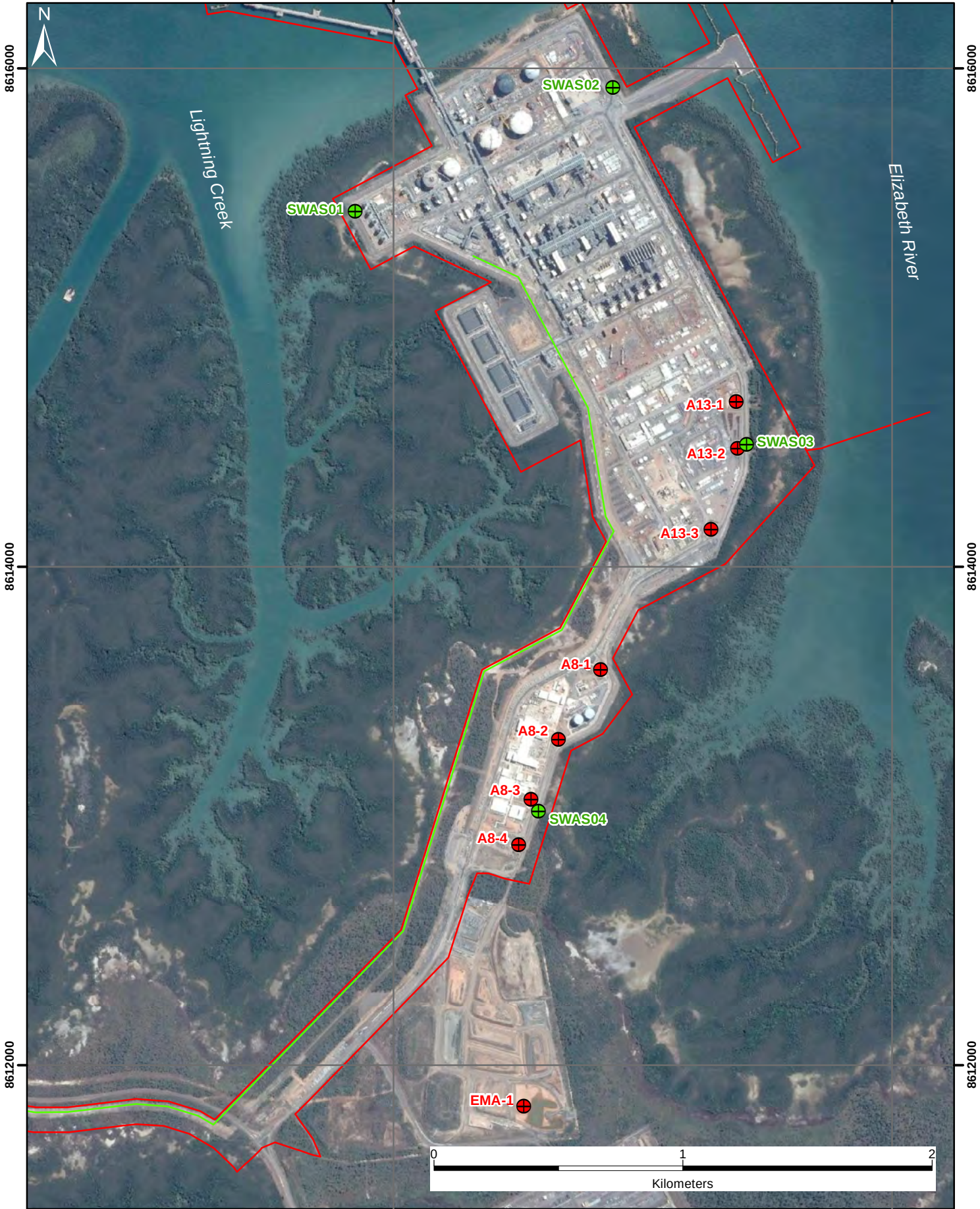
Table 6-3 Surface Water Monitoring Locations

Monitoring Site	Details	Location	Coordinates (GDA 1994; Map Zone 52)	
			Easting (m)	Northing (m)
SWAS01	Auto-sampler locations	Drainage outfall	707846.46	8615426.32
SWAS02		Drainage outfall	708880.75	8615924.12
SWAS03		Drainage outfall	709416.24	8614490.70
SWAS04		Drainage outfall	708581.76	8613017.45
BPSW20	Offsite marine locations	Creek sampling	707430.74	8615395.71
BPSW22		Creek sampling	707464.07	8613391.11
BPSW23		Harbour sampling	709519.94	8613552.60
BPSW24		Harbour sampling	709699.38	8614249.85
BPSW25		Harbour sampling	709755.77	8614895.84
BPSW26		Harbour sampling	709619.91	8615367.51
BPSW27		Harbour sampling	708859.94	8616247.11
BPSW28		Harbour sampling	708500.11	8616141.28

Monitoring Site	Details	Location	Coordinates (GDA 1994; Map Zone 52)	
			Easting (m)	Northing (m)
BPSW29		Creek sampling	708302.31	8614129.37
BPSW30		Harbour sampling	706994.96	8616305.72
BPSW31		Harbour sampling	709924.96	8616262.15
BPSW32		Harbour sampling	710770.24	8613659.48
BPSW33		Harbour sampling	704982.67	8616649.22
BPSW34		Harbour sampling for GEP	705551.88	8611207.46
BPSW35		Creek sampling for GEP	705153.21	8611856.51
CSSW01	Reference sites	Harbour sampling	707935.72	8618950.72
CSSW02		Harbour sampling	709232.90	8619045.06
CSSW03		Harbour sampling	706647.45	8615016.69
CSSW04		Harbour sampling	711585.15	8612420.98

708000

710000



Site Boundary

Gas Export Pipeline

Surface Water Monitoring Locations

Auto-Sampler Monitoring Locations

Basin Sampling Locations

Onsite Monitoring Locations

Figure 6-1

INPEX
Bladin Point

GREENCAP

Date: 30/08/2016

Author: malcolm.nunn

Map Scale: 1:20,000

Revision: A

Coordinate System: GDA 1994 MGA Zone 52

INDRA
05 DEC 2016
Issue

No warranty is given by the provider of this data, including accuracy, reliability, completeness or suitability) and accept no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of or reliance upon the data. Data must not be used for direct marketing or be used in the context of any legal proceedings.

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— Site Boundary

— Gas Export Pipeline

Surface Water Monitoring Locations

⊕ Offsite Marine Sampling Locations

⊙ Reference Sites

Offsite Monitoring Locations

Figure
6-2

INPEX
Bladin Point

GREENCAP

Date: 30/08/2016

Author: malcolm.nunn

Map Scale: 1:50,000

Revision: A

Coordinate System: GDA 1994 MGA Zone 52

INDRA
05 DEC 2016
Issue

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6.5 Surface Water Monitoring Program

A summary of the surface water monitoring approach as from the EIMP approval date is provided in Table 6-4.

Table 6-4 Surface Water Monitoring Summary

Frequency	Monitoring Methodology	Monitoring Parameters	Locations
Monthly	Determination of potential impacts of surface water discharge on the receiving environment through sampling locations upstream, downstream, at the point of discharge and reference sites. Samples are collected for laboratory analysis to supplement in situ analysis of key parameters.	In situ analysis for physico-chemical parameters (temperature, pH, DO, ORP, EC, salinity and turbidity). Total and dissolved metals analysis including aluminium, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, silver, vanadium and zinc. Cations, anions and sulfate concentrations. Total recoverable hydrocarbons, benzene, toluene, ethylbenzene, xylenes and naphthalene. Nutrients including ammonia, total nitrogen, nitrate, nitrite, total phosphorus and filterable reactive phosphorus. Chlorophyll-a and bacteria (<i>E. coli</i> and enterococci).	BPSW20, BPSW22 to BPSW33. CSSW01 to CSSW04.
Quarterly	As above.	As above.	BPSW34, BPSW35
During discharge	Auto samplers to collect water samples during surface water basin overtopping events. Sampling frequency is adjusted to capture different size events to enable adaptive response to identified spills and changes in catchment size and structure. Samples are collected for laboratory analysis to supplement in situ analysis of EC and turbidity which are collected automatically at the point of sampling.	In situ analysis for physico-chemical parameters (turbidity and EC). Dissolved metals analysis including aluminium, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, silver, vanadium and zinc. Cations, anions and sulfate concentrations. Total recoverable hydrocarbons, benzene, toluene, ethylbenzene, xylenes and naphthalene. Nutrients including ammonia, total nitrogen, nitrate, nitrite, total phosphorus and filterable reactive phosphorus.	SWAS01 to SWAS04

6.6 Monitoring Methods

6.6.1 Data Collection

Surface water samples are collected using standard practices for surface water sampling as detailed below and in accordance with Australian and New Zealand Standard (AS/NZS) 5667.9:1998 *Water Quality – Sampling Part 9: Guidance on sampling from marine water* (AS/NZS 5667.9).

The key procedures to be undertaken in the field are described below:

- Visual inspection of surface water collection points and sediment basins to determine the presence or absence of oil, grease, iron floc and floating matter;

- In situ quality measurements (pH, total dissolved solids [TDS], EC, DO, temperature, turbidity and ORP) are undertaken prior to sample collection using a multi-parameter instrument. All field equipment are calibrated in accordance with the manufacturer's instructions;
- Collection of surface water samples and field QA/QC samples for laboratory analysis after field quality parameter measurement;
- Decontamination of all non-dedicated sampling equipment between sample locations; and
- Proper disposal of used disposable sampling equipment.

6.6.2 Auto-sampler Data Collection

Four surface water auto-sampler units are located at drainage outfalls at strategic locations in the drainage structure to monitor over-topping events (**Figure 6-1**). The complexity of the free-draining surface water systems onsite precludes precise location monitoring and the need to segregate all catchments.

The location of these samplers is designed to provide a snapshot of the water quality leaving the Site across the main construction catchments for the LNG plant. These samplers are not intended to report on all water leaving the Site for compliance purposes as this is covered by operational sampling prior to discharge, which demonstrates compliance with Project objectives.

The installation and use of auto-samplers allows the collection of flow-triggered water samples during significant rainfall events. These auto-samplers are programmed to sample nominated stages of the rainfall event. The units are programmed to sample at the commencement of the rain event (T0), ten minutes after commencement of the rain event (T1) and twenty minutes after commencement of the rain event (T2). Once the rainfall event has passed, samples are safely retrieved, decanted into appropriate sampling containers and submitted for analysis at a National Association of Testing Authorities (NATA) accredited laboratory. A total of four auto-sampler locations have been commissioned for representative sampling of the surface water quality catchments discharging from Site.

The auto-samplers are triggered by Doppler sensors and capture and retain a time series of water samples. These samples are then correlated with rainfall data recorded at the onsite meteorological monitoring station. The auto-samplers allow for the collection of up to three rain events which equates to 12, one litre samples of water. The auto-samplers analyse for EC and turbidity at the point of sample collection, while pH is scheduled for laboratory analysis. When the auto-sampler has collected a sample, the system sends an email notification to which is attached the EC and turbidity data.

The typical operation of the auto-samplers is summarised as follows:

- A rain event is sensed and the unit turns on;
- Decontamination of the auto-sampler is performed whereby all fluid from the previous sampling event is purged. This automatically occurs after each sampling event and prior to the next sampling event;
- The unit measures flow by polling the flow meter every five minutes. Once flow is detected in a positive direction, the logger enables logging;
- The logger triggers the collection of samples following the detection of a flow of more than eight centimetres in height. This can be adjusted to adapt to changing requirements in the frequency of surface water sampling collection;
- The first flush sample is collected (T0) and subsequent samples then collected at ten minute (T10) and 20 minute (T20) intervals;
- The logger records EC and turbidity readings at five minute intervals, for as long flow in a positive direction is detected; and
- Following the conclusion of the rain event, the unit resets and starts the sequence again. Samples from up to three rain events (a maximum of 12 samples) can be stored until the sample bottles need to be re-set. The sample bottles are then decontaminated following sample collection using a phosphate-free detergent and deionised water.

The frequency of auto-sampler surface water sample collection at each location can vary considerably based on the following factors:

- Size of the monitoring catchment;
- Number of current operational basins and drains within the catchment;
- Dominant surface type within the catchment;
- Management controls currently in place within the catchment, e.g. is the water being retained or already been pumped out for dust suppression reuse purposes;
- Number and frequency of drainage outfalls located in the regulating reservoir of the catchment; and
- Localised variations in both total rainfall quantity and intensity of events.

6.6.3 Field Records

At each surface water sampling location, the field records include the following minimum information:

- Exact location (sample point number/name and/or GPS coordinates), sampling time, date and the name of the sampler(s);
- Sample type, number of containers, sample preservatives and sample collection order;
- Weather conditions;
- Sample collection equipment and method;
- Purging records, for example, water quality meter calibration records;
- Sample equipment decontamination procedures, where non-disposable sampling equipment is utilised; and
- Any comments on exceptions or issues regarding the sample collected.

6.6.4 Sample Labels

Each sample label includes the following information:

- Subcontractor and sampler's name;
- Sample point identification and unique sample number;
- Date and time sample was taken; and
- What was sampled (e.g., storm water) and why (e.g., metal analysis).

6.6.5 Calibration of Field Equipment

Field instruments including the pH probe, EC probe, turbidity meter and DO meter are calibrated as per the manufacturer's instructions and Australian Standards prior to each sampling day and in the event of unusual sampling results.

Equivalent calibrated backups units are available on the same day for all field equipment so that equipment failures do not result in data gaps.

For auto-sampler units, the EC probe, turbidity meter and DO meter are calibrated as per the manufacturer's instructions and Australian Standards and in the event of unusual sampling results.

6.6.6 Chain of Custody

A chain of custody (CoC) form is completed to accompany the samples to the laboratory for submission for analysis. In each instance, the following are undertaken:

- The CoC form is completed in pen;
- All information requirements are completed on the form;
- All eskies are dispatched under seal of custody to the nominated laboratories;
- The CoC form conveys instructions to the laboratory, such as analyses to be performed, field preparation (filtered or not filtered, as applicable, etc.) and limits of reporting (LORs) required to be achieved;

- On delivery to the laboratory, the receiving person inspects the eskies, note the presence or otherwise of ice or freezer bricks if specified on the CoC form, measure the temperature and record each entry on the relevant CoC form;
- The completed CoC form is transmitted to Subcontractor within 24 hours of the delivery of samples to the laboratory; and
- CoC forms are presented with the original laboratory certificates in completed future monitoring reports.

6.6.7 Sample Preservation and Holding Times

The selection of the appropriate sample containers, preservation procedures, sample storage requirements and holding times are undertaken in accordance with those recommended by AS/NZS 5667.1:1998 *Water Quality Sampling – Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples*. All primary samples and associated QA/QC samples are shipped to the laboratory to ensure holding times are achieved. The laboratory is notified of the shipment of samples and their expected arrival. Sample preservation and holding times are summarised in **Table 6-5** below.

Table 6-5 Sample Preservation and Holding Times

Parameter	Container	Preservation	Holding Time ¹	Lab Method
TSS	HDPE and QA Verified Contaminant Free	None	7 days	APHA 2540D
Conductivity	HDPE and QA Verified Contaminant Free	None	28 days	APHA 21 st ed.
TDS (Calc)	HDPE and QA Verified Contaminant Free	None	7 days	APHA 2510 B
Major Cations+Hardness (Ca, Mg, Na, K)	HDPE and QA Verified Contaminant Free	None	7 days	APHA 3120
Major Anions (Cl, SO ₄ , F Alkalinity)	HDPE and QA Verified Contaminant Free	None	28 days	APHA 4500 SO4 APHA 4500-Ci – B APHA 2320 B APHA4500 F –C
Nutrient Water Suite: Total N and P (including NO _x and TKN), NO ₂ , NO ₃ , Reactive P, Ammonia as N)	HDPE and QA Verified Contaminant Free	None	NO ₂ , NO ₃ : 2 days. Others: 28 days	APHA 4500 NH3- - H APHA 4500 Norg/NO3 APHA 450– P – H APHA 4500 P - G
Total Metals - low level As, Al, Cd, Cr, Co, Cu, Pb, Ag V, Zn	HDPE and QA Verified Contaminant Free	Lab acidified with ultra-pure nitric acid	6 Months	APHA 3125
Total Mercury (Hg)	HDPE and QA Verified Contaminant Free	Lab acidified with ultra-pure nitric acid	28 days	CV/FIMS
Dissolved Metals - low level As, Al, Cd, Cr, Co, Cu, Pb, Ag, V, Zn	HDPE and QA Verified Contaminant Free	Field filtered and Lab acidified with ultra-pure nitric acid	6 months	APHA 3125
TPH/TRH (C ₆ -C ₄₀) BTEXN	Glass QA Verified Contaminant Free Vials	Field filtered and Lab acidified with ultra-pure nitric acid	14 days	GC-FID

Parameter	Container	Preservation	Holding Time ¹	Lab Method
Chlorophyll-a	HDPE and QA Verified Contaminant Free	None	2 days	10200H
<i>E. coli</i> (MPN) Colilert	HDPE and QA Verified Contaminant Free	Na ₂ S ₂ O ₃	1 day	Report 71
Enterococci (MPN)	HDPE and QA Verified Contaminant Free	Na ₂ S ₂ O ₃	1 day	ASTM D6503-99

¹ Day = 24 hours measured from time collected.

All samples are refrigerated during the course of the working day and in transit to the laboratory in cooler boxes packed with ice or cooling blocks. Nominated laboratories are instructed to retain all the sampling extracts obtained for the analysis of organic parameters to be kept under refrigeration for at least 30 days after the issue of the laboratory report. This allows time for the laboratory report to be reviewed and repeat tests or additional tests, to be conducted within the extract holding time.

6.6.8 Laboratory Reports

Laboratory reports are issued in accordance with the requirements of NATA endorsement and, as a minimum, include the following information appended within the monitoring report:

- The test results for the samples;
- The test results for the laboratory's in-house duplicates;
- The test results for the laboratory's in-house surrogate and matrix spike recovery determinations; and
- The extraction (where applicable) and analysis dates which would be used to determine compliance with the permitted holding times.

6.6.9 Field Quality Assurance and Quality Control

Surface water quality control samples are collected at the following frequencies:

- Field duplicate (intra laboratory duplicates) samples at one per 20 water samples per monitoring event;
- Field triplicate (inter laboratory replicates) samples at one per 20 water samples per monitoring event;
- Field blank samples at one per day and field rinsate samples at one per day; and
- Trip blanks one per cooler box containing samples scheduled for benzene, toluene, ethylbenzene and xylene (BTEXN) analysis.

6.6.10 Laboratory Quality Assurance and Quality Control

The laboratory selected to conduct the analysis of surface water samples are be accredited by NATA and able to demonstrate that it can achieve the required analytical LOR and quality.

Furthermore the following QA/QC procedures are used:

- Analyses are reviewed by NATA and meet NATA accreditation parameters, which meet ISO/IEC 17025:2005 *General requirements for the competence of testing and calibration laboratories* (ISO/IEC 17025) and ISO 9001:2008 *Quality management systems – requirements* (ISO 9001). In addition, the laboratory's QA/QC procedures are reviewed by external consultants on an annual basis;
- Method blanks are processed and analysed to detect any contamination resulting from sample preparation, extraction or analysis. After each batch of samples is analysed, a blank sample is run to see if this returns a value below or near the detection limit of the analytical technique;
- The samples are split into sub-samples to check the precision of the analyses at a duplication of 10%;

- Surrogate spikes are undertaken, with one sample in every batch spiked. As a known quantity of a surrogate is added to each sample prior to extraction, the quantity of surrogate recovered after the analytical process provides a measure of analytical performance;
- Matrix spikes are analysed with at least one sample in every sample batch spiked. As a known quantity of the analyte is added to each sample prior to extraction, the quantity of analyte recovered after the analytical process provides a measure of analytical performance;
- Laboratory instruments are calibrated daily at the beginning of each process batch of analyses on a specific analyser. A continuing calibration verification is run at a minimum frequency of one in every 20 samples or at least one per each process batch of analyses on a specific analyser. Control figures are produced weekly to identify outliers or possible trends for particular tests or instruments; and
- The laboratory is certified by NATA to conduct the specific tests required, unless NATA does not certify a particular analysis or method specified in this plan. In the instances where NATA accreditation is not available, standard industry practice is applied.

7. GROUNDWATER

7.1 Summary of Compliance Requirements

Groundwater monitoring undertaken in accordance with the EIMP meets the compliance requirements set out in the following legislation, policies, guidelines and approval requirements associated with the Project.

7.1.1 Legislation

Under the Water Act, beneficial uses and objectives can be declared for groundwater.

On 29 June 2010, the Administrator for the Northern Territory issued the *Declaration of Beneficial Uses and Objectives – Elizabeth-Howard Rivers Region Groundwater* (Elizabeth-Howard Declaration). This declaration extends across the majority of the Site.

The Elizabeth-Howard Declaration also provides that the following objectives apply to groundwater:

- The WQOs specified in Table 8 in the Darwin Harbour WQOs; and
- If particular WQOs relevant to a beneficial use are not specified in that Table – the relevant guidelines specified in Chapters 3, 4, 5 and 6 of the ANZECC Guidelines and the document entitled *Australian Drinking Water Quality Guidelines* (ADWG) (National Health and Medical Research Council (NHMRC, 2004) apply.

7.1.2 Approval Requirements

Condition 8 of the EPA7 (as amended) approval for the Project requires that the Approval Holder must do all things reasonable and practicable to ensure the Project does not adversely affect the Declared Beneficial Uses and Objectives, including those applying to groundwater in the Elizabeth-Howard Rivers region.

The CEMP sets out a number of objectives, targets and indicators that apply to the groundwater monitoring program and these have been incorporated into the program.

7.1.3 Policies and Guidelines

In accordance with the Elizabeth-Howard Declaration, the groundwater quality objectives for the Project are based on the Darwin Harbour WQOs, the ANZECC Guidelines or the ADWG. The appropriate use of these objectives is reflective of the water source and beneficial uses, namely that fresh groundwater trigger values must use the freshwater criteria from the ANZECC Guidelines or the ADWG and saline groundwater must use the marine water criteria from the ANZECC Guidelines.

The AEMR (2014) confirmed that the groundwater on Site is mostly saline groundwater that is unsuitable for drinking water purposes. The AEMR (2014) also confirmed that groundwater discharges from Site into the marine environment, rather than a freshwater environment. Accordingly, the adoption of marine trigger values (where available) is in accordance with EPA7 (as amended), which specifies that marine trigger values from the ANZECC Guidelines must be used.

7.2 Updates to the Environmental Impact Monitoring Program

7.2.1 Alignment of Trigger Values with the CEMP

The following groundwater trigger values have been modified to align with the CEMP:

- pH – the lower limit of the trigger value range will be changed from 7 to 6 pH units;
- Aluminium – will be changed from 55 µg/L to 24 µg/L;
- Arsenic (III) and arsenic (V) – will be removed as monitoring parameters and will be replaced with total arsenic with a trigger value of 2.3 µg/L, as this is the more conservative of the two previous trigger values for arsenic (III) and (V);
- Chromium (III) – will be changed from 27.4 µg/L to 10.0 µg/L;
- Manganese – will be changed from 80 µg/L to 390 µg/L; and
- Nickel – will be changed from 70 µg/L to 7 µg/L.

7.2.2 Modifications to Monitoring Approach

The lower limit for pH has changed from 7 to 6 pH units to align with the upper estuary trigger value as specified in Darwin Harbour WQOs.

7.2.3 Refinement of Monitoring Locations

The GEP groundwater monitoring program comprises monitoring and assessment of the groundwater levels and quality during the construction of the pipeline through the monthly sampling of nine groundwater bores (MW04d, MW05d, MW08d, MW10a, MW11a, MW14, MW16, MW18b and MW20b) which are located between the beach valve and the gas reception area. The monitoring commenced in September 2014.

Construction activities (e.g. ASS excavations, deep soil mixing and vegetation clearing) had the potential to result in the deterioration of adjacent aquatic ecosystems including a decline in groundwater quality through the introduction of nutrients, metals, hydrocarbons and an altered physico-chemical environment. Given that construction and reinstatement works are now complete, a review of the potential risk sources and monitoring requirements was undertaken in AEMR (2016).

An important issue to note is that whilst ASS excavation works were completed in August 2015, groundwater impacts (due to ASS disturbance) may not be observed immediately at specific GEP monitoring bores because the velocity of groundwater flow is generally in the order of 15-30 m per year. Given the distances between those bores in potential ASS areas and the locations where the majority of deep soil mixing and ASS treatment took place, it could take a minimum of 12-18 months for any potentially impacted plume to be detected in these GEP bores. Therefore, despite the cessation of construction activities, the risk source has not been removed in certain locations along the GEP corridor.

Following the assessment and analysis in AEMR (2016), the following was recommended:

- Monitoring bores MW04d, MW05d and MW08d be removed from the monitoring program because they are not located in areas of known ASS and therefore the risk source has been removed; and
- Based on groundwater velocity and transit times, monitoring at bores MW10a, MW11a and MW14 cease at the end of the 2016/17 wet season (i.e. April 2017). These bores are located in known ASS areas and are currently monitored on a monthly basis to assess any potential ASS mobilisation impacts that may have arisen in the August 2015 excavations. Monitoring of these bores is required until April 2017 because this would provide sufficient time to detect any potential groundwater impacts from ASS mobilisation. Following evidence that no adverse impacts have occurred these monitoring sites will be removed from the EIMP.

The projected date for their removal is the second quarter of 2017 subject to the provisions in Chapter 5.

EIMP (Rev 6) included a provision for the installation of groundwater monitoring bore BPGW39 on Site. This bore will not be required because the extensive, existing groundwater monitoring network provides sufficient coverage to adequately monitor groundwater quality and any potential impacts that may arise from Site activities and discharges.

7.2.4 Adjustment of Monitoring Equipment

EIMP (Rev 6) requires the installation of data loggers in all bores on Site, including the GEP bores. Data loggers will not be installed in the GEP bores because loggers are not critical in the detection of the potential effects of deep soil mixing and ASS mobilisation on the groundwater. The potential impacts on groundwater manifest over a much longer timeline (months rather than days) and this can be captured by the existing monthly monitoring of groundwater.

Further to the above, the telemetry systems and data loggers that are currently installed in the 35 bores on Site are also not critical in the detection of potential ASS impacts and mobilisation and can be assessed using the existing monthly monitoring of groundwater. In addition, the equipment is not intrinsically safe and presents a potential ignition source and for safety reasons will be removed when the Site is declared a MHF.

Groundwater sampling is currently undertaken using the low-flow sampling technique, which is not intrinsically safe and presents a potential ignition source. Therefore, when the Site is declared a MHF, sampling will be undertaken using an intrinsically safe methodology (e.g. bailing method).

These changes will be done in accordance with the process outlined in **Chapter 5**.

7.3 Groundwater Trigger Values

In accordance with the EPA7 (as amended), the relevant trigger values from the Darwin Harbour WQOs and ANZECC Guidelines for marine waters will be adopted for the Project (**Table 7-1**).

Table 7-1 Groundwater Monitoring Trigger Values

Parameter	Detection Method	Trigger Value ¹	Reference
pH	In situ	6 lower limit; 8.5 upper limit	<i>Water quality objectives for the Darwin Harbour region - background document</i> (NRETAS 2010)
TSS	Laboratory	Assessed for temporal variation	N/A
Turbidity	In situ		
Ammonia	Laboratory	20 µg/L	<i>Water quality objectives for the Darwin Harbour region-background document</i> (NRETAS 2010)
Total nitrogen	Laboratory	300 µg/L	
Total phosphorus	Laboratory	30 µg/L	
Oxides of nitrogen	Laboratory	20 µg/L	
FRP	Laboratory	10 µg/L	
Aluminium	Laboratory	24 µg/L	Golding <i>et al.</i> , 2015
Filtered total arsenic	Laboratory	2.3 µg/L	Australian and New Zealand guidelines for fresh and marine water quality (ANZECC 2000a; 2000b)
Cadmium	Laboratory	0.7 µg/L	
Chromium (III)	Laboratory	10.0 µg/L	
Chromium (VI)	Laboratory	4.4 µg/L	
Cobalt	Laboratory	1 µg/L	
Copper	Laboratory	1.3 µg/L	
Lead	Laboratory	4.4 µg/L	
Manganese	Laboratory	390 µg/L	J. Stauber and R. Van Dam Pers.Com. 23 rd March 2015

Parameter	Detection Method	Trigger Value ¹	Reference
Mercury (inorganic)	Laboratory	0.1 µg/L	Australian and New Zealand guidelines for fresh and marine water quality (ANZECC 2000a; 2000b)
Nickel	Laboratory	7 µg/L	
Silver	Laboratory	1.4 µg/L	
Vanadium	Laboratory	100 µg/L	
Zinc	Laboratory	15 µg/L	
Benzene	Laboratory	500 µg/L	
Ethylbenzene	Laboratory	5 µg/L	
Toluene	Laboratory	180 µg/L	
Xylenes	Laboratory	75 µg/L	
Naphthalene	Laboratory	50 µg/L	
TPH/TRH ²	Laboratory	600 µg/L	Ministry of Infrastructure and the Environment 2013, Groundwater intervention value

¹ The shaded cells represent a change between the EIMP (Rev 6) and this EIMP. In some cases, the change may relate to the description of the parameter or the trigger value that applies. In some cases, additional parameters are monitored.

² Laboratory analysis for oil/grease/TRH and BTEXN is required if visible oil sheen or odour is detected or in the event hydrocarbon contamination of groundwater is suspected. The analytical method used is TRH by Gas Chromatography-FID method (MPL is LTM-ORG-2010). Where TRH is detected over the prescribed limits a silica gel clean-up is undertaken and reanalysed to remove false positive natural oil results. Further interrogation in specific types of hydrocarbons can be undertaken, if needed, through interpretation of the chromatography signatures. Characterisation of specific types of hydrocarbons may be required initially to determine composition and variation in composition, if any.

7.4 Monitoring Sites

The locations of the bores as from the EIMP approval date are outlined in **Table 7-2** and **Figure 7-1**.

Table 7-2 Groundwater Sampling Locations and Rationale

Monitoring Location	Co-ordinates (GDA 1994; Map Zone 52)		TOC (m AHD)	Depth (m)	Top of Screen (m AHD)	Base of Screen (m AHD)	Details
	Easting (m)	Northing (m)					
BH602	707760.30	8611812.20	8.29	10.00	4.59	-2.41	Extractive Minerals Area
BPGW01	707569.70	8611771.10	7.42	10.00	5.72	-3.28	
BPGW02	708194.06	8611650.20	7.75	10.00	6.05	-2.95	
BPGW03	708653.31	8611700.43	7.76	10.00	5.96	-3.04	
BPGW04	708658.20	8612140.20	7.81	10.00	6.11	-2.89	
BPGW05	708569.85	8612567.83	5.01	10.00	3.31	-5.69	
BPGW06	708066.29	8612230.08	10.10	10.00	8.40	-0.60	
BPGW07	708632.90	8613125.90	3.75	5.30	2.05	-2.25	Operations complex
BPGW08A	708464.00	8613233.00	7.44	10.50	5.44	-3.56	
BPGW09	708878.46	8613608.87	3.71	5.00	2.01	-1.89	
BPGW10	708996.08	8613887.88	6.94	10.00	5.24	-3.76	East of haul road, south of temporary facilities area
BPGW11	709272.60	8614564.30	6.83	10.00	5.13	-3.87	Temporary office facilities
BPGW12A	708928.70	8614016.80	5.73	10.40	4.33	-4.67	Boundary of site, west of temporary facilities area
BPGW13A	708827.30	8614231.50	5.79	10.30	4.57	-4.54	Western boundary of site

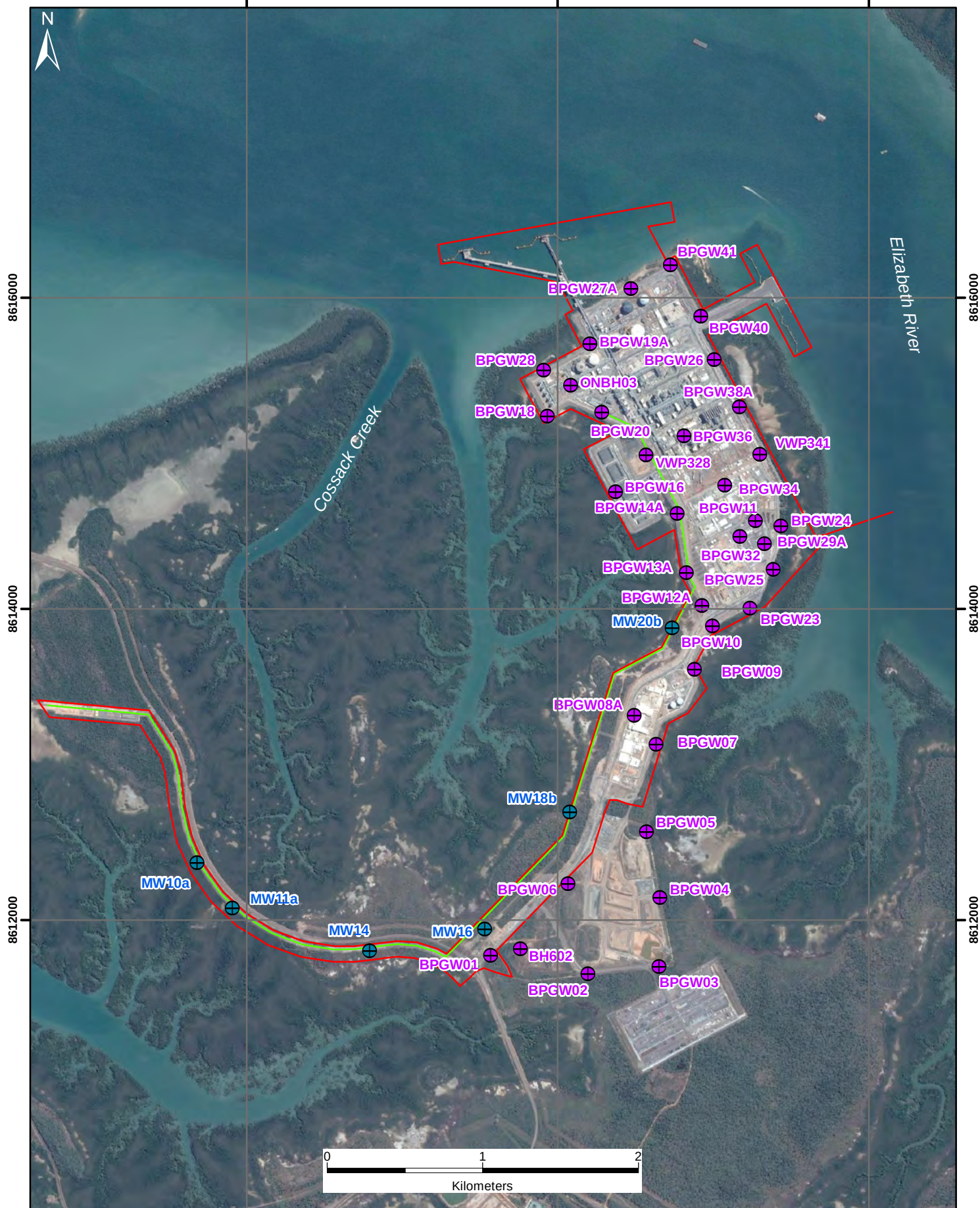
Monitoring Location	Co-ordinates (GDA 1994; Map Zone 52)		TOC (m AHD)	Depth (m)	Top of Screen (m AHD)	Base of Screen (m AHD)	Details
	Easting (m)	Northing (m)					
BPGW14A	708768.10	8614611.00	6.42	10.40	5.04	-3.96	
BPGW16	708372.35	8614751.90	3.65	7.00	1.95	-4.05	Western boundary of flare pad
BPGW18	707935.12	8615236.09	5.23	7.00	1.53	-2.47	Southwest corner of tankage flare
BPGW19A	708208.40	8615701.50	4.46	6.10	4.52	-4.48	North boundary of LPG tanks, south-west of Jetty
BPGW20	708284.81	8615261.91	5.73	10.20	2.67	-6.33	Eastern boundary of tankage flare
BPGW23	709238.30	8614000.60	5.54	10.00	3.84	-5.16	Boundary of site, south of temporary facilities area
BPGW24	709434.00	8614528.90	5.39	10.00	3.69	-5.31	Boundary of site, east of temporary facilities area
BPGW25	709384.60	8614254.10	5.24	10.00	3.54	-5.46	Boundary of site, southeast of temporary facilities area
BPGW26	709006.37	8615600.87	6.86	9.00	1.81	-4.19	Eastern boundary of site, south of MOF
BPGW27A	708470.53	8616057.15	6.44	7.15	5.44	-0.71	Northern boundary of site, condensate tank area
BPGW28	707910.13	8615531.18	5.44	7.30	2.44	-2.56	Boundary of site, north of tankage flare
BPGW29A	709328.76	8614419.48	5.88	10.00	4.88	-4.12	Temporary office facilities, adjacent medical centre
BPGW32	709172.40	8614461.30	7.41	10.00	5.71	-3.29	Temporary office facilities
BPGW34	709073.50	8614791.87	7.79	9.10	5.79	-2.01	Central part of the site (LNG processing trains and gas storage areas)
BPGW36	708811.46	8615108.98	7.95	10.30	5.95	-3.05	
BPGW38A	709168.20	8615296.40	-	9.00	5.56	0.91	Eastern boundary, temporary facilities area
BPGW40	708921.40	8615881.75	5.76	7.50	0.56	-2.44	Adjacent to module offloading facility causeway
BPGW41	708726.28	8616208.83	5.54	7.30	1.54	-2.46	Northeast corner of site, adjacent condensate tanks area
ONBH03	708084.68	8615436.12	7.31	11.00	-1.75	-4.75	Central tankage flare
VWP328	708568.90	8614990.20	5.87	10.00	1.33	-4.67	East of flare pad
VWP341	709300.30	8614993.60	7.44	10.00	2.39	-3.81	Eastern boundary, temporary facilities area
MW10a ¹	705682.00	8612367.00	3.61	4.00	0.40	-1.10	GEP
MW11a ¹	705908.00	8612076.00	4.03	2.70	1.70	0.40	
MW14	706791.00	8611801.00	5.29	7.50	0.50	-2.50	
MW16	707530.00	8611941.00	6.57	8.50	2.30	-2.70	
MW18b ¹	708078.00	8612690.00	5.17	10.00	-2.50	-5.50	
MW20b ¹	708735.00	8613875.00	4.24	8.30	-0.40	-4.40	

¹ The use of the letters 'a' and 'b' indicates that bores that are sunk either side of the GEP in approximately the same location.

706000

708000

710000



- Site Boundary
- Gas Export Pipeline
- Monitoring Locations**
- Groundwater Sampling Locations
- EIMP GEP Groundwater Sampling Locations

Groundwater Sampling Locations

Figure
7-1

INPEX
Bladin Point

GREENCAP

Date: 30/08/2016

Author: malcolm.nunn

Map Scale: 1:32,000

Revision: A

Coordinate System: GDA 1994 MGA Zone 52

INDRA
05 DEC 2016
Issue

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R:\Projects\2016\INPEX\GIS\Maps\BP_EIMP\9\FIG_7_01_Groundwater_160830.mxd

7.5 Groundwater Monitoring Approach

A summary of the groundwater monitoring approach as from the EIMP approval date is provided in Table 7-3.

Table 7-3 Groundwater Monitoring Summary

Frequency	Monitoring Methodology	Monitoring Parameters	Locations
Continuous (15 minute intervals)	In situ analysis of groundwater parameters using data loggers in bores. Groundwater elevations are also be monitored.	To include groundwater elevation, pH, DO, ORP, EC and salinity. Due to installation constraints only pH will monitored in five wells.	All bores across the monitoring network, with the exception of the GEP bores.
Monthly	Groundwater sampling is currently undertaken using the low-flow sampling technique, which is not intrinsically safe due to the equipment being a potential ignition source. Therefore, when the Site is declared a MHF, sampling will be undertaken using an intrinsically safe methodology (e.g. bailing method). In situ analysis is undertaken using calibrated meters. Samples are submitted for NATA-accredited analyses.	Total recoverable hydrocarbons including benzene, toluene, ethylbenzene, xylenes and naphthalene.	Six bores across the network (sites moved as required in response to spills, leaks and hydrocarbon detections).
		In situ analysis for physico-chemical parameters (temperature, pH, DO, ORP, EC, salinity and turbidity). Total and dissolved metals ¹ analysis including arsenic, aluminium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, silver, vanadium and zinc. Cation and anion concentrations. Nutrients including ammonia, total nitrogen, nitrate, nitrite, total phosphorus and filterable reactive phosphorus.	All bores across the monitoring network.

¹ Includes speciated chromium analysis.

7.6 Monitoring Methods

7.6.1 Data Collection

Groundwater sampling is undertaken in accordance with the following:

- *Methodology for the Sampling of Groundwaters* developed by the Northern Territory Department for Mines and Energy, March 2009; and
- AS/NZS 5667.11:1998 *Water Quality Sampling – Guidance on sampling of groundwater*.

The field procedure for groundwater sampling is as follows:

- Measurement of the depth to water and depth to the base of the well using an interphase groundwater level meter allowing detection of floating non-aqueous phase liquids in groundwater bores;

- The groundwater quality parameters of pH, EC, DO, temperature, turbidity and ORP are monitored. Collection of groundwater samples shall be undertaken when the field parameters are stabilised within the ranges required by the documents referenced above, indicating that groundwater entering the bore screen is representative of the groundwater in the aquifer;
- Samples analysed for metals are filtered using 0.45 µm vacuum driven filters in the field prior to filling sampling containers as required in the abovementioned guiding documents. In-line filters are not used due to the significant amount of fines present in the aquifers underlying the Site;
- Groundwater samples are collected in the appropriate sampling containers provided by the NATA-accredited analytical laboratories;
- Groundwater samples are stored in a chilled cooler box immediately after sampling and then delivered to the analytical laboratories with accompanying CoC documentation;
- The laboratories used for the sample analyses have NATA accreditation;
- Purged water is retained and returned to Subcontractor offices for storage and disposal in accordance with NT licencing requirements; and
- The non-dedicated sampling equipment (e.g., water level meters, water quality meter probes) is decontaminated between sample locations using a phosphate free detergent and deionised water.

7.6.2 Field Records

At each groundwater sampling location, the field records include the following minimum information:

- Exact location (sample point number/name and/or GPS coordinates), sampling time, date and the name of the sampler(s);
- Sample type, number of containers, sample preservatives and sample collection order;
- Weather conditions;
- Sample collection equipment and method;
- Purging records, including the progressive drawdown and volume pumped;
- Water quality meter calibration records;
- Sample equipment decontamination procedures, where non-disposable sampling equipment is utilised; and
- Any comments on exceptional issues regarding the sample collected.

7.6.3 Sample Labels

Each sample label includes the following information:

- Subcontractor and sampler's name;
- Sample point identification and unique sample number;
- Date and time sample taken; and
- What was sampled (e.g., storm water) and why (e.g., metal analysis).

7.6.4 Calibration of Field Equipment

Field instruments including the pH probe, EC probe, turbidity meter and DO meter are calibrated as per the manufacturer's instructions and Australian Standards prior to each sampling day and in the event of unusual sampling events. The calibration event and results are recorded in the calibration record.

Equivalent calibrated backup units are available on the same day for all field equipment so that equipment failures do not result in data gaps.

7.6.5 Chain of Custody

A CoC form is completed to accompany the samples to the laboratory for submission for analysis. In each instance, the following is undertaken:

- The CoC form is completed in pen;
- All information requirements are completed on the form;
- All eskies are dispatched under seal of custody to the nominated laboratories;
- The CoC form conveys instructions to the laboratory, such as analyses to be performed, field preparation (filtered or not filtered, as applicable, etc.) and LORs required to be achieved;
- On delivery to the laboratory, the receiving person inspects the eskies, note the presence or otherwise of ice or freezer bricks if specified on the CoC form, measure the temperature and record each entry on the relevant CoC form;
- The completed CoC form is transmitted to Subcontractor within 24 hours of the delivery of samples to the laboratory; and
- CoC forms are presented with the original laboratory certificates in completed future monitoring reports.

7.6.6 Sample Preservation and Holding Times

The sample preservation and holding times set out in **Table 6-5** apply to groundwater monitoring.

7.6.7 Laboratory Reports

Laboratory reports are issued in accordance with the requirements of NATA endorsement and include the following information appended within the monitoring report:

- The test results for the samples;
- The test results for the laboratory's in-house duplicates;
- The test results for the laboratory's in-house surrogate and matrix spike recovery determinations; and
- The extraction (where applicable) and analysis dates which would be used to determine compliance with the permitted holding times.

7.6.8 Field Quality Assurance and Quality Control

Groundwater quality control samples are collected at the following frequencies:

- Field duplicate (intra laboratory duplicates) samples at one per 20 water samples per monitoring event;
- Field triplicate (inter laboratory replicates) samples at one per 20 water samples per monitoring event;
- Field blank samples at one per day and field rinsate samples at one per day; and
- Trip blanks one per cooler box containing samples scheduled for BTEXN analysis.

7.6.9 Laboratory Quality Assurance and Quality Control

The laboratory selected to conduct the analysis of groundwater samples are accredited by NATA and able to demonstrate that it can achieve the required analytical LOR and quality for the majority of analytes. Furthermore the following QA/QC procedures are used:

- Laboratory analyses are reviewed by NATA and meet NATA accreditation parameters, which meet ISO/IEC 17025 and ISO 9001. In addition, the laboratory's QA/QC procedures are reviewed by external consultants on an annual basis;
- Method blanks are processed and analysed to detect any contamination resulting from sample preparation, extraction or analysis. After each batch of samples is analysed, a blank sample is run to see if this returns a value below or near the detection limit of the analytical technique;

- The samples are split into sub-samples, to check the precision of the analyses at a duplication of 10%;
- Surrogate spikes are undertaken, with one sample in every batch spiked. As a known quantity of a surrogate is added to each sample prior to extraction, the quantity of surrogate recovered after the analytical process provides a measure of analytical performance;
- Matrix spikes are analysed at one sample in every sample batch spiked. As a known quantity of the analyte is added to each sample prior to extraction, the quantity of analyte recovered after the analytical process provides a measure of analytical performance;
- Laboratory instruments are calibrated daily at the beginning of each process batch of analyses on a specific analyser. A continuing calibration verification is run at a minimum frequency of one in every 20 samples or at least one per each process batch of analyses on a specific analyser. Control figures are produced weekly to identify outliers or possible trends for particular tests or instruments; and
- The laboratory is certified by NATA to conduct the specific tests required, unless NATA does not certify a particular analysis or method specified in this plan. In the instances where NATA accreditation is not available, standard industry practice is applied.

8. MANGROVE COMMUNITY HEALTH, SEDIMENTS AND BIO-INDICATORS

8.1 Summary of Compliance Requirements

Mangrove monitoring undertaken in accordance with this EIMP meets the compliance requirements set out in the following policies, guidelines and approval requirements associated with the Project.

8.1.1 Legislation

There are no prescribed legislative criteria in the Northern Territory relating to mangrove community health.

8.1.2 Approval Requirements

The CEMP sets out a number of objectives, targets and indicators that apply to the mangrove community health monitoring program and these have been incorporated into the program.

8.1.3 Policies and Guidelines

8.1.3.1 Overview

The concept of acceptability criteria or trigger levels has been applied to numerous marine-based projects such as dredging-related turbidity and monitoring of seagrasses or corals, but there have been very few projects in which the concept has been applied to mangrove habitats.

While references such as English *et al* (1997), Moritz-Zimmerman *et al* (2002) and others, provide information on appropriate research-based parameters and methods that can be monitored to characterise mangroves and mangrove habitats, there is a lack of information on Australian mangroves that provide ready-made acceptability criteria and trigger levels that can be applied to the Project.

One case study involving the development and application of interim acceptability criteria for mangrove health and habitat condition has been done for the mangrove monitoring program established at the Fortescue Metals Group port site at Port Hedland, Western Australia (Port Hedland Port Authority, 2012). Interim acceptability criteria were developed during the background monitoring phase (early 2006) and, after completion of construction phase monitoring in 2009, the construction data was reviewed (URS Australia Pty Ltd, 2010).

The review confirms that the majority of the original criteria were appropriate for the Project in terms of providing a warning of the potential for impacts on mangroves, hence an exceedance of the criteria identifies the need for further investigation or additional monitoring. It was noted that a particular criterion exceedance may or may not actually result in any measurable effect on mangrove health or condition, hence the need to implement contingency measures to mitigate impacts should be assessed on a case-by-case basis.

The *Ichthys Project: Nearshore Environmental Monitoring Plan* (Cardno, 2013) (NEMP) set out a mangrove monitoring program designed to detect potential changes in mangrove health associated with the Ichthys Project. This EIMP has referenced NEMP triggers to detect potential changes in mangrove community health.

8.1.3.2 Sediment Quality

The ANZECC Guidelines provide values against which comparison with the collected data is possible. However, it is necessary to develop background data/trigger values for the areas under investigation. While the sediment quality data collected during the background monitoring and construction phase establishes the preliminary values for local background information, the ANZECC Guidelines provide the best option for interpretation and comparison.

The ANZECC Guidelines provide two values: the interim sediment quality guideline (ISQG) low and ISQG high trigger values. The low and high values correspond to the effects range, low and median, used in the United States National Oceanic and Atmospheric Administration (NOAA) listing (Long *et al*, 1995). Trigger values are defined as concentrations of an analyte below which there is a low risk that adverse biological effects will occur. They are levels that trigger the need for continued monitoring (in low risk situations) or further ecosystem-specific investigations (in high-risk situations).

The recommended guideline values for a range of metals, metalloids, organometallic and organic sediment contaminants are expressed as concentrations on a dry weight basis. For organic compounds, values are normalised to 1% organic carbon before comparison. If the sediment organic carbon content is markedly higher than 1%, the guideline value should be relaxed (i.e. made less stringent), because additional carbon binding sites reduce the contaminant bioavailability.

8.1.3.3 Sedimentation and Erosion

No guidelines or policies directly address sedimentation and erosion impacts on mangroves. The NEMP established changes in sedimentation within mangroves and inferred whether any changes were a result of intertidal sedimentation associated with the Ichthys Project. This EIMP has referenced the NEMP triggers to detect potential changes in sedimentation/erosion within mangroves.

8.1.3.4 Bio-indicators

High concentrations of metals and hydrocarbons are known to affect benthic macro fauna, because many metals and hydrocarbons are potentially toxic to organisms that live within the sediment matrix or at the sediment-water interface (Clark, 2001). Furthermore, many organisms that live in or on the sediment are known to accumulate metals and hydrocarbons in their tissue (bio-accumulation) and can cause a threat to human health if consumed. The measurement of metals and hydrocarbons in the tissue of organisms can also be used as an indicator for bio-availability of contaminants in the environment (Gay and Maher, 2003).

Molluscs, particularly members of the Potamidids are suitable species to use as bio-indicators of contaminants in the environment due to their benthic life history and feeding behaviour of sweeping up fine algae and detritus as a non-selective deposit feeder. Contaminants in the intertidal zone that are deposited on the silt would be readily ingested by these benthos.

In respect of the EIMP, the large mud whelk (*Telescopium telescopium*) has been selected as an indicator of bio-accumulation for the following reasons:

- Mud whelks are edible snails and have been consumed (both historically and currently) by local indigenous populations and they occur in reasonable abundance within the mangroves of Darwin Harbour (Peerzada *et al*, 1990);
- Mud whelks are algal grazers moving across the surface of mangrove sediments, thereby providing a measure of the bio-available fraction of contaminants on or within the underlying sediments (Peerzada *et al*, 1990);
- Mud whelks have limited mobility and it is assumed that the present populations will not significantly move outside the potential zone of influence from Site-related impact sources; and
- In 1990 a study was undertaken to establish background information on metal concentrations in *Telescopium* sp. from Darwin Harbour (Peerzada *et al*, 1990).

In order to assess results obtained from analysis of mud whelk tissue, two different approaches have been chosen:

1. The data is compared against the National Food Standards (FSANZ, 2005) for molluscs. The concept of 'generally expected levels' (GELs) are to provide a benchmark against which unacceptable contamination of food can be identified and provide a trigger for remedial action if the GEL is exceeded. Maximum limits set the maximum residue limits allowed in food; and
2. The data is assessed against historical data obtained for *Telescopium* sp. in Darwin Harbour in 1990 (Peerzada *et al*, 1990) and 2013 (French, 2013). This data was collected in order to establish natural background levels of ten metals/metalloids (aluminium, iron, manganese, mercury, nickel, arsenic, cadmium, chromium, zinc and selenium) in the mud whelk to assess any potential pollution in the harbour area. Trigger values are available for four of these ten metals/metalloids.

This collection and analysis of mud whelk lipid content is an indicator of physiological condition.

8.2 Updates to the Environmental Impact Monitoring Program

8.2.1 Refinement of Monitoring Locations and Frequencies

A number of new monitoring transects were established in 2015 (BPMC24, 25, 26, 27, 28, 29 and CSMC03 and 04) to monitor potential impacts on mangrove community health from Site activities and discharges. The locations of these transects were identified as indicative in EIMP (Rev 6) and the final locations are provided in this EIMP.

Mangrove community health monitoring (e.g. tree condition, canopy cover) will continue at BPMC05 to BPMC07 to evaluate potential recovery of the mangroves following a known mud wave recorded in this area in June 2013. Sedimentation, sediment quality and bio-indicator monitoring are not required because these are not indicators of mangrove recovery. Monitoring at these locations will continue until July 2017.

If impacts at mangrove monitoring locations along the GEP arise (e.g. ASS mobilisation through the groundwater expression pathway), these will start to manifest in the 2016 dry season because of groundwater transit times (AEMR [2016]). Therefore, monitoring of the mangrove sites along the GEP corridor is required until April 2017 (i.e. the end of the 2016/17 wet season) because this would provide sufficient time to detect any potential groundwater impacts from ASS mobilisation. Following evidence that no adverse impacts have occurred monitoring sites BPMC27 to BPMC29 will be removed from the EIMP. The projected date for their removal is the second quarter of 2017 subject to the provisions in **Chapter 5**.

8.2.2 Frequency of Bio-indicator Monitoring

The frequency of bio-indicator monitoring increased from bi-annual to quarterly sampling, in response to elevated metal concentrations detected in June 2014 onwards². The risk pathway for elevated metals is still present (e.g. groundwater expression into the fringing mangrove community) and therefore the EIMP has been updated to reflect this monitoring frequency and provide increased resolution of the dataset and allow seasonal variations of metal concentrations in bio-indicators to be determined.

This change will be done in accordance with the process outlined in **Chapter 5**.

² These elevated metals concentrations were identified, assessed and reported to the NT EPA as part of AEMR (2015).

8.3 Mangrove Trigger Values

8.3.1 Overview

The trigger values set out in **Table 8-1** will apply to the mangrove monitoring program. The identification of background conditions specifically in relation to mangrove community health, sediment and bio-indicators, is described further in **Section 8.5.2**.

Table 8-1 Mangrove Monitoring Trigger Values

Monitoring Parameter	Trigger Value	Application of Trigger Value	Comments
Mangrove and benthic community health	30% reduction ¹ in canopy cover, tree condition (including pneumatophores) and fauna burrows.	30% reduction in canopy cover, tree condition (including pneumatophores) and fauna burrows.	Fauna burrow density represents an early indicator of potential impact to benthic community health. Fauna burrow density may naturally decline by up to 30% during the wet season, hence high variability determines the trigger value.
Sediment deposition and erosion	5 cm increase/decrease in ground level, averaged over 1 m ² and a 12 month period and/or evidence of 5 cm sediment (veneer) deposition from mini-cores and comparison to reference sites.	Sediment height trigger values applied to the variation (>5 cm) in sediment height over a 12 month period. Sediment veneer deposition trigger values are applied to the variation (>5 cm) in veneer over a 12 month period in comparison to control sites.	In terms of potential sediment smothering or erosion impacts, an increase/decrease of 5 cm in ground level (indicating 5 cm of sediment deposition/erosion) within a 12 month period is appropriate as it is not possible to accurately account for factors such as the rate of sediment deposition or erosion and the type of sediment deposited (e.g. sand versus finer material such as clay/silts).
Sediment quality (metals and hydrocarbon concentration)	Exceedance of ANZECC Guidelines.	Trigger values applied to the quarterly laboratory results.	In the absence of site-specific data, the ANZECC Guidelines are used in the first instance as a guide to acceptability. In the event of an exceedance, Site conditions and reference site data are used to guide further actions.
Bio-indicators	Exceedance of the FSANZ (2005) GELs for molluscs.	Trigger values applied to the bi-annual laboratory results (wet weight).	In the absence of site-specific data, the FSANZ (2005) interim sediment quality guidelines are used in the first instance as a guide to acceptability.

¹ A 30% reduction means a 30% decrease relative to the background data collected in June 2012 and seasonal canopy cover, which is gauged from a comparison of impact sites and reference sites.

Exceeding the trigger value does not necessarily mean that adverse biological effects will occur, but further investigations are undertaken to determine cause (Simpson *et al.*, 2005).

8.3.2 Sediment Quality

The trigger values in relation to sediment quality are set out in **Table 8-2**.

Table 8-2 Sediment Quality Parameters and Trigger Values

Parameter	Detection Method	Trigger Values		Reference
		ISQG Low mg/kg dry wt	ISQG High mg/kg dry wt	
Antimony	Laboratory	2.0	25	Australian and New Zealand guidelines for fresh and marine water quality (ANZECC 2000)
Arsenic	Laboratory	20	70	
Cadmium	Laboratory	1.5	10	
Chromium	Laboratory	80	370	
Copper	Laboratory	65	270	
Lead	Laboratory	50	220	
Mercury	Laboratory	0.15	1	
Nickel	Laboratory	21	52	
Silver	Laboratory	1	3.7	
Zinc	Laboratory	200	410	

8.3.3 Bio-indicators

The trigger values that apply to the assessment of bio-indicators (mud whelks) are set out in **Table 8-3**.

Table 8-3 Mud Whelk Trigger Values

Parameter	Detection Method	Trigger Value mg/kg (wet weight)	Reference
Arsenic	Laboratory	1	Food Standards Australia New Zealand (2011)
Cadmium	Laboratory	2	
Lead	Laboratory	2	
Mercury	Laboratory	Mean of >0.5	

8.4 Monitoring Sites

8.4.1 Impact Sites and Reference Sites

Mangrove community health, sediment quality and bio-indicator monitoring locations are outlined in **Figure 8-1**.

The three main mangrove assemblages, namely: the hinterland margin, the tidal flat and the tidal creek (**Figure 8-2**) are monitored via the following monitoring locations:

- Twenty impact sites with transects fringing the boundary of the Site. Each transect comprises one survey plot and numerous survey points for monitoring changes in topographic elevation and sedimentation; and
- Four reference sites with transects at locations in the Middle Arm area. Each transect comprises three survey plots. These sites were selected to allow for comparison of the results recorded at the impact sites.

The transects are located perpendicular to the Site and measure the movement or changes in distribution of habitat-specific species communities, offer the opportunity to correlate those changes with sedimentation measurements and provide a description of overall community structure. In contrast, the establishment of the monitoring plots allow for a discrete community description and provides opportunity for detailed measurement of localised parameters.

The impact sites have been located at:

- Expected outflow or high risk sites at, or adjacent to, areas where current construction and development activity is occurring and may potentially result in sedimentation and impacts on water quality; and
- Expected outflow or high risk sites at, or adjacent to, sites where development activity is expected to occur within the following two years. These sites monitor the effects of future works and provide localised baseline data.

In establishing the impact sites, the following factors were considered:

- Prevailing water currents and potential for contamination of the impact sites by activities unrelated to the Project;
- Potential for data skewing associated with other land uses in the vicinity; and
- Site access.

Reference sites have been established in areas representative of the impact sites but in locations not anticipated to be affected by the Project, or by other localised external influences such as urban development or industry. They have been established to provide a reference point to assess monitoring data in a location exposed to annual environmental or seasonal variation, such as drought, excessive rainfall etc. which baseline measurements may not be able to account for.

In the longer term, reference sites may also be used to measure the success of rehabilitation and revegetation efforts. Reference sites reflect the attributes of sites selected for mangrove community health data collection including:

- Predominant species or species mix in mangrove community – representative of all communities impacted by development;
- Age structure and location in mangrove community stream order;
- Prevailing water current strength and direction, including the potential for influence by development external to the Project; and
- Aspect and bathymetric criteria.

The reference and impact site locations as from the EIMP approval date are identified in **Table 8-4** and **Table 8-5**.

Table 8-4 Mangrove Monitoring – Impact Sites

Transect ID	Details	Starting Point ID	Easting (m)	Northing (m)
BPMC01	Located on the western boundary of the Site adjacent to the Causeway.	1001	708859.45	8613853.47
BPMC05	Located on the western boundary of the Site adjacent to the Flare Pad.	5001	708347.00	8614708.00
BPMC06	Located on the western boundary of the Site adjacent to the Flare Pad.	6001	708203.85	8614976.58
BPMC07	Located on the western boundary of the Site adjacent to the Flare Pad.	7001	708479.00	8615099.00
BPMC08	Located on the western boundary of the Site adjacent to the Tank Flare	8001	707935.69	8615216.94
BPMC09	Located on the northern boundary of the Site adjacent to the Tank Flare	9001	707794.16	8615486.20
BPMC10	Located on the northern boundary of the Site adjacent to the Jetty	10001	708134.82	8615674.51
BPMC11	Located on the northern boundary of the Site adjacent to the MOF	11001	708754.14	8616229.03
BPMC16	Located on the eastern boundary of the Site adjacent the LNG trains	16001	709160.69	8615381.51
BPMC17	Located on the eastern boundary of the Site adjacent the Power Generation Area	17001	709269.73	8615118.92
BPMC20	Located on the eastern boundary of the Site adjacent to the Causeway	20001	709285.11	8614019.55
BPMC21	Located on the eastern boundary of the Site adjacent to the Causeway	21001	708916.08	8613728.88
BPMC22	Located on the eastern boundary of the Site adjacent to the Combined Operations Complex	22001	708661.25	8613228.39
BPMC23	Located on the eastern boundary of the Site adjacent to the Combined Operations Complex	23001	708602.83	8612626.00
BPMC24	Located on the western boundary of the Site adjacent to the Flare Pad	24001	708802.00	8614247.00
BPMC25	Located on the western boundary of the Site adjacent to the Tank Flare	25001	708060.68	8615273.16
BPMC26	Located on the northern boundary of the Site adjacent to the MOF	26001	708828.01	8616073.00
BPMC27	Located on the western boundary of the Site adjacent to the GEP	27001	706100.00	8611935.00
BPMC28	Located on the western boundary of the Site adjacent to the GEP	28001	705730.00	8612288.00
BPMC29	Located on the western boundary of the Site adjacent to the GEP	29001	705560.00	8612814.00

Table 8-5 Mangrove Monitoring - Reference Sites

Transect ID	Details	Starting Point ID	Easting (m)	Northing (m)
CSMC01	Located to the east of the Site	C1001	712726.55	8612493.75
CSMC02	Located to the west of the Site	C2001	705229.36	8614131.60
CSMC03	Located to the west of the Site	C3001	703948.86	8614703.41
CSMC04	Located to the south of the Site	C4001	710002.00	8608188.00



- Site Boundary
- Mangrove Transects
- Gas Export Pipeline
- Mangrove Transects (Reference Sites)

Mangrove Monitoring Locations

**Figure
8-1**

**INPEX
Bladin Point**



Date: 30/08/2016

Author: malcolm.nunn

Map Scale: 1:35,000

Revision: A

Coordinate System: GDA 1994 MGA Zone 52

INDRA
05 DEC 2016

No warranty is given in relation to the accuracy, reliability, completeness or suitability and accept no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of or reliance upon the data. Data must not be used for direct marketing or be used in any way for any purpose other than that for which it was provided.

R:\Projects\2008\INPEX\GIS\Maps\BP_EIMP\9FIG_8_01_Mangroves_160830.mxd

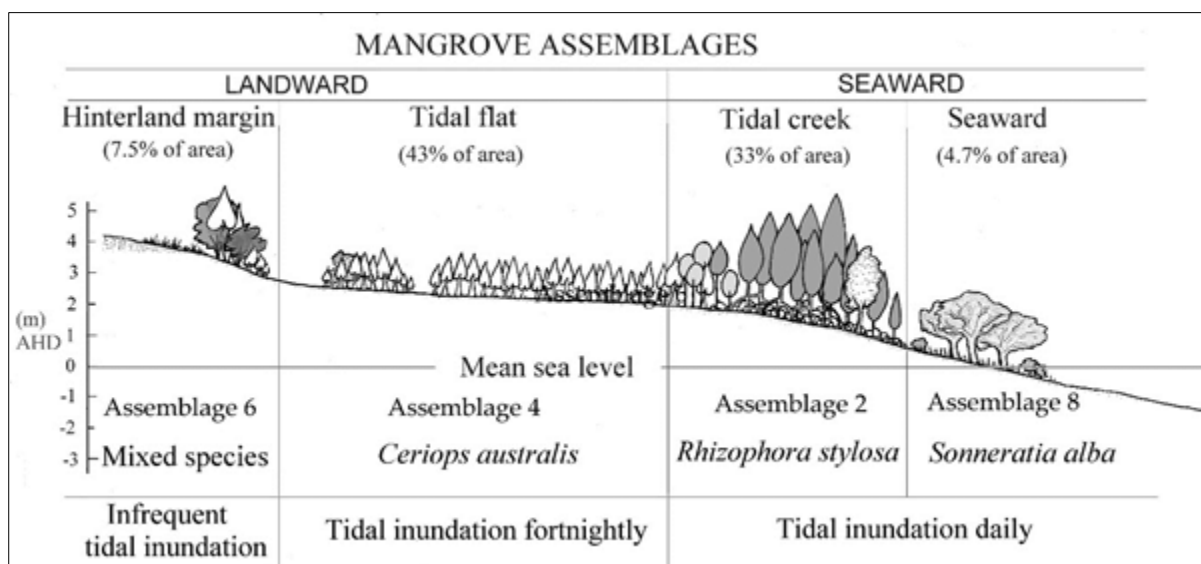
8.5 Monitoring Approach and Methodology

Mangrove community health, sediment quality and bio-indicator monitoring is undertaken in accordance with the methods outlined in the CEMP. The key indicators for the quarterly monitoring program are measured within permanent 10 m x 10 m monitoring plots (divided into four 5 m x 5 m quadrants) and 1 m x 1 m quadrats and comprise:

- Seedlings – measured in each of the three permanent 1 m x 1 m quadrats adjacent to each survey plot;
- Canopy cover – measured in each of the four survey quadrants;
- Tree condition – measured in each of the four survey quadrants;
- Pneumatophores – measured in each of the three permanent 1 m x 1 m quadrats adjacent to each survey plot;
- Benthic community health (fauna burrows) – measured in each of the three permanent 1 m x 1 m quadrats adjacent to each survey plot;
- Photo-monitoring – four digital images taken at fixed points;
- Sediment height – measurement of sedimentation/erosion by recording relative ground levels at four fixed reference markers (survey plot corner posts) and ground level disturbance is monitored at a series of survey points along each transect;
- Sediment quality – assessment of sediment particle size distribution, moisture content, total metals, bio-available metals and hydrocarbons (where required) within sediments potentially impacted by sediment deposition and/or ASS disturbance; and
- Bio-indicators – analysis of mangrove molluscs *Telescopium telescopium* (mud whelk) tissue for bio-accumulation of heavy metals and hydrocarbons (where required).

8.5.1 Assemblages, Transects, Study Plots and Quadrats

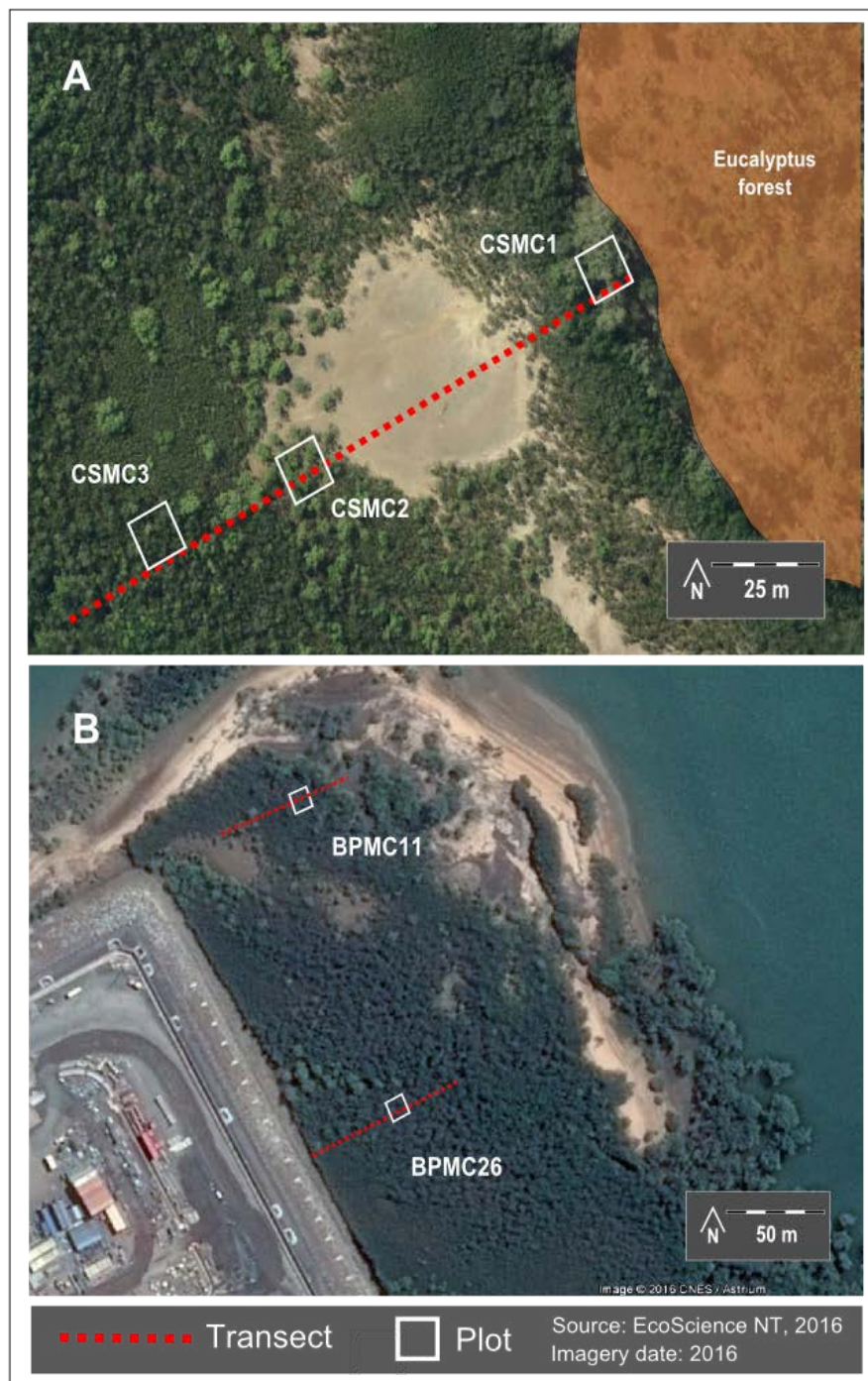
Twelve distinct types of mangrove community have been defined and mapped in Darwin Harbour and are termed 'assemblages/zones' by Brocklehurst and Edmeades (1996). Four of these, the hinterland margin, tidal flat, tidal creek and seaward, accounted for approximately 80% of the total mangrove area. The pattern of zonation generally evident in Darwin Harbour and the relationship between these assemblages and tidal elevation is shown in **Figure 8-2** (after Metcalfe, 2007).



Source: Metcalfe (2007).

Figure 8-2 Zonation of Mangroves in Darwin Harbour

For the majority of monitoring sites, transects are established from the landward mangrove margin for a variable distance into the mangroves in a seaward direction. Remaining transects are generally oriented perpendicular to Site construction activities (**Figure 8-3**). Transects are marked with flagging tape and the location of fixed survey points identified with numbered metal tags. A permanent 10 m x 10 m survey plot has been established along each transect within one (or more) of the three most landward assemblages – the hinterland margin, the tidal flat and the tidal creek.



A = Reference sites
B = Impact sites

Figure 8-3 Typical Orientation of Transects and Survey Plots

Each 10 m x 10 m monitoring plot is divided into four 5 m x 5 m quadrants (indicated by a red dotted line on **Figure 8-4**). During routine monitoring the following measurements are obtained from each survey plot:

- Three random replicate canopy cover measurements (depicted by brown ovals) in each of the four quadrants (n= 12);
- Assessment of tree and foliage condition (colour, turgidity, dust cover) within each of the four quadrants;
- One photograph taken from the centre of the survey plot facing each of the four corner posts (n= 4);
- Sediment quality, including pH, is obtained from one location in each survey plot and veneers within each of the four quadrants;
- Bio-indicators (when present) are obtained from within each survey plot; and
- Four replicate sediment height measurements (depicted by blue arrows) collected around each of the four corner posts (n= 16).

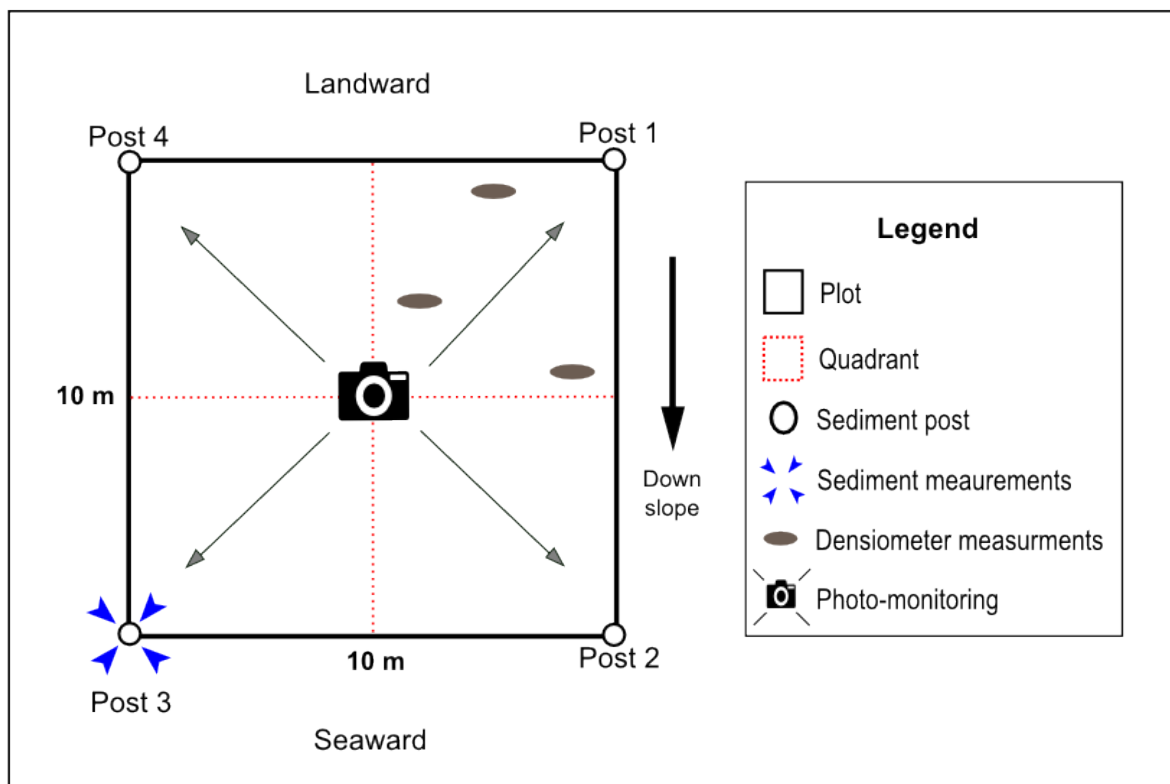


Figure 8-4 Schematic Representation of a Survey Plot

Three permanent 1 m² quadrats have been established adjacent to each survey plot to monitor seedlings, pneumatophores and fauna burrows. Monitoring of three permanent quadrats occurs outside each survey plot to avoid disturbance through trampling. During each quarterly survey a photograph is taken of each of the three 1 m² quadrats per location and these photo-monitoring images are used to gauge and document any major changes in these indicators.

8.5.2 Establishment of Background Conditions

The establishment of background conditions provides a reference point against which mangrove health monitoring data is measured. As a result of this process, a comparison can be made between the potential impacts of the Project and conditions which are naturally occurring. The monitoring program has utilised existing field baseline data from June 2012 to assess any potential mangrove impacts associated with the Project.

Land-based baseline data is drawn from:

- Interpretation, analysis and extrapolation of baseline data and archival data collected for the Project under the current mangrove community health monitoring program; and
- The NEMP.

Land-based baseline data provides a standard measurement for each of the discrete mangrove communities in a given ecological niche for each of the mangrove community health parameters that are measured.

8.5.3 Mangrove Community Health Field Survey Data Collection

8.5.3.1 Base Data

The following base data is recorded at each monitoring plot at impact and reference sites:

- Date and time;
- Collector(s);
- Transect /plot identification;
- Tide (high/low/coming in/going out); and
- Observations and comments.

8.5.3.2 Community Structure

Community structure provides an overview of the context in which the various mangrove community health parameters are measured. Changes in community structure may be triggered by adverse environmental conditions.

Upon establishment of each plot, community structure will be recorded including:

- Assemblage;
- Community description including upper, mid and lower strata;
- Species present; and
- Upper, mid and lower stratum height and overall average height.

The initial community structure description will enable comparison should any changes be documented throughout the monitoring project period.

8.5.3.3 Canopy Cover

Monitoring plots provide the opportunity for a detailed analysis and description of the mangrove community. The 'Stricklers' modified densiometer method' (Strickler, 1959) has advantages over the unmodified method, including: more time-effective measurement, and therefore the opportunity for increased replication; minimisation of the risk of double counting some parts of the canopy; and emphasis of overhead vegetation over foreground vegetation, which is the main source of bias in canopy cover measurements (Ode, 2007). Additionally, mounting the instrument on a tripod is more consistent than holding the instrument at a nominal waist height (Burres, 2010), and allows accurate measurement of low canopy communities.

8.5.3.4 Tree Condition

Changes in foliage condition and pneumatophore condition may indicate changing environmental conditions. The following methods are applied:

- Foliage condition (visual examination):
 - o Colour – may indicate nutrient stress, water stress or gaseous stress
 - o Damage and agent
 - o Defoliation- foliage loss
 - o Turgidity – loss of turgidity may indicate water stress resulting from chemical or physical stresses including:
 - Osmotic potential/changed water relations
 - Sedimentation and deoxygenation
 - Acidification or changed salts component
 - o Dust cover – dense dust can impede photosynthesis and the presence of dust on the foliage may also indicate a past air borne plume.
- Pneumatophores:
 - o Within each plot, three permanent 1 m² quadrats are established to monitor pneumatophores. Attributes surveyed during pneumatophore density estimations include height, any morphological aberrations such as forking or their adventitious growth off stems (e.g. Getter *et al.*, 1985), along with algal growth. A photographic record is also collected to allow temporal comparisons to be made. Change in pneumatophores may occur due to hydrocarbons, siltation, oxygen deprivation, dysfunctional gas exchange, altered water relations or mechanical damage and act as an early indicator for change in mangrove community health. Predominant use of the data is the pneumatophore height and growth aberrations. Height increases in the short term, within a specific site, are a result of oxygen deprivation via extended submersion periods or erosion of the substrate, the latter being easily detected by the visibility of cable roots. Height decreases usually occur as a result of sedimentation. The trigger value set against this attribute is used in conjunction with height observations to act as a trigger to indicate the need for further investigation, part of which is a comparison of the photographic records. As noted by Stubbs and Saenger (2002), healthy mangrove communities do not display twisting and curling of pneumatophores and several studies have noted that this is observed after environmental stresses, particularly oil pollution (Böer, 1993) or periods of extended flooding (Allaway *et al.*, 2002). Therefore the presence of any pneumatophore aberrations in monitoring plots are used as an indicator for stress to initiate further investigations.

8.5.3.5 Photo Monitoring

Photo-monitoring provides a visual record of a community's appearance at the time of data collection. It can be readily and easily compared with photographs taken on other occasions to visually support data that indicates an increase or decline in community health.

At each plot, photo-monitoring are carried out as follows:

- From each cardinal point across centre point towards opposite cardinal point; and
- Each photo monitoring photograph includes a whiteboard status board indicating transect and plot number and direction of photograph.

8.5.3.6 Benthic Mangrove Community Health

Within each site, on a quarterly basis three 1 m² quadrats are randomly placed to count fauna burrows in the substrate. High numbers of burrows indicate that the habitat is able to support a large abundance of individuals indicating high ecological productivity. A reduction in fauna burrows within or across monitoring plots may reflect changes in other parameters such as siltation, sediment quality and water quality.

8.5.3.7 Sedimentation and Erosion

To monitor for potential sedimentation/erosion and mud wave effects that may arise from construction activities, a series of ground level profiles (as transects) are surveyed on the tidal flats adjacent to the Site. Depending on the location of particular transects, some would extend from the Site boundary across the tidal flats and to the tidal creek or seaward edge of the mangrove zone. Transects include survey points within the monitoring sites.

Monitoring consists of Real Time Kinematic (RTK) GPS surveying of ground levels along transects that extend through the mangrove zone. Each transect comprises a series of points where the horizontal position coordinates and ground surface levels (AHD reduced level) are obtained during the background survey period and then re-surveyed annually during construction to determine if any significant changes to ground surface levels had occurred that may indicate sediment deposition or erosion. Additional surveying may be required if mud waves develop in mangroves outside of the Site boundary.

Surveying contractors estimate that, for RTK GPS equipment in good conditions (good satellite geometry and open country), the expected horizontal measurement precision is ± 0.02 m (2 cm) and the expected vertical measurement precision is ± 0.025 m (2.5 cm). This estimate is made on the basis of the manufacturer's specifications. Where mangrove canopy cover exceeds 90%, an extendable pole is used to ensure measurements can be taken. The accuracy and precision of the GPS equipment is assessed in the field. Due to the low vertical accuracy of the GPS, exceedances identified by this method are confirmed through collection and analysis of mini-cores.

Relative ground levels are recorded at the monitoring sites to monitor for potential accumulation of sediment or erosion in the mangrove ecosystem. Sediment accumulation has the potential to cause mangrove stress if the depositing material accumulates in excess of natural sedimentation rates and to sufficient depths to bury the aerial root system. At each monitoring site, the plot corner markers (painted star pickets, PVC pipes or similar firmly entrenched in the ground) serve as sediment height reference markers and sediment heights are recorded relative to each corner marker by measuring the vertical distance between the top of the corner marker and the ground, with a tape measure. The overall ground level for a site during a sampling event is calculated as the mean of the four readings recorded in each plot.

This data is collected on a quarterly basis at the same time as monitoring mangrove health. Observational data on the presence of foreign sediment veneers that may be deposited over the existing mangrove muds are collected during the quarterly surveys. Evidence for this occurring would be the deposition of terrestrial silt/clay veneers of a different colour or texture over existing mangrove substrates, or increases in sediment heights/ground levels. Should such veneers be evident then a series of cores of the top 10 cm of substrate is collected to characterise the nature and depth of the veneers.

8.5.3.8 Sediment Quality

The identification of possible anthropogenic influences on coastal systems through the measurement of metals and hydrocarbons accumulated within the sediment has been successfully applied in coastal environments (Chapman and Wang, 2001; Guerra-Garcia and Garcia-Gomez, 2004; Mucha *et al*, 2005). This method is based on the determination of naturally-occurring metal and hydrocarbon concentrations, usually referred to as background and/or reference data. Possible contamination from routine operations or spills can then be assessed through comparison measurements with these background data.

Because many metal species bind preferentially to the finer particle fractions in sediments (Batley 1995), naturally high concentrations of metals are found to be prevalent in sediments where the total amount of sediment particles that are small (clay and silt grain size) exceed the amount of sediment particles that are large (grain size >63 µm, sand and gravel) (Guerra-Garcia and Garcia-Gomez, 2004). Therefore, a sediment quality assessment generally involves the determination of measurement of metal concentrations and of grain size distribution to differentiate between natural variability and external inputs.

Background monitoring of metal and hydrocarbon concentrations and particle size distribution in mangrove sediments is done to ascertain background concentrations so that potential contamination from either routine operations or spills could be assessed in the future through comparison with results.

Within each mangrove monitoring plot a sample of sediment from the mudflat surface is collected for metal and hydrocarbon analysis in a subplot of 1 m x 1 m. By using a sterile wooden surgical spatula, the sediment surface (top 1 cm to 5 cm) is scraped and the scraped material is directly transferred into a whirlpak bag (for metal analysis) or into a solvent washed jar (for hydrocarbon analysis). Disposable latex gloves are worn to prevent contamination of the sample.

Sample preservation, storage, transport, data validation and analytical methods are determined in consultation with the relevant laboratory.

Laboratory analyses are undertaken to determine:

- Grain size distribution;
- Concentrations of the total and bio-available metal and metalloid analyses including arsenic, cadmium, chromium, cobalt, copper, lead, mercury, nickel, silver, vanadium and zinc;
- Concentrations of TRH and polycyclic aromatic hydrocarbons (PAH) when required (e.g. following a hydrocarbon spill); and
- Organic carbon in the sediment to allow standardisation of hydrocarbon data (silica gel clean up).

8.5.3.9 Bio-indicators

All attempts are made to collect mud whelks from all the transects however, due to the alignment of the Site boundary, mangrove zones where mud whelks occur may not always be present. Mud whelks are collected under a Research Permit issued under Section 17 of the *Fisheries Act 2011* (NT).

Approximately 12 large (adult size) mud whelks (*T. Telescopium*) will be collected at each plot and contained in a large Whirlpak™ bag which will then be placed inside a press seal bag and stored on ice. All attempts will be made to collect mud whelks however, due to the alignment of the Project boundary, mangrove zones where they occur may not always be present. Therefore, the number of individuals collected depends upon their presence and abundance at the time and/or seasonal changes.

Quarterly sampling of mud whelks are used to determine the metals concentrations (see **Table 8-7**). Hydrocarbon analyses is included unless an event such as a spill occurs that would trigger the need for hydrocarbon analyses to be included.

The whirlpak bag is placed inside a press seal bag and stored on ice. No mud whelk tissue material is to be extracted from the mud whelk shells during the field survey (this occurs during laboratory analysis). The snail inhabiting the shells typically retracts back into the inner parts of the shell once collected and placed into the whirlpak bags, thus minimising any potential for contamination through contact with the plastic.

A summary of the mangrove monitoring approach as from the EIMP approval date is provided in **Table 8-6**.

Table 8-6 Mangrove Monitoring Summary

Frequency	Monitoring Methodology	Monitoring Parameters	Locations
Quarterly (March, June, September and December)	An assessment is done on the health of mangrove communities through comparison of reference site data on parameters including canopy cover, tree condition and benthic community health. Photographs of mangrove condition are taken from standard reference points at monitoring sites. Sedimentation, sediment quality and bio-indicator monitoring are not required in this program. The purpose of the program is to monitor mangrove recovery and these parameters are not indicators of mangrove recovery.	Community structure: - species height class/age class/life form and seedling recruitment and mortality. Canopy cover: - projected canopy cover. Tree condition: - canopy condition class; - foliage condition (colour, damage and agent, turgidity, dust cover); and - pneumatophores (number, size, visual record). Photo monitoring (visual record of a community's appearance). Benthic mangrove community health: - fauna burrows.	BPMC05 to BPMC07
Quarterly (March, June, September and December)	An assessment is done on the health of mangrove communities through comparison of reference site data on parameters including canopy cover, tree condition and benthic community health. Photographs of mangrove condition are taken from standard reference points at monitoring sites. Sediment samples are collected from the top 1 to 5 cm of sediment within intertidal areas using a sterile scoop. If potential impacts are observed (e.g. discoloured surface sediments might indicate acid leachate is occurring), a sample may be collected for determination of pore water quality, acid soluble metals and/or acid volatile sulphides to determine the level of risk posed by the sediment. This is supported by cores to investigate the presence and thickness of veneers of different material overlying the mangrove substrates. Elevation of marker stakes are measured to determine the effects, if any, on ground surface. Data is assessed for trends and against reference sites	Community structure: - species (including weed species), height class/age class/ life form; and seedling, sapling and tree recruitment and mortality. Canopy cover: - projected canopy cover. Tree condition: - canopy condition class; - foliage condition (colour, damage and agent, turgidity, dust cover); and - pneumatophores (number, size, visual record). Photo monitoring (visual record of a community's appearance). Benthic mangrove community health: - fauna burrows. Sedimentation, erosion and sediment quality: - bio-available metals analysis including antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver and zinc; - TRH (when required); and - change in ground level and veneer deposition.	BPMC01, BPMC08 to BPMC11, BPMC16, BPMC17, BPMC20 to BPMC09 and CSMC01 to CSMC04
Quarterly (March, June, September and December)	<i>Telescopium telescopium</i> (mud whelks) are collected and analysed for bio-accumulation of metals. The start and end points of mud whelk distribution along each transect is recorded with GPS coordinates.	Concentrations of arsenic, cadmium, lead and mercury in molluscs.	
Annually (June)	Sediment depth is monitored by relative elevation of sediments measured by surveyed benchmarks.	Sediment depth.	

8.5.4 Sample Preservation, Storage and Transport

Sediment and mud whelk samples are handled with clean, decontaminated tools and/or dedicated disposable nitrile gloves. All samples (with the exception of metals) are kept on ice during field work and mud whelk samples are transferred to a freezer as soon as practicable. At the completion of the field survey, all sediment and mud whelk samples are transported to the relevant laboratory and packed in insulated containers with freezer bricks.

The unique sample code for each sediment and mud whelk sample is recorded on a field data sheet and entered onto a CoC form. Field data sheets are retained for sample cross-referencing.

8.5.5 Laboratory Analyses

Methods of analysis of sediment and mud whelk tissue are shown in in **Table 8-7** below.

Table 8-7 Laboratory Analytical Methods for Sediment and Mud Whelks

Analysis	Laboratory	Limit of Reporting	Method Description
pH, total metals and bio available metals in sediment (Ag, Al, As, Cd, Co, Cu, Cr, Fe, Mn, Hg, Ni, Pb, Sb, V and Zn)	Eurofins (Darwin)	0.1-10 mg/kg	1M HCl (bio-available metals)
TRH and PAH in sediments	Eurofins (Darwin)	0.1 mg/kg	Extraction with acetone/hexane
Metals in mud whelk tissue: Al, As, Cd, Cu, Cr, Fe, Mn, Hg, Ni, Pb, Zn (wet weight).	Analytical Reference Laboratory (ARL) (Perth)	0.1-0.5 mg/kg	Nitric/Hydrochloric acid / Hydrogen Peroxide digestion ASTM 1994 D 3974-90 Atomic Absorption Spectroscopy / ICP- OES NEPM Method No 201, EPA Method 3120 AAS – Cold Vapour Generation ASTM D 3223-95, APHA 3112 B, EPA SW-846 Method 7471A, Varian VGA-77 Publication No 85 101047 00 AAS – Vapour Generation - APHA, 3030 F, 3114, Varian VGA-77, Publication No 85 101047 00 AAS – Vapour Generation - APHA, 3030 F, 3114, Varian VGA-77, Publication No 85 101047 00
TPH and PAH in mud whelk tissue (wet weight)	ARL (Perth)	TPH: 40 µg/kg PAH: 5 µg/kg (individual compounds)	Aqueous alkaline digestion, extraction with hexane, liquid-liquid partitioning with water and sodium sulfate, hexane extracts concentrated K-D evaporator.

The following analyses are undertaken:

- Moisture content of sediment and mud whelks at each site, determined during sample processing; and
- Lipid content of mud whelks at each site, determined using a Soxhlet extraction/gravimetric method.

These additional analyses are carried out to provide data to be used in the future to assess differences in contaminant concentrations between sites and between surveys.

Establishing the moisture content of the sediment and bio-indicators enables the metal concentrations, which are reported on a dry weight basis, to be converted to a wet weight basis for comparison with national food standards (FSANZ, 2005).

The analysis of lipid content was included as an indicator of physiological condition as it may influence the levels of both metals and hydrocarbons in mud whelks. Examples of these processes can be found in various literatures, affecting invertebrates and vertebrates alike (e.g. Connell, 1974).

8.5.6 Field Quality Assurance and Quality Control

Sediment and mud whelk QA/QC samples are collected in accordance with ANZECC Guidelines and include the following:

- One duplicate sample collected per 10 primary samples for mud whelk samples, and one duplicate sample collected per 20 primary samples for sediment quality samples;
- One triplicate sample collected per 20 primary samples;
- One rinsate sample collected per sampling round; and
- One field blank sample collected per sampling round.

8.5.7 Laboratory Quality Assurance and Quality Control

The data is reviewed as part of the ESDAT database system for conformity with QA/QC principles and methodologies. ESDAT is an environmental data management, analysis and reporting software program for environmental data. Any inconsistencies or inadequacies are presented together with the analytical results. The QA/QC procedures used during analyses for organic and metal contaminants were reviewed by NATA in November 2009 and meet NATA 17025:2005 and ISO 9001 accreditation parameters. In addition, their laboratory QA/QC procedures are reviewed by external consultants on an annual basis.

Method blanks are processed and analysed in the same way as the mud whelk tissue samples, the aim being to detect any contamination resulting from sample preparation, extraction or analysis. After each batch of samples is analysed, a blank sample is run to see if this returns a value below or near the detection limit of the analytical technique.

The samples are split into sub-samples, to check the precision of the analyses at a duplication of 10%.

Surrogate spikes are undertaken, with one sample in every batch spiked. A known quantity of a surrogate is added to each sample prior to extraction, the quantity of surrogate recovered after the analytical process provides a measure of analytical performance.

Matrix spikes are undertaken, with one sample in every sample batch spiked. Spiking of mud whelk samples is analysed for metals where samples are spiked using standard solutions of the metal analysed. As a known quantity of the analyte is added to each sample prior to extraction, the quantity of analyte recovered after the analytical process provides a measure of analytical performance.

Instruments are calibrated daily, with a calibration curve produced from the analysis of one blank and three standards. The concentrations of the standards cover the range of concentrations expected to be found in the samples to be analysed.

9. AIR QUALITY

9.1 Summary of Compliance Requirements

Dust monitoring undertaken in accordance with the EIMP meets the compliance requirements set out in the following legislation, policies, guidelines and approval requirements associated with the Project.

9.1.1 Legislation

The Commonwealth's *National Environment Protection Council Act 1994* (NEPC Act), and complementary State and Territory legislation, allows the National Environment Protection Council to make National Environment Protection Measures (NEPMs), which set out national objectives designed to assist in protecting or managing particular aspects of the environment.

NEPMs can be made about a variety of environmental matters including ambient air quality. The *National Environmental Protection (Ambient Air Quality) Measure 1998* (Cth) (as amended July 2003) (NEPM [1998]) is designed to set out a goal that relates to the desired environmental outcomes and that guides the formulation of strategies for the management of human activities that may affect the environment. The desired environmental outcome of NEPM (1998) is ambient air quality that allows for the adequate protection of human health and well-being.

9.1.2 Policies and Guidelines

There are no established NEPM criteria for the assessment of dust deposition or other applicable Northern Territory guidelines.

The New South Wales Office of Environment and Heritage has adopted the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (Department of Environment and Conservation NSW, 2005). This document sets out criteria for dust deposition, expressed as g/m²/month above background level, and has been adopted for the Project.

The NEPM (1998) sets out criteria for PM₁₀, expressed as µg/m³ for the daily (24 hr) average, which have been adopted for the Project.

9.1.3 Approval Requirements

The CEMP sets out a number of objectives, targets and indicators that apply to the dust monitoring program and these have been incorporated into the program.

9.2 Updates to the Environmental Impact Monitoring Program

9.2.1 Refinement of Monitoring Locations

In accordance with EIMP (Rev 6), two new dust monitoring locations were established (BPPM04 and BPDD14). These locations were identified as indicative in the EIMP (Rev 6) and the final locations are provided in this EIMP.

9.2.2 Adjustment of Monitoring Frequency

The EIMP (Rev 6) identified the need to undertake dust mass determination to identify gravimetric K-factors but did not specify how often this should occur. Dust mass determination is undertaken on an annual basis.

9.3 Air Quality Trigger Values

The dust trigger values that apply to the dust monitoring program are summarised in **Table 9-1**.

PM_{2.5} is primarily monitored to assess impacts on human health and has the potential to penetrate deeply into the lung, irritate and corrode the alveolar wall and impair lung function. In addition, PM_{2.5} has the potential to clog stomatal openings of plants and interfere with the functions of photosynthesis which can lead to growth stunting or mortality in some plant species. Particulate quantification for PM_{2.5} is included as part of the total PM₁₀ concentration where the larger fractions also have the ability to cause dust deposition on vegetation and impair photosynthesis and growth.

As PM_{2.5} is included as part of the total PM₁₀ concentration and is primarily used to assess human health risk as opposed to environmental risks, the requirement to monitor for PM_{2.5} has been removed from the EIMP.

For the purposes of the Project, PM₁₀ is monitored to assess potential impacts on environmental and human health receptors. Accordingly, the assessment of PM₁₀ monitoring results against the trigger value was focussed on Palmerston and the Bladin Central Enterprise Park as the closest residential receptors to the Site.

Dust deposition monitoring locations within the Site provide data on potential impacts on the mangrove community fringing the Site and comparative data for dust deposition monitoring at Palmerston.

Table 9-1 Dust Trigger Values

Parameter	Values	Reference
PM ₁₀	Daily (24 hour) average of 50 µg/m ³	<i>National Environment Protection (Ambient Air Quality) Measure (2003)</i>
Dust deposition	Annual average of 2 g/m ² /month above background level. Where there is no background level measured, the Project applies the appropriate variation to this value of 4 g/m ² /month in accordance with the methodology.	New South Wales Department of Environment and Climate Change, <i>Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (2005)</i>

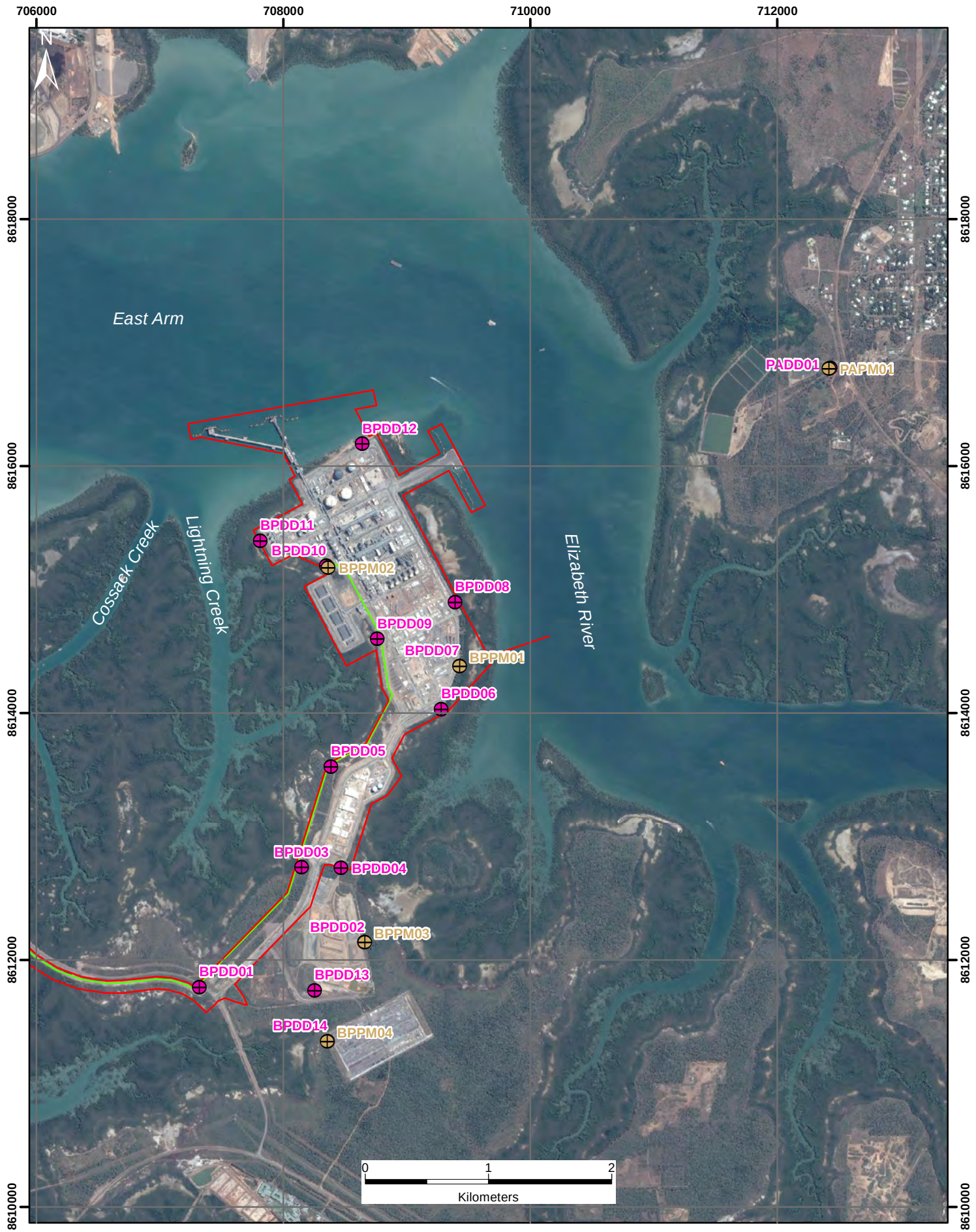
9.4 Monitoring Sites

Dust monitoring is undertaken at the locations in **Table 9-2** and **Figure 9-1**.

Table 9-2 Dust Monitoring Locations

Monitoring Point	Co-ordinates (GDA 1994; Map Zone 52)		Details	Rationale
	Easting (m)	Northing (m)		
Dust Deposition Monitoring Locations				
BPDD01	707345.00	8611750.00	Wickham Point Road, opposite entrance to access road	Dust deposition stations monitor the rate of deposition of dust in the vicinity of vegetation, especially adjacent mangrove communities.
BPDD02	708658.00	8612140.70	Extractive Minerals Area	
BPDD03	708148.00	8612748.00	Outside western boundary of Site	
BPDD04	708466.00	8612741.00	OPS complex	
BPDD05	708385.00	8613564.00	Outside western boundary of Site	
BPDD06	709279.00	8614028.00	Boundary of Site, south of TOF and temporary facilities area	

Monitoring Point	Co-ordinates (GDA 1994; Map Zone 52)		Details	Rationale
	Easting (m)	Northing (m)		
BPDD07	709428.00	8614378.00	Boundary of Site, east of TOF	
BPDD08	709295.00	8614872.00	Temporary facilities area, north-east end	
BPDD09	708760.00	8614599.00	Boundary of Site, west of temporary facilities area	
BPDD10	708349.00	8615189.00	Western boundary of Site, opposite north end of flare pad	
BPDD11	708024.00	8615385.00	Central tankage flare	
BPDD12	708639.00	8616178.00	Northeast corner boundary of Site, adjacent condensate tanks area	
BPDD13	708252.00	8611751.00	Southern end of extractive minerals area	
BPDD14	708358.60	8611339.13	Southern-most corner of the Site	Dust deposition station monitors potential impacts to the Bladin Central Enterprise Park.
PADD01	712429.87	8616791.40	Larrakeyah Turf Farm	Dust deposition station monitors potential impacts in Palmerston.
PM₁₀ Monitoring Locations				
PAPM01	712421.47	8616788.45	Larrakeyah Turf Farm	Monitoring of PM ₁₀
BPPM01	709428.00	8614378.00	Boundary of Site, east of temporary office facilities	Monitoring of PM ₁₀
BPPM02	708361.80	8615171.20	Western boundary of Site, opposite north end of flare pad	Monitoring of PM ₁₀
BPPM03	708658.10	8612140.70	Eastern boundary of Extractive Minerals Area	Monitoring of PM ₁₀
BPPM04	708356.72	8611337.74	Bladin Central Enterprise Park	Monitoring of PM ₁₀



- Site Boundary
- Gas Export Pipeline
- Dust Monitoring Location (Dust Deposition Sample)
- Dust Monitoring Location (Particulate Matter Sample)



Dust Monitoring Locations		
Figure 9-1	INPEX Bladin Point	
Date: 30/08/2016	Author: malcolm.nunn	
Revision: A	Map Scale: 1:40,000	
	Coordinate System: GDA 1994 MGA Zone 52	

9.5 Summary of Air Quality Monitoring Approach

A summary of the approach to dust monitoring is provided in **Table 9-3**.

Table 9-3 Dust Monitoring Summary

Frequency	Monitoring Methodology	Sample Analysis	Locations
Continuous sampling	PM ₁₀ measurement through near-forward light scattering samplers (E Samplers). Dust mass determination is undertaken.	N/A	BPPM01 to BPPM04; PAPM01.
Monthly	Dust is collected in dust deposition gauges.	Gravimetric dust determination	BPDD01 to BPDD14; PAAD01.
Annually	E-Sampler dust mass determination is undertaken	Gravimetric dust determination	BPPM01 to BPPM04; PAPM01.

9.6 Monitoring Methods

9.6.1 Sampling, Analysis and Data Quality Objectives

As outlined in the CEMP, the objective of dust management for the Project is to minimise adverse impacts from dust generation on the environment and the health of the workforce during construction. The EIMP focuses on the environmental compliance monitoring aspects of dust generation only.

Sampling primarily aims to indicate compliance with the dust criteria. Following interpretation of results, sampling is then used to inform Site personnel in order to trigger specific management actions for dust minimisation. The environmental impacts of dust generation are related to the settlement of dust on the mangrove communities and potential impacts on physiological functioning or survival and are covered in the mangrove chapter of the EIMP (**Chapter 8**).

9.6.2 Rationale

The sampling locations have been selected to target emissions at the Site boundary and at sensitive receptors identified during the impact assessment for the EIS. These receptors include mangrove vegetation, residences at the City of Palmerston and the Bladin Central Enterprise Park.

As outlined in the CEMP, samples for analysis include:

- Dust deposition; and
- PM₁₀.

9.6.3 Detailed Description of the Sampling Methods

Three methods of dust sampling have been developed for the Project:

1. Monthly sampling of dust deposition in accordance with AS/NZS 3580.10.1:2003 *Methods for sampling and analysis of ambient air – Method 10.1: Determination of particulate matter – Deposited matter – Gravimetric method* (AS/NZS 3580.10.1);
2. Continuous sampling and light scatter analysis PM₁₀; and
3. Gravimetric analysis of PM₁₀.

These three methods are described in further detail below.

9.6.3.1 Dust Deposition

Dust deposition sampling is undertaken using the methodology described in AS/NZS 3580.10.1. This involves the installation of dust deposition gauges at monitoring sites. Sampling media deployed at each gauge consists of one four litre glass dust deposition bottle (nominal volume) and a 150 ±10 mm diameter glass funnel. The funnel is supported firmly in the neck of the dust deposition bottle by a plastic stopper with a groove or outlet pipe to allow water overflow under excessive rainfall conditions. Dust deposition bottles are pre-conditioned with approximately 20 mL of copper sulfate solution which acts as a fungicide and does not affect the dust sample results.

The four litre bottle volume is almost four times the maximum monthly rainfall experienced in Darwin, so overflow of the bottle during storm events is not expected to occur.

Sample bottles are retrieved on a monthly basis (for routine monitoring programs, the period of exposure is typically 30 ± 2 days) and submitted to Eurofins (Darwin). Chain of custody documentation is provided with all samples as required by the laboratory and a record of these forms is kept on the ESDAT database.

9.6.3.2 Continuous Sampling and Analysis of PM₁₀

Continuous sampling and analysis of PM₁₀ is undertaken using the E-Sampler, manufactured by Met One Instruments Inc. The E-Sampler is a type of nephelometer which automatically measures and records real-time airborne PM₁₀ particulate concentration levels using the principle of forward laser light scatter.

The data is downloaded from each E-Sampler remotely using a combination of radio telemetry, if possible between sites, and a central modem. The downloaded data is in a CSV file which can be automatically opened with Microsoft excel or most spread sheet programs.

Particulate weight per unit volume (mg/m³) is the standard measurement for the E-Sampler.

9.6.3.3 Gravimetric Analysis of PM₁₀

In addition to real-time particulate concentration monitoring, the E-Sampler has a built-in 47 mm filter sampler which is used to examine the gravimetric K-factor (slope multiplier) to correct the E-Sampler real-time signal to match the local particulate type. The accuracy of the mass output can be negatively affected by variations in size, colour, shape and index of refraction of the sampled particles. Once determined, the K-factor remains valid for that unit and site as long as the particulate type is consistent. In this case, examination of the gravimetric K-factor will be undertaken once annually at the beginning of the dry season to account for potential variation of particulates due to changing Site conditions, construction progress and the progressive transition from the construction to the commissioning phase.

A filter disc is weighed on a microbalance before and after being run in each E-Sampler for a set period of time. The resulting mass of the dust on the filter is then correlated with the concentrations that each E-Sampler recorded over the same time period, and a correlation factor calculated. New correlation factors will be programmed into each E-Sampler and will remain valid as long as the primary particulate type remains consistent.

9.6.4 Field Records

At each sampling location the field records are included the minimum of the following information:

- Exact location (sample point number/name and/or GPS coordinates), sampling time, date and the name of the sampler(s);
- Sample type, number of containers, sample preservatives, sample collection order;
- Weather conditions;
- Sample collection equipment and method;
- Sample equipment decontamination procedures, where non-disposable sampling equipment is utilised; and
- Field notes are to include comments on any exceptional issues regarding the sample collected.

9.6.5 Sample Labels

Each sample label includes the following information:

- Subcontractor and sampler's name;
- Sample point identification and unique sample number;
- Date and time sample was taken; and
- What was sampled and why.

9.6.6 Chain of Custody and Sample Analysis

A CoC form is completed to accompany the samples to the laboratory for submission for analysis. In each instance the following is undertaken:

- The CoC form is completed in pen;
- All information requirements are completed on the form; and
- The completed CoC form is transmitted within 24 hours of the delivery of samples to the laboratory for confirmation of instructions.

Chain of custody forms are presented with the original laboratory certificates in the completed monitoring reports.

Dust deposition and E-Sampler filter samples are analysed by the NATA-accredited laboratory in accordance with AS3580.10.1. Data is provided in the AS-recommended units of g/m²/month. Data collected during the monitoring programs is compiled monthly in the Project database.

9.6.7 Field Quality Assurance and Quality Control

Field QA/QC is applied to the following tasks:

- Task 1: Installation of dust deposition gauges and E-Samplers;
- Task 2: Deployment and retrieval of dust deposition bottles;
- Task 3: Routine inspection, maintenance, and calibration of E-Samplers; and
- Task 4: Deployment and retrieval of 47 mm gravimetric filters.

Field data sheets record the time, locations, initial of the sampler, surrounding site photograph number and general observations of the site during Tasks 1 to 4 listed above. Relevant information is also be recorded on CoC forms for Tasks 2 and 4.

E-Sampler inspection, maintenance and calibration are carried out for Task 3 as per manufacturer's recommendations with inspection, maintenance and calibration sheets recorded in the Project database.

9.6.8 Laboratory Quality Assurance and Quality Control

A copy of signed CoC forms acknowledging receipt date, time and identity of samples is kept on the Project database.

All samples is analysed by a NATA accredited laboratory using Australia Standard methods. A certificate of analysis is provided with all results which details laboratory acceptance criteria and quality control standards.

9.6.9 Quality Assurance and Quality Control Data Evaluation

Data is evaluated to show completeness by identifying periods where sampling was not undertaken (annual service, instrument malfunction, adverse weather such as cyclones). These gaps are highlighted in monthly reports, quarterly reports and in the annual report.

10. AIRBORNE NOISE

10.1 Summary of Compliance Requirements

Airborne noise monitoring undertaken in accordance with the EIMP meets the compliance requirements set out in the following legislation, policies, guidelines and approval requirements associated with the Project.

10.1.1 Legislation

The WMPC Act defines noise that has an adverse effect on the amenity of an area as an environmental nuisance (Section 4). Noise from a development site may be considered an environmental nuisance and may be considered an offence under the Act.

10.1.2 Policies and Guidelines

The NT EPA has published the *Noise guidelines for development sites in the Northern Territory* (2013) (Noise Guidelines). The Noise Guidelines are designed to protect noise-sensitive receptors from unreasonable construction noise while protecting an active development industry.

The Noise Guidelines provide that noise emitted from a development site may be considered an environmental nuisance or pollution under the WMPC Act if:

- a) The construction activity is conducted:
 - outside the hours of 7 am and 7 pm Monday to Saturday; or
 - on a Sunday or public holiday outside the hours of 9 am and 6 pm
- b) The construction activity was not carried out in accordance with 'AS 2436 Guide to Noise and Vibration Control on Construction, Maintenance and Demolition Sites';
- c) 48 hours' notice was not given to the occupiers of all noise-receiving premises where noise levels for the development site are likely to be of concern including:
 - a description of proposed construction activity likely to cause nuisance;
 - the time(s) and date(s) for the construction activity; and
 - the name and phone number of the person to whom a complaint may be made about noise emissions from the site; or
- d) The activity was not carried out in accordance with a Noise Management Plan registered with the NT EPA.

10.1.3 Approval Requirements

The CEMP sets out a number of objectives, targets and indicators that apply to the airborne noise monitoring program and these have been incorporated into the program.

10.2 Updates to the Environmental Impact Monitoring Program

In accordance with EIMP (Rev 6) a new noise monitoring location was established (BPAN02). This location was identified as indicative in EIMP (Rev 6) and the final location is provided in this EIMP.

10.3 Airborne Noise Trigger Values

The CEMP (Table 6.11.1) provides the following airborne noise trigger values that apply:

- For residential premises:
 - o 55 dB(A) from 7 am to 7 pm (day-time noise limit); and
 - o 45 dB(A) from 7 pm to 7 am (night-time noise limit).
- For industrial premises:
 - o 70 dB(A) at all times.

The Noise Guidelines provide that, 'Construction noise levels should not exceed...(the appropriate value) within 15m of a Noise Sensitive Receptor (NSR) or at or on the boundary of the NSR'.

The Noise Guidelines also provide that, 'The above measurements are measured as L_{Aeq} , which is the equivalent continuous (energy average) level (A-weighted)'. AS/NZS 2436 requires that the time constant of the sound level meter or logger be set to 'fast' and that statistical metrics of L_{A1} , L_{A10} , L_{A90} as well as the L_{Amax} be reported in addition to the L_{Aeq} values.

From combining the noise trigger values with the measurement guidance, the following measureable noise limits for noise generated by construction works associated with the Project can be derived:

- Any freefield L_{Aeq} measurement recorded at a residential NSR between 7 am and 7 pm shall not exceed 55 dB(A);
- Any freefield L_{Aeq} measurement recorded at a residential NSR between 7 pm and 7 am shall not exceed 45 dB(A); and
- Any freefield L_{Aeq} measurement recorded at an industrial NSR at any time shall not exceed 70 dB(A).

In accordance with AS2436 noise measurements or noise logging intervals shall have duration of between 5 – 30 minutes. The nominal measurement period for this Project is 15 minutes, but may be varied should it be warranted by specific circumstances. Noise measurements are taken at a height of 1.2 to 1.5 m above ground level (AGL), and more than 3 m from a reflective surface other than the ground, and within 15 m of a NSR or at the boundary of the NSR.

Should facade noise measurements be required, the measured values shall have a facade correction of -1.5 dB applied prior to assessment against Project performance criteria. All facade measurements are conducted within 1 m of the most exposed facade preferable in the middle of an operable window or door of a habitable space.

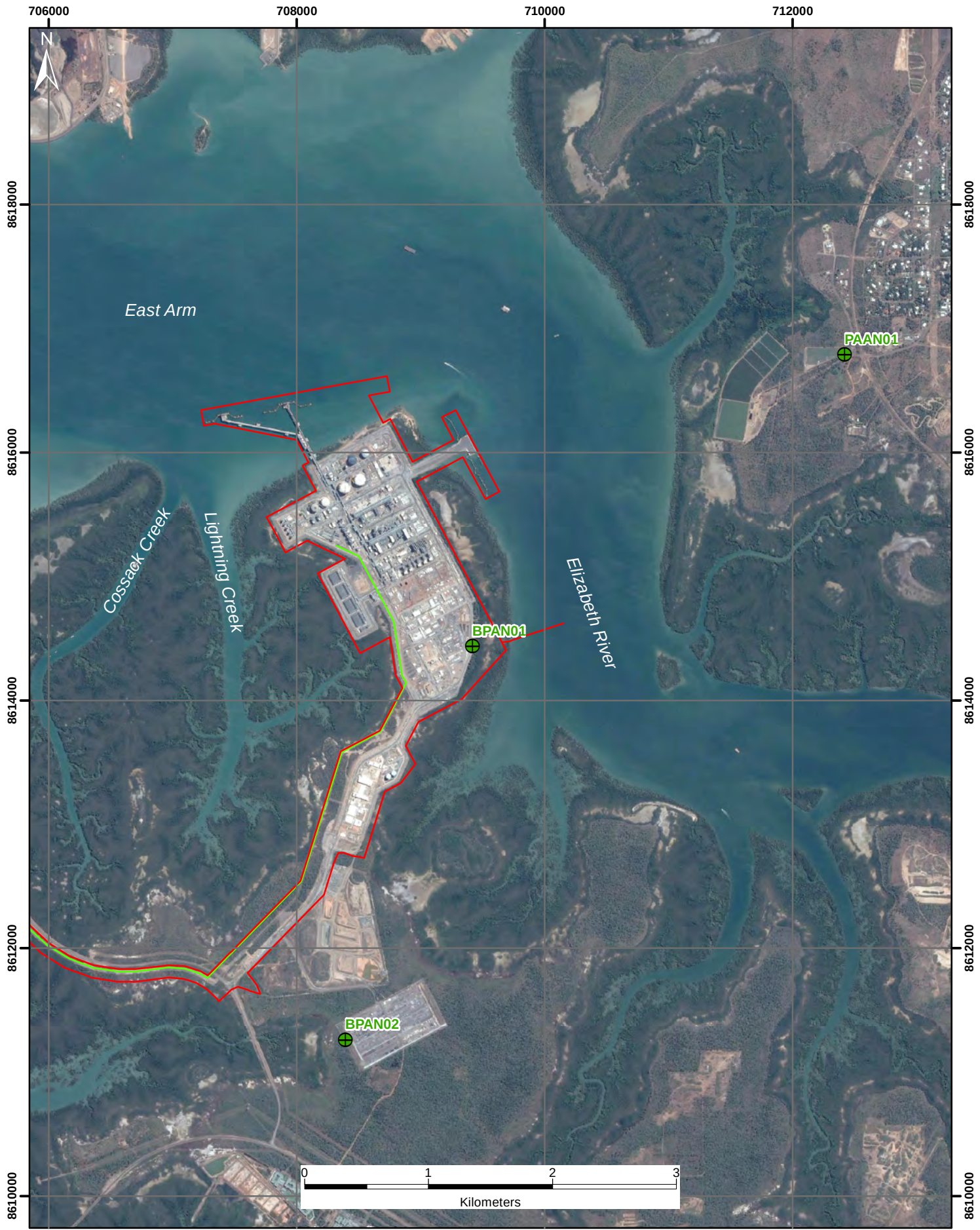
For any attended measurements the sound level meter is checked with a field calibrator immediately before and after the measurement period. Noise loggers should be checked with a field calibrator monthly. Attended noise measurements are avoided during adverse weather conditions. Continuous noise monitoring shall report concurrent weather conditions and remove from the assessment noise measurements that have been affected by adverse weather conditions.

10.4 Monitoring Sites

Monitoring is undertaken at the sites identified in **Table 10-1**. The locations of monitoring sites are presented in **Figure 10-1**.

Table 10-1 Noise Monitoring Locations

Monitoring Point	Co-ordinates (GDA 1994; Map Zone 52)		Details
	Easting (m)	Northing (m)	
BPAN01	709418.50	8614433.00	Located on the eastern boundary of the Site adjacent to the Temporary Office Facilities.
BPAN02	708394.16	8611260.64	Located at the southern corner of Area 1888, the closest onsite location to the Bladin Central Enterprise Park.
PAAN01	712421.45	8616788.43	Located at the Turf Farm on Catalina Road in Palmerston.



- Site Boundary
- Gas Export Pipeline
- ⊕ Noise Monitoring Locations

Noise Monitoring Locations		
Figure 10-1	INPEX Bladin Point	
Date: 30/08/2016	Author: malcolm.nunn	
Revision: A	Map Scale: 1:40,000	
	Coordinate System: GDA 1994 MGA Zone 52	

10.5 Summary of Monitoring Approach

A summary of the approach to airborne noise monitoring is provided in **Table 10-2**. The noise locations are monitored on a continuous basis.

Table 10-2 Airborne Noise Monitoring Summary

Frequency	Monitoring Methodology	Sample Analysis	Locations
Continuously throughout the construction program	Assessment of sound levels dB(A) and comparison to initial data. Permanent sound monitors to be deployed; these continuously record sound. These recordings are referenced if Project noise limits are exceeded or complaints are received.	N/A	BPAN01, BPAN02, PAAN01.

10.6 Monitoring Methods

10.6.1 Monitoring, Analysis and Data Quality Objectives

The approach to noise monitoring is based on the general methodology outlined in the CEMP and the objective of noise management for the Project is to minimise the impacts of construction noise on local communities (nearest sensitive receptors).

Noise monitoring primarily aims to indicate compliance with the noise trigger values. Following interpretation of results, monitoring is used to inform Site personnel in order to trigger specific management actions for noise verification and/or minimisation if impacts are observed.

10.6.2 Rationale

The sampling locations have been selected to target noise emissions both at the Site boundary and at the closest sensitive receptor identified during the EIS. The closest receptor is the residential area at Palmerston.

Following the EIS, the Bladin Central Enterprise Park, approximately 2 km south of the Site, has become operational, and has been captured as a noise sensitive receptor site to monitor any potential noise impacts from the Site activities.

10.6.3 Detailed Description of the Monitoring Methods

Noise monitoring is undertaken in accordance with AS 1055.1:1997 *Acoustics - Description and measurement of environmental noise* (AS 1055.1), AS 2436 and the Noise Guidelines.

Three sound level meters (Noise Monitoring Terminals [NMTs]) are installed, commissioned and maintained at the proposed monitoring sites. The NMTs include audio recording storage for two months, are solar powered, have telemetric capability, and have an associated anemometer for measuring wind speed and wind direction. Data is accessible using a standard PC with common web browsers. Short message service (SMS) alerts can be initiated as required.

Noise measurements are taken at a height of 1.2 m to 1.5 m AGL and more than 3 m from any potentially noise reflective surface.

Unattended NMTs are used to continuously monitor sound levels (in decibels) during general construction activities. Results from the noise loggers are assessed on a monthly basis, or following receipt of a noise complaint.

Audio is continuously recorded and these recordings are referenced if Project noise limits are exceeded or complaints are received.

In the event a noise complaint is received and validated, or noise monitoring results exceed specified noise criteria, management actions are implemented by Contractor.

10.6.4 Field Quality Assurance and Quality Control

Calibration of airborne noise equipment is undertaken in accordance with the manufacturer's recommendations. Field data sheets record the time, locations, initial of the sampler, surrounding site photograph number and general observations of the site.

Noise logger inspection, maintenance and calibration are carried out as per manufacturer's recommendations with inspection, maintenance and calibration sheets recorded in the Project database.

10.6.5 Quality Assurance and Quality Control Data Evaluation

Data is evaluated to show completeness by identifying periods where sampling was not undertaken due to, for example annual service, instrument malfunction and adverse weather such as cyclones. These gaps are recognised in monthly reports, quarterly reports and in the annual report.

11. FLORA AND FAUNA

11.1 Summary of Compliance Requirements

Flora and fauna monitoring undertaken in accordance with this EIMP meets the compliance requirements set out in the following legislation, policies, guidelines and approval requirements associated with the Project.

11.1.1 Legislation

The Commonwealth's EPBC Act is the central piece of environmental legislation that provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places. The EPBC Act focuses on the protection of matters of national environmental significance (MNES), with the States and Territories having responsibility for matters of state and local significance which, in the Northern Territory, is administered through the TPWC Act.

11.1.2 Approval Requirements

The CEMP sets out a number of objectives, targets and indicators that apply to the flora and fauna monitoring program and these have been incorporated into the monitoring program.

11.1.3 Policies and Guidelines

The flora and fauna monitoring program is conducted in accordance with policies and/or guidelines which have been detailed in the CEMP, such as specific native and introduced species management plans.

11.2 Flora and Fauna Trigger Values

Trigger values have been established to assess impacts on flora and fauna within and surrounding the Site. An assessment against the flora trigger values are only carried out following vegetation clearing. If no vegetation clearing takes place, an assessment against these trigger values is not required.

The flora and fauna trigger values that apply to the flora and fauna monitoring program are summarised in **Table 11-1**.

Table 11-1 Flora and Fauna Monitoring Trigger Values

Monitoring Parameter	Trigger Value	Indicators
Disturbance to flora and alteration of mangrove communities outside the Site boundary due to Site activities ¹	Vegetation clearing within the approved clearing boundary	Clearing permits
	No detected impact to mangroves outside the Site boundary attributable to the works (acceptable change in mangrove habitat is <30% reduction in canopy cover and in tree condition [including pneumatophores])	Results from mangrove community health monitoring program
Injury or death to native terrestrial fauna attributable to Site activities	Zero incidents of death or injury attributable to Site activities	Reported events of native fauna injuries/deaths attributable to Site activities

¹ The Site boundary is illustrated in **Figure 1-2**.

11.3 Monitoring Sites

Flora and fauna monitoring applies across the Site.

11.4 Summary of Monitoring Approach

A summary of the approach to flora and fauna monitoring is provided in **Table 11-2**.

Table 11-2 Flora and Fauna Monitoring Summary

Frequency	Monitoring Methodology	Sample Analysis	Locations
As required (i.e. if clearing occurs)	Visual assessment of clearance against the clearance permit. Clearing limits are collected using DGPS	N/A	The area/s where clearing occurs
Quarterly	Mangrove community health monitoring ¹	N/A	BPMC01, BPMC08 to BPMC11, BPMC16 to BPMC17 and BPMC20 to BPMC29. CSMC01 to CSMC04.
Daily	Documentation of all native fauna injuries and deaths in event registers	N/A	Site

¹ Refer to **Chapter 8** which sets out the mangrove community health monitoring program.

11.5 Monitoring Methods

11.5.1 Clearance Limits

If further clearing occurs on Site, the clearance is assessed against the clearance permit, and the results reported in the next AEMR. Clearance limits are measured using DGPS surveys and compared with the approved clearing limits to demonstrate that all disturbance is contained within the development footprint.

11.5.2 Mangrove Community Health Monitoring

The mangrove community health monitoring program is undertaken in accordance with **Chapter 8** of the EIMP, and the results reported as part of the mangrove monitoring program.

11.5.3 Fauna Event Reporting

All fauna deaths occurring on Site trigger event reporting and fauna relocation activities are recorded in the fauna registers by Subcontractors at Site. Fauna events are recorded through the MYOSH Safety Management Software. Event registers relating to fauna injuries and deaths are maintained by all Subcontractors operating on Site and are provided to Contractor. Review of events, corrective actions and trends occur on a quarterly basis as part of normal Site operations, however, this is outside the scope of the EIMP reporting.

Monitoring results are subject to review and yearly trend analysis is provided in the AEMR. Significant outcomes of the fauna monitoring is presented in the AEMR, including fauna relocations, as well as a summary of corrective and preventative actions to minimise fauna fatalities.

12. WEEDS

12.1 Summary of Compliance Requirements

Weed and pest monitoring undertaken in accordance with this EIMP meets the compliance requirements set out in the following legislation, policies, guidelines and approval requirements associated with the Project.

12.1.1 Legislation

The Northern Territory's *Weeds Management Act 2001* (WM Act) was established to ensure all land managers are responsible for carrying out weed control on land that they manage. The WM Act applies to all land users in the Northern Territory.

Additionally, the EPBC Act recognises key threatening processes as processes which may threaten the survival, abundance or evolutionary development of a native species or ecological community. Several invasive species are listed as key threatening processes due to their impacts, either physical or biological, on native species and/or natural ecosystem functions.

12.1.2 Approval Requirements

The CEMP sets out a number of objectives, targets and indicators that apply to the weed and pest monitoring program and these have been incorporated into the program.

12.1.3 Policies and Guidelines

The weed and pest monitoring program is conducted in accordance with policies and/or guidelines detailed in the CEMP, such as the *Northern Territory Weed Management Handbook* (NRETAS, 2009) and specific weed and pest species management plans. Weed and pest monitoring take places on a quarterly basis.

12.2 Weed and Pest Trigger Values

The weed and pest trigger values that apply to the weed and pest monitoring program are summarised in **Table 12-1**.

Table 12-1 Weed and Pest Monitoring Trigger Values

Monitoring Parameter	Trigger Value	Indicator
Introduction of new weed species to the Site and the spread of 'declared' weed species and Weeds of National Significance (WONS) within the Site	Zero introduction and spread of new weeds to Site	Weed register developed from weed surveys for the Site
	Effective and strategic control of weeds	Weed control programs
Introduction and increase in populations or terrestrial and marine invasive species to the Bladin Point and Middle Arm Peninsula	Effective and strategic control with no reported increase in abundance or distribution of pest species as compared to the baseline data	Number of events relating to introductions of marine pests or terrestrial invasive species attributable to the works

12.3 Monitoring Sites

The weed monitoring program applies across the entire Site with the exception of the Heritage Hill area (**Figure 1-2**) which is excluded due to cultural heritage considerations.

12.4 Summary of Monitoring Approach

A summary of the approach to weed monitoring is provided in **Table 12-2**.

Table 12-2 Weed Monitoring Summary

Frequency	Monitoring Methodology	Sample Analysis	Locations
Quarterly	Visual survey to review onsite weed management efficacy. Weed locations are captured by GPS and newly identified weed locations are incorporated into the weed inventory	N/A	Site

12.5 Monitoring Methodology

Weed surveys are undertaken on a quarterly basis within the Site boundary in accordance with the *Guidelines for Weed Data Collection in the Northern Territory* (NRETAS, 2010b).

A summary of the monitoring methodology is provided as follows:

- The site is surveyed in a gridded approach to make infestations easier to identify and to track any spread;
- GPS points are taken at each infestation and/or individual plant;
- Photographs of all infestations are taken to document any spread, identify the species and document the lifecycle of the species over the changing seasons (this aids in identifying the best times for treatment as required); and
- Maps are developed and updated following each survey to show any spread or reductions of infestations as appropriate.

Each quarterly survey includes the following minimum information:

- The precise location of the invasive weed species is recorded using a handheld GPS device and includes the monitoring date, unique area identification name/number and GPS coordinates;
- GPS point or polygon, photograph, voucher of plant (sample), if needed for identification purposes; and
- Field notes include comments on any exceptional issues regarding the survey collected.

13. MAJOR HAZARD FACILITY AND SEPARABLE PORTIONS

As the Project progresses into commissioning and operations, the Site will be classified as a MHF as defined by Safe Work Australia as “locations such as oil refineries, chemical plants and large fuel and chemical storage sites where large quantities of hazardous materials are stored, handled or processed”. The trigger for the Site being defined as a MHF is the introduction of 200 tonnes of propane to the propane sphere.

In a hazardous area there is a requirement to take special precautions in the design, installation, operation and maintenance of electrical equipment in order to minimise the risk of ignition. Catastrophic failure of the plant is not considered when defining the hazardous areas, but is to be considered when selecting equipment located in non-hazardous areas, which is required for emergency or essential service. The design of the facility is to be such that the frequency, duration and quantity of release of flammable materials both in normal and abnormal operation are to be minimised as far as reasonable practicable. The hazardous area classification is to consider all operating scenarios, i.e. plant start-up, operation and shutdown.

Electrical equipment located in hazardous areas shall comply with a suitable explosion protection standard. Australian Standards (AS/NZS 60079.14 section 4.3) requires all Hazardous Area Equipment to be supplied with a Certificate of Conformity in accordance with the International Electrotechnical Commission System for use in Explosive Atmospheres (IEC Ex) or the Australian/New Zealand Certification Scheme for Electrical Equipment for use in Explosive Areas (ANZEx) scheme, issued by an approved Certification Body.

Figure 13-1 outlines Separable Portions (SP) 1-6 where areas of the Site will be handed over from Contractor to Company and simultaneous operations (SIMOPS) will take place. The separable portions are required to adhere to the same rules for electrical equipment as the MHF until all systems and equipment are Ready For Start Up (RFSU) but also allow construction and commissioning to continue outside the separable portions.

The EIMP monitoring assets located in the separable portions themselves and around the northern parts of the Site are also outlined in **Figure 13-1**. During commissioning, should a designated monitoring location be deemed no longer possible to use, because of safety concerns, an alternative site will be sought that still allows the objectives of the EIMP to be met.

In order to meet the requirements and precautions of the MHF and separable portions, no permanent non-intrinsically safe equipment can be in place within hazardous areas.

The EIMP monitoring assets have been evaluated in terms of:

- Locations within, and relative to, the separable portions;
- Access should the current access areas become restricted as a result of the MHF requirements;
- Type of equipment utilised in the monitoring these assets (e.g. intrinsically safe or not); and
- Potential heat radiation zones (e.g. flare pad), understood to be 100 m from the centre point of each, individual facility.

Table 13-1 below presents the monitoring locations that are likely to be affected, why they will be affected and the separable portion in which they are located.

Separable portions are scheduled to come into effect in chronological order with SP1 and SP6 last. At this stage, the start dates for each separable portion going live have not been finalised.

Table 13-1 Separable Portions and Potentially Impacted Locations

Monitoring Location	Monitoring Parameter	Separable Portion	Potential MHF Restrictions
BPGW09	Groundwater	SP1	Telemetry system and micro-purge sampling technique.
BPGW10	Groundwater	SP1	Telemetry system and micro-purge sampling technique.
BPGW12A	Groundwater	SP1	Telemetry system and micro-purge sampling technique.
BPGW13A	Groundwater	SP1	Telemetry system and micro-purge sampling technique.
BPGW14A	Groundwater	SP1	Telemetry system and micro-purge sampling technique.
BPGW16	Groundwater	SP1	Telemetry system and micro-purge sampling technique.
VWP328	Groundwater	SP1	Telemetry system and micro-purge sampling technique.
BPGW36	Groundwater	SP1	Telemetry system and micro-purge sampling technique.
BPGW18	Groundwater	SP2	Telemetry system and micro-purge sampling technique.
ONBH03	Groundwater	SP2	Telemetry system and micro-purge sampling technique.
BPGW28	Groundwater	SP2	Telemetry system and micro-purge sampling technique.
BPGW19A	Groundwater	SP2	Telemetry system and micro-purge sampling technique.
BPGW27A	Groundwater	SP2	Telemetry system and micro-purge sampling technique.
BPGW41	Groundwater	SP2	Telemetry system and micro-purge sampling technique.
BPGW40	Groundwater	SP2	Telemetry system and micro-purge sampling technique.
BPGW20	Groundwater	SP4	Telemetry system and micro-purge sampling technique.
Weather Station	Weather	SP2	Meteorological monitoring probes and sensors.
SWAS01	Surface water Auto-sampler	SP2	Automated sample collection and data communications
SWAS02	Surface water Auto-sampler	SP2	Automated sample collection and data communication

The telemetry systems and data loggers that are currently installed in the 35 bores on Site are not critical in the detection of the potential effects of deep soil mixing and ASS mobilisation on the groundwater. The potential impacts on groundwater manifest over a much longer timeline and this can be captured by the existing monthly monitoring of groundwater. In addition, the equipment is not intrinsically safe and for safety reasons will be removed when the Site is declared a MHF.

Groundwater sampling is currently undertaken using the low-flow sampling technique, which is not intrinsically safe due to the equipment being an ignition source. Therefore, when the Site is declared a MHF, sampling will be undertaken using an intrinsically safe methodology (e.g. bailing method).

The weather station is located in the north-eastern section of the Site (near BPGW41) and will be inside SP2. Following communications with the supplier, it has been identified that a number of the sensors and communication probes are deemed non-intrinsically safe. In order to eliminate the risk it is proposed that the weather station is relocated to a non-hazardous area.

Two surface water auto-samplers have also been identified as being non-intrinsically safe and will be relocated to a non-hazardous area.

The noise, dust, mangrove and marine surface water monitoring assets located in close proximity to the separable portions do not require the use of intrinsically safe equipment and are outside of the heat radiation zones. As such, no changes are proposed in these monitoring programs.

The above-mentioned adjustments to the EIMP monitoring program to accommodate the MHF designation and separable portions will occur in a phased manner prior to the introduction of the 200 tonnes of propane to the propane sphere.

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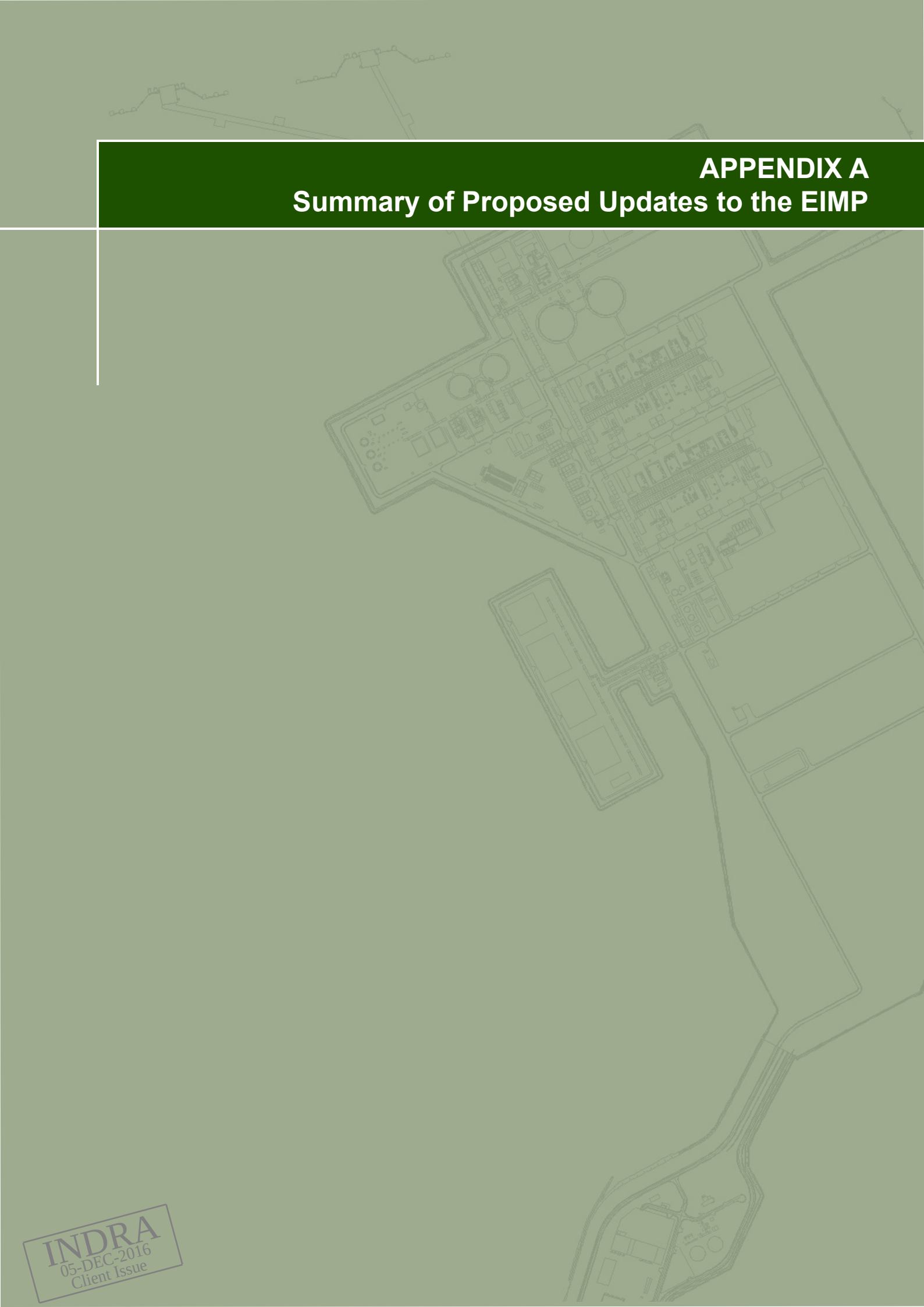
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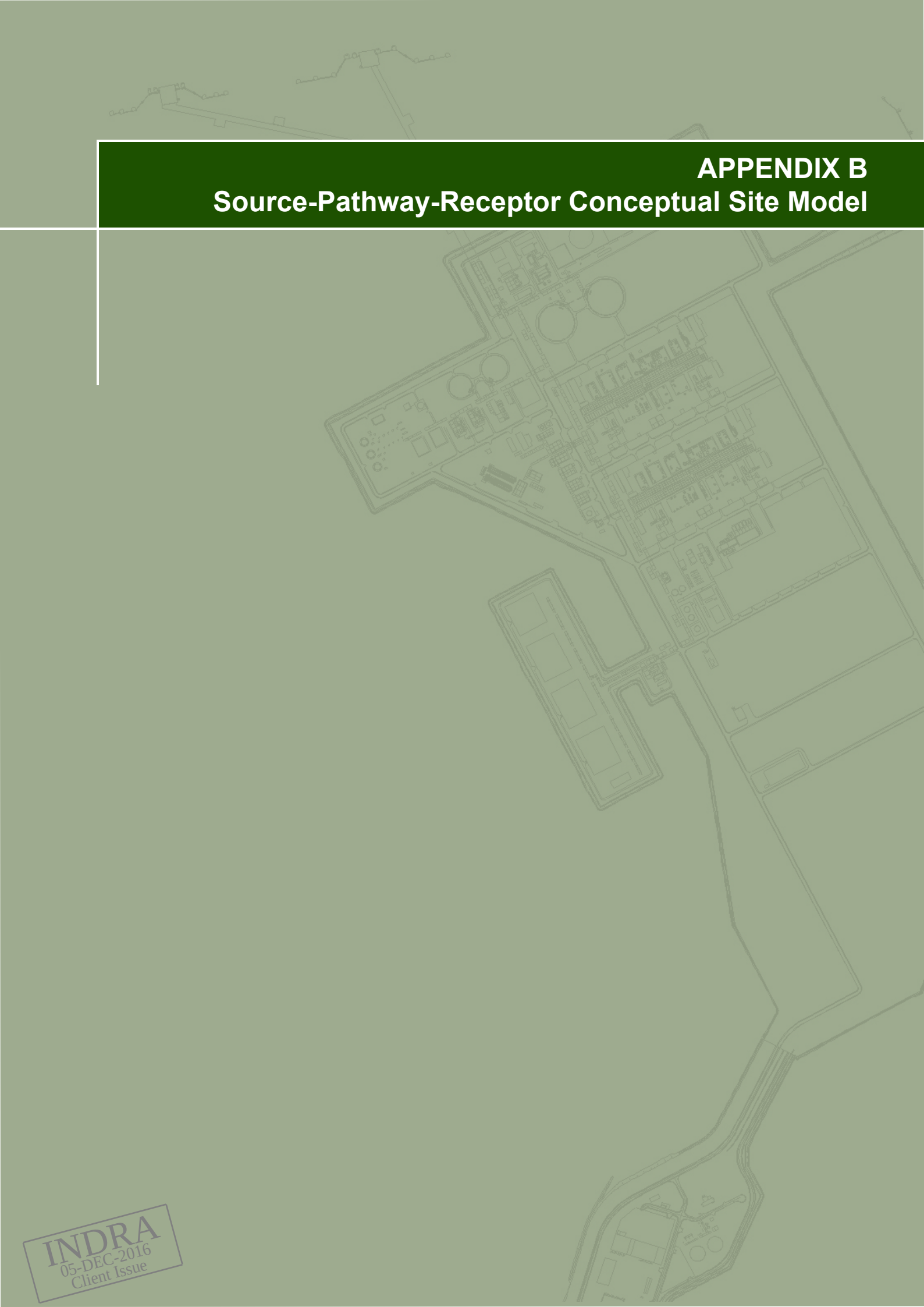
APPENDIX A

Summary of Proposed Updates to the EIMP

Table A-1 Summary of Proposed Updates to the EIMP

Monitoring Program	EIMP Rev 6 Monitoring Methodology	Current EIMP Monitoring Methodology	Rationale	Change from EIMP Rev 6 to this EIMP
Surface Water	Surface water trigger values were based on guidance provided in <i>Water Quality Objectives for the Darwin Harbour Region – Background Document</i> (Darwin Harbour WQOs) and the <i>Australian and New Zealand Guidelines for Fresh and Marine Water Quality</i> (Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, 2000) (ANZECC Guidelines).	The following receiving environment surface water trigger values will be aligned with the <i>Ichthys Onshore LNG Facilities - Construction Environmental Management Plan</i> (L092-AH-PLN-10001) (INPEX Operations Australia Pty Ltd, 2016) (CEMP): - Dissolved oxygen (DO); - Chlorine; - Aluminium; - Arsenic (III), arsenic (V) and total arsenic; - Chromium (III); - Manganese; - Nickel; and - TPH/TRH and toluene.	The CEMP is approved by the Northern Territory Environment Protection Authority (NT EPA). In accordance with the Project's Environment Protection Approval (EPA7 [as amended]), the EIMP must be aligned with the CEMP. See Section 6.2.1 for further details. In summary: - DO – the upper limit of 100% saturation will be removed as super-saturated conditions are not anticipated in Darwin Harbour or from the Project's activities. The lower limit of 80% saturation is retained; - Aluminium and manganese – Australian marine species trigger values are now available; - Chlorine changed to reflect current instrument detection levels with no turbidity or total suspended solids (TSS) influence. Measurement of chlorine only applies when wastewater has been shock dosed with chlorine and does not include potable water treatment; - Chromium – ANZECC errata corrected; - Arsenic – change to remove speciation from the EIMP and instead compare total arsenic and adopt the existing conservative arsenic (III) trigger value; - Nickel – 99% marine trigger value adopted to align with CEMP and ANZECC recommendations; - TRH – trigger value set at the detection limit, which depends on the chain length of the hydrocarbons analysed as well as interference and will range between 100 to 500 µg/L. The onsite trigger value of 600 µg/L remains the same; and - Toluene – 99% marine trigger value adopted to align with the CEMP approach for BTEXN.	MODIFICATION OF THE RECEIVING ENVIRONMENT SURFACE WATER TRIGGER VALUES TO ALIGN WITH CEMP
Surface Water	Monitoring of arsenic (III) and arsenic (V) (arsenic speciation) was undertaken as part of the surface water monitoring program and total filtered arsenic was not monitored.	Arsenic speciation will be replaced with the monitoring and analysis of total filtered arsenic. The arsenic (III) trigger value of 2.3 µg/L derived from the ANZECC Guidelines will be applied to the total filtered arsenic results.	The arsenic (III) trigger value is more stringent than the trigger value for arsenic (V) and as total filtered arsenic is primarily comprised of the sum of the arsenic (III) and arsenic (V) concentrations, this represents a conservative approach.	REPLACEMENT OF ARSENIC SPECIATION WITH MONITORING OF TOTAL FILTERED ARSENIC
Surface Water	Surface water monitoring was undertaken at the onsite and offsite monitoring locations identified in Table 6-4.	The locations for the surface water sampling sites BPSW34, BPSW35, CSSW03 and CSSW04 were identified in EIMP (Rev 6) as indicative only. Final coordinates for these locations are provided in this EIMP. The monitoring frequency at BPSW34 and 35 will be changed from monthly to quarterly, and monitoring at these locations will cease at the end of the 2016/17 wet season (the projected date for their removal is May 2017 subject to the provisions in Chapter 5 of the EIMP).	Indicative monitoring locations proposed in EIMP (Rev 6) have been finalised and confirmed in this EIMP. For BPSW34 and 35, if impacts along the GEP arise (e.g. ASS mobilisation through the groundwater expression pathway) these will start to manifest in the 2016 dry season because of groundwater transit times (the last ASS treatment activities were recorded in August 2015) (AEMR [2016]). Following evidence that no adverse impacts have occurred, these monitoring sites will be removed from the EIMP (the projected date for their removal is May 2017 subject to the provisions in Chapter 5 of the EIMP).	REFINEMENT OF RECEIVING ENVIRONMENT SURFACE WATER MONITORING LOCATIONS AND MONITORING FREQUENCIES
Surface Water	The auto-samplers will undertake in situ analysis for physico-chemical parameters including temperature, DO, oxidation reduction potential (ORP), electrical conductivity (EC), salinity and turbidity.	The auto-samplers will collect data relating to physico-chemical parameters as follows: - Turbidity and EC will be measured by in situ probes; - Salinity values will be calculated by applying a conversion factor to the EC values; and - pH values will be determined as part of the laboratory analysis of the water samples collected by the auto-samplers.	The in situ analysis of physico-chemical parameters is subject to the equipment limitations of the auto-samplers.	ADJUSTMENT OF PHYSICO-CHEMICAL PARAMETERS MONITORED BY THE AUTO-SAMPLERS
Surface Water	In situ analyses will be undertaken using telemetered water quality meters attached to navigation buoys.	The marine buoys will be decommissioned and continuous monitoring of physico-chemical parameters will cease.	This change is justified by the cessation of the construction activities at the MOF and Jetty and the subsequent removal of the construction risk sources in Darwin Harbour, in particular piling. AEMR (2016) also demonstrated that there is a good correlation between the monthly surface water monitoring results and the continuous marine buoy results. This provides confirmation of the longer term trends that have been identified in the monthly monitoring program (dating back to October 2012) and also supports the conclusion that monthly surface water monitoring is sufficient to identify any impacts that may arise from Site activities or discharges from Site going forward.	REMOVAL OF MARINE BUOYS AND CESSATION OF CONTINUOUS MONITORING OF PHYSICO-CHEMICAL PARAMETERS
Groundwater	Groundwater trigger values were based on guidance provided in the Darwin Harbour WQOs and the ANZECC Guidelines.	The following groundwater trigger values will be aligned with the CEMP: - pH; - Aluminium; - Arsenic (III) and arsenic (V) and total arsenic; - Chromium (III); - Manganese; and - Nickel.	The CEMP is approved by the NT EPA. In accordance with the Project's Environment Protection Approval (EPA7 [as amended]), the EIMP must be aligned with the CEMP. - pH – aligns with the upper estuary trigger specified in the Darwin Harbour WQOs; - Aluminium and manganese – Australian marine species trigger value is now available; - Arsenic – change to remove speciation from the EIMP and instead compare total arsenic and adopt the existing conservative arsenic (III) trigger value; - Chromium – ANZECC errata corrected; and - Nickel – 99% marine trigger value adopted to align with CEMP and ANZECC recommendations.	MODIFICATION OF GROUNDWATER TRIGGER VALUES TO ALIGN WITH CEMP
Groundwater	Monitoring of arsenic (III) and arsenic (V) (arsenic speciation) was undertaken as part of the groundwater monitoring program and total filtered arsenic was not monitored.	Arsenic speciation will be replaced with the monitoring and analysis of total filtered arsenic. The arsenic (III) trigger value of 2.3 µg/L derived from the ANZECC Guidelines will be applied to the total filtered arsenic results.	The arsenic (III) trigger value is more stringent than the trigger value for arsenic (V) and as total filtered arsenic is primarily comprised of the sum of the arsenic (III) and arsenic (V) concentrations, this represents a conservative approach.	REPLACEMENT OF ARSENIC SPECIATION WITH MONITORING OF TOTAL FILTERED ARSENIC

Monitoring Program	EIMP Rev 6 Monitoring Methodology	Current EIMP Monitoring Methodology	Rationale	Change from EIMP Rev 6 to this EIMP
Groundwater	Groundwater quality monitoring was undertaken at the locations identified in Table 7-2. A new monitoring bore BPGW39 will be installed and monitored.	Monitoring bores MW04d, MW05d and MW08d will be removed from the monitoring program. Monitoring at bores MW10a, MW11a and MW14 will cease at the end of the 2016/17 wet season, following evidence that no adverse impacts have occurred (the projected date for ceasing monitoring is May 2017 subject to the provisions in Chapter 5 of the EIMP). Monitoring bore BPGW39 will not be installed and monitored.	Monitoring bores MW04d, MW05d and MW08d can be removed from the monitoring program because they are not located in areas of known ASS. Monitoring bores MW10a, MW11a and MW14 within the GEP be retained and monitored on a monthly basis to assess any potential ASS mobilisation impacts that may have arisen in the most recent August 2015 excavations, and provide further data on specific parameters that recorded elevated concentrations over the construction period. Based on the inferred groundwater travel times in these areas, the monitoring of these bores should continue until the end of the 2016/17 wet season as this would provide sufficient time to detect any potential groundwater impacts (AEMR [2016]). Following evidence that no adverse impacts have occurred, these monitoring sites will be removed from the EIMP (the projected date for ceasing monitoring is May 2017 subject to the provisions in Chapter 5 of the EIMP). BPGW39 will not be required because the extensive, existing groundwater monitoring network provides sufficient coverage to adequately monitor groundwater quality and any potential impacts that may arise from Site activities and discharges.	REMOVAL/REFINEMENT OF GROUNDWATER MONITORING LOCATIONS
Groundwater	Data loggers will be installed in all bores across the Site. Telemetry systems and data loggers collect continuous physico-chemical data in the 35 bores on the main Site. The low-flow sampling technique is used to sample the bores on the main Site.	Data loggers will not be installed in GEP bores. The telemetered program in the 35 bores on the main Site will cease when the Site becomes a Major Hazard Facility and the low-flow sampling technique will be replaced with an intrinsically safe methodology e.g. bailing.	Data loggers are not critical in the detection of the potential effects of deep soil mixing and ASS mobilisation on the groundwater. The potential impacts on groundwater manifest over a much longer timeline (months rather than days) and this can be captured by the existing monthly monitoring of groundwater. In addition, the telemetry systems and data loggers are not intrinsically safe and represent an ignition source and explosive risk when the Site becomes a Major Hazard facility, and will need to be removed due to safety considerations. Data from the monthly monitoring program will be used to assess potential groundwater impacts from Site activities and/or spills. Given that the low-flow sampling technique is not intrinsically safe, once the Site becomes a MHF, the groundwater sampling will then be undertaken on a monthly basis using an intrinsically safe methodology (e.g. bailing).	REDUCTION IN THE NUMBER OF DATA LOGGERS INSTALLED ACROSS THE SITE
Mangrove Community Health (Transects)	Mangrove monitoring was undertaken along the transects identified in Table 8-4 and Table 8-5.	New monitoring transects BPMC24, 25, 26, 27, 28, 29 and CSMC03 and 04 were established in 2015 to monitor potential impacts on mangrove community health from Site activities and discharges. The locations of these transects were identified as indicative in EIMP (Rev 6) and the final locations are provided in this EIMP. Mangrove community health monitoring will continue along transects BPMC05 to BPMC07. Monitoring at these locations will cease in July 2017. Mangrove monitoring along the GEP corridor (BPMC27 to BPMC29) will cease at the end of the 2016/17 wet season following evidence that no adverse impacts have occurred (the projected date for ceasing monitoring is May 2017 subject to the provisions in Chapter 5 of the EIMP).	Indicative monitoring locations proposed in EIMP (Rev 6) have been finalised and confirmed in this EIMP. Mangrove community health monitoring will continue at BPMC05 to BPMC07 to evaluate potential recovery of the mangroves following a known mud wave recorded in this area in June 2013. Sedimentation and erosion, sediment quality and bio-indicator monitoring are not required and will not be undertaken at BPMC05 to BPMC07. If impacts along the GEP arise (e.g. ASS mobilisation through the groundwater expression pathway) these will start to manifest in the next dry season because of groundwater transit times (the last ASS treatment activities were recorded in August 2015) and as the groundwater recedes in the affected areas and causes potential oxidation of ASS. To date, the GEP monitoring has only included one full dry season in 2015 and monitoring in the 2016 dry season will provide further insights into whether any surface water impacts have arisen. Monitoring through the 2016/17 wet season will provide further evidence on whether the patterns are due to natural variation or impacts arising from the construction and commissioning of the GEP. Following evidence that no adverse impacts have occurred within the GEP, these mangrove sites will be removed from the EIMP (the projected date for ceasing monitoring is May 2017 subject to the provisions in Chapter 5 of the EIMP).	REFINEMENT OF MANGROVE MONITORING LOCATIONS AND MONITORING FREQUENCIES
Mangrove Community Health (bio-indicators)	Bio-indicator monitoring will occur on a bi-annual basis.	Bio-indicator monitoring will occur on a quarterly basis.	The frequency of bio-indicator monitoring will increase from bi-annual to quarterly sampling, in response to elevated metal concentrations detected in June 2014. This will provide increased resolution of the dataset and allow seasonal variations of metal concentrations in bio-indicators to be determined.	INCREASE IN FREQUENCY OF BIO-INDICATOR MONITORING
Dust	Dust monitoring was undertaken at the monitoring locations identified in Table 9-2.	The locations for BPPM04 and BPDD14 were identified in EIMP (Rev 6) as indicative only. Final coordinates for these locations are provided in this EIMP.	Indicative monitoring locations proposed in EIMP (Rev 6) have been finalised and confirmed in this EIMP.	REFINEMENT OF AIR QUALITY MONITORING LOCATIONS
Dust	Dust mass determination will be undertaken to identify gravimetric K-factors.	Dust mass determination to identify gravimetric K-factors is undertaken on an annual basis.	The EIMP (Rev 6) identified the need to undertake dust mass determination to identify gravimetric K-factors but did not specify how often this should occur. Dust mass determination is undertaken on an annual basis.	CLARIFICATION OF MONITORING FREQUENCY
Noise	Noise monitoring was undertaken at the monitoring locations identified in Table 10-1.	The location for BPAN02 was identified in EIMP (Rev 6) as indicative only. The final coordinates for this location are provided in this EIMP.	The indicative monitoring location proposed in EIMP (Rev 6) has been finalised and confirmed in this EIMP.	REFINEMENT OF NOISE MONITORING LOCATIONS



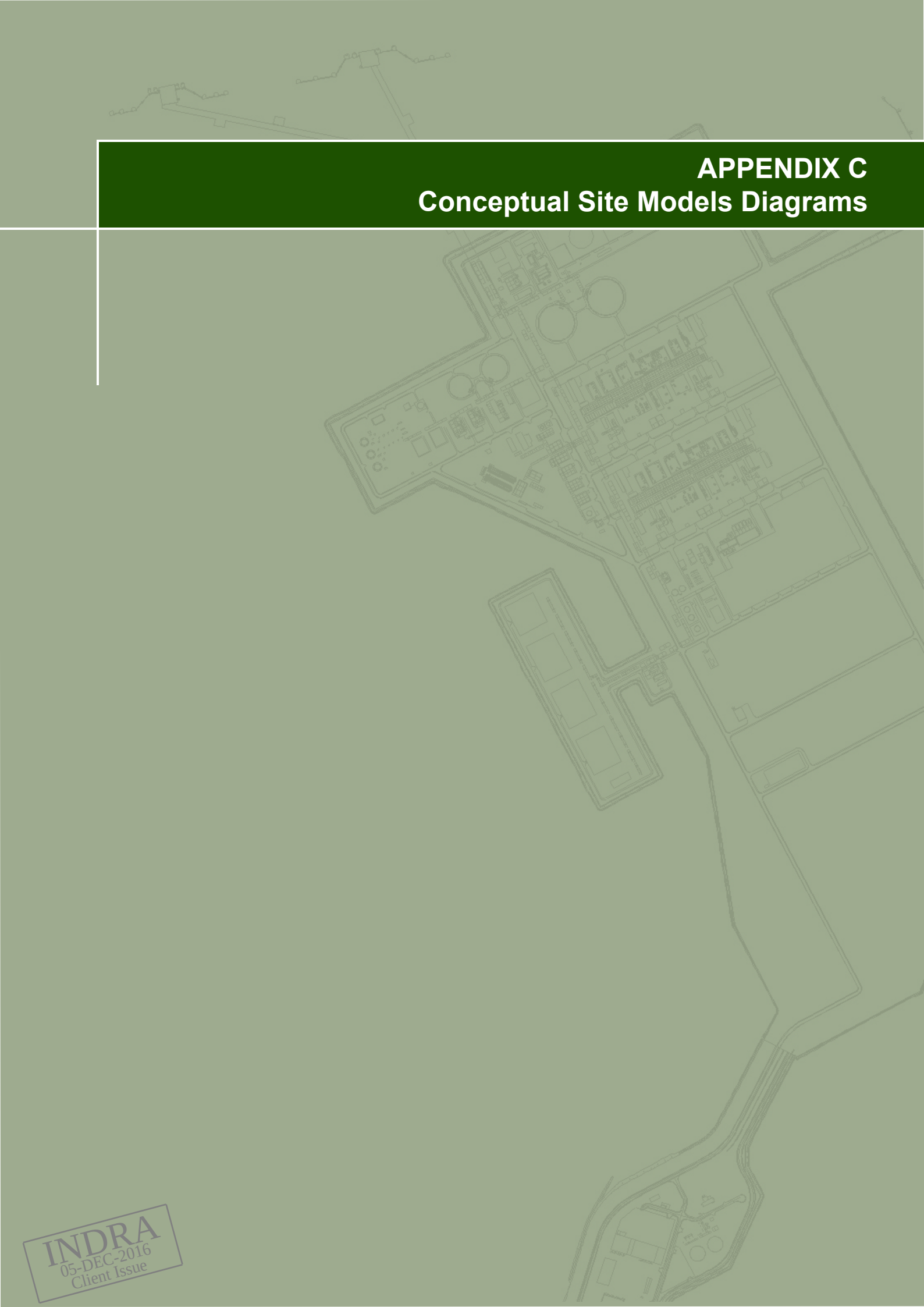
APPENDIX B

Source-Pathway-Receptor Conceptual Site Model

Table B-1 Source-Pathway-Receptor Conceptual Site Model

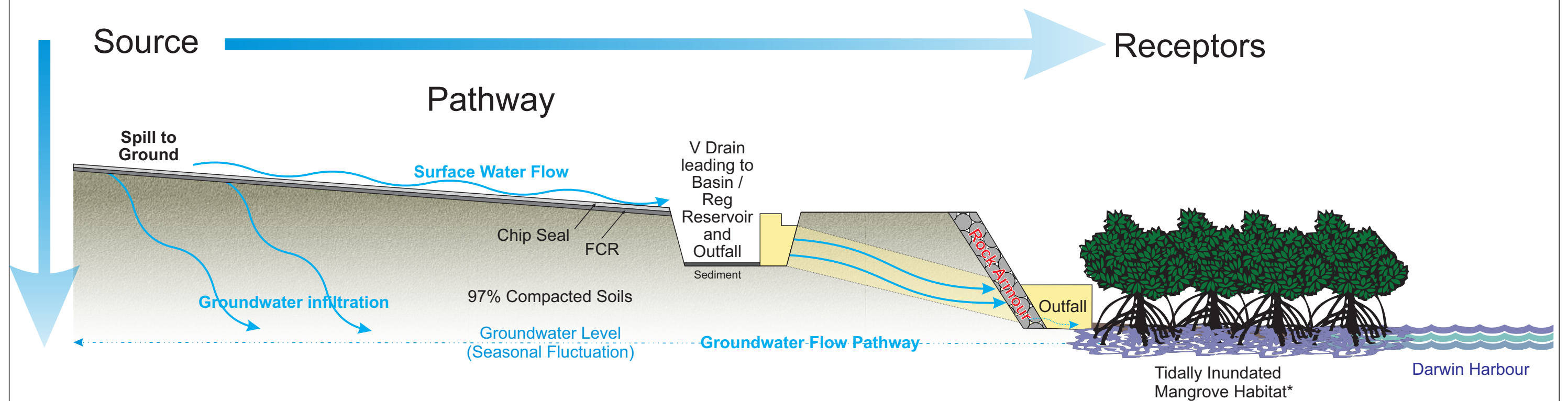
Source/Activity	Risk Register Reference Number	Potential Release Mechanism	Contaminants of concern	Pathway and Monitoring Program	Exposure Route	Receptors	Project Phase
Earthworks, ground improvement works and general construction activities. Dewatering and discharge of construction water from excavation pits/trenches including extraction and disposal of groundwater.	5, 6, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42,43, 55, 56, 66	Sealing and ground improvement works resulting in modified soil permeability and decreased infiltration/recharge and altered groundwater flows and levels, altered drainage, isolation of groundwater system from freshwater system, reduced health of mangrove community. Inappropriate handling and discharge of construction water resulting in: - Contamination of soil, surface water, groundwater and potential migration to Darwin Harbour with deterioration of receiving environment health; - Temporary lowering of groundwater level exposes ASS and results in generation of sulfuric acid. Potential acidification and heavy metal contamination of surrounding soil and groundwater; - Erosion of unsealed surfaces; - Ground improvement resulting in mud wave or adverse effects on mangrove habitat; and - Air emissions and dust deposition smothering surrounding vegetation and reducing growth.	Nutrients, metals, hydrocarbons and physico-chemical parameters – with trigger values. Groundwater elevation.	Soil, groundwater and surface water.	Infiltration, ASS mobilisation and groundwater expression to near shore environment.	Landward mangrove habitat Seaward mangrove habitat. Intertidal benthic. Soft bottom benthic. Water column.	Construction.
GEP earthworks and ground improvement works.	7, 103, 104, 105, 106, 107	Deep soil mixing making the soil profile impermeable causing the following potential impacts: - Increased surface runoff; - Alteration to surface water drainage and directions; - Reduced surface water infiltration to groundwater isolating the groundwater system from freshwater recharge; - Lowering of groundwater table and potential for seawater intrusion and potential for PASS to oxidise if not in an anaerobic state in surrounding areas; and - Reduced health of mangrove communities, or mortality occurs, due to reduced flow through of fresh groundwater.	Nutrients, metals, hydrocarbons and physico-chemical parameters – with trigger values. Groundwater elevation.	Soil, groundwater and surface water.	Infiltration, ASS mobilisation and groundwater expression to near shore environment.	Landward mangrove habitat. Seaward mangrove habitat. Intertidal benthic. Soft bottom benthic. Water column.	Construction.
General nearshore construction activities including geotechnical investigations.	8, 9, 10, 11	STP, MOF and Jetty construction resulting in deterioration of aquatic environmental health including decline in water quality and seabed impacts and temporary, localised disruption of natural behaviour or displacement of marine megafauna.	Nutrients, metals, hydrocarbons and physico-chemical parameters – with trigger values. Groundwater elevation.	Surface water.	Creation of sediment plume and aquatic noise impacts.	Landward mangrove habitat. Seaward mangrove habitat. Intertidal benthic. Soft bottom benthic. Water column. Aquatic megafauna.	Construction.
Vessel movements during MOF and Jetty operations including the refuelling of vessels and large marine construction equipment.	16, 24, 25	Vessel collision causing a spill of hydrocarbons into Darwin Harbour.	Hydrocarbons.	Surface water.	Surface water hydrocarbon plume.	Landward mangrove habitat. Seaward mangrove habitat. Intertidal benthic. Soft bottom benthic. Water column. Aquatic megafauna.	Construction, Pre-Commissioning and Commissioning.
Vessel operational activities including wash-down, ramp, general waste (liquid, solid and ablution) storage/handling of fuels, oils, greases, chemicals, and other dangerous goods and hazardous substances.	22, 101	Uncontrolled release of liquid and solid wastes, contaminants, dangerous goods or hazardous substances resulting in: - Surface water pollution; and - Effects on marine flora/ fauna.	Nutrients, metals, hydrocarbons.	Surface water.	Surface water plume and precipitation to sediments.	Landward mangrove habitat. Seaward mangrove habitat. Intertidal benthic. Soft bottom benthic. Water column. Aquatic megafauna.	Construction, Pre-Commissioning, Commissioning and Demobilisation.

Source/Activity	Risk Register Reference Number	Potential Release Mechanism	Contaminants of concern	Pathway and Monitoring Program	Exposure Route	Receptors	Project Phase
Creation of topsoil stockpiles, over excavation of the Extractive Materials Area (EMA) and excessive removal of topsoil.	58, 59, 62, 63	Erosion of unsealed surfaces, modified soil permeability, infiltration/recharge and altered groundwater flows and levels.	Nutrients, metals, hydrocarbons and physico-chemical parameters – with trigger values. Groundwater elevation.	Soil, groundwater and surface water.	Infiltration, ASS mobilisation and groundwater expression to near shore environment.	Landward mangrove habitat. Seaward mangrove habitat. Intertidal/soft bottom benthic. Water column.	Construction.
Air emissions	66, 67, 68, 130, 131, 139,156, 159, 160, 161, 164, 180, 187	Dust generation, resulting in: • nuisance, amenity and health impacts on nearby communities; and • decreased vegetation health. Generation of combustion emissions, gas release increasing levels of atmospheric pollution (NOx, SOx) and increasing levels of greenhouse gases.	PM ₁₀ , NO _x , SO _x , Greenhouse Gas Particulate and O ₃ .	Air.	Photosynthesis and respiration.	Landward mangrove habitat. Seaward mangrove habitat. Local residents.	Construction, Pre-Commissioning and Commissioning.
Vibration and noise from construction and commissioning activities.	71, 72, 76, 120, 122, 155, 165, 180	Noise and vibration causing nuisance, disturbance or health impacts on the local community.	Sound levels.	Air.	Nuisance sound.	Local residents.	Construction, Pre-Commissioning, Commissioning and Demobilisation.
Weed and pest management.	57, 81, 82, 83, 84, 85, 86, 87	Marine vessels entering the nearshore development area, plant, vehicles, foot access, and materials entering and exiting the Site from elsewhere in the Northern Territory or Australia.	Vegetation.	Soil and Air.	Direct contact.	Landward mangrove habitat Seaward mangrove habitat	Construction, Pre-Commissioning, Commissioning and Demobilisation
Storage and handling and/or transfer of dangerous goods and hazardous solids.	114, 115	Uncontrolled release of dangerous goods or hazardous solids resulting in: • Release of dust to the environment; • Potential contamination of soil, surface water and groundwater following contact with water; and • Potential eventual migration of contaminants to Darwin Harbour.	Metals and nutrients – with trigger values.	Soil, groundwater, surface water and air.	Infiltration and groundwater expression to near shore environment, inhalation, respiration, photosynthesis.	Landward mangrove habitat. Seaward mangrove habitat. Intertidal benthic. Soft bottom benthic. Water column.	Construction, Pre-Commissioning, Commissioning.
Storage, handling and/or transfer of dangerous goods and hazardous liquids.	21, 23, 69, 70, 93, 95, 96, 97, 98, 99, 102, 10, 109, 110, 120, 123, 124,125, 126, 127,128, 132, 133,134, 35,136a, 140, 141,185	Uncontrolled release of dangerous goods or hazardous liquids resulting in: • Soil, surface water and groundwater pollution; and • Potential eventual migration of contaminants to Darwin Harbour.	Nutrients, metals, hydrocarbons.	Soil, groundwater, surface water.	Infiltration and groundwater expression to near shore environment.	Landward mangrove habitat. Seaward mangrove habitat. Intertidal benthic. Soft bottom benthic. Water column. Aquatic megafauna.	Construction, Pre-Commissioning, Commissioning and Demobilisation.
Hydrostatic testing, flushing and process waters to include but not limited to HVAC condensation water, HRSG and UTB water with ammonia and blowdown neutralisation, demineralisation brine, AGRU rinsing and degreasing water, cooling system flushing water and passivation water, as well as AOC / COC water which may collect in the downstream basins.	112, 116, 117, 118, 119, 143, 144, 146, 147, 148, 151, 152, 153, 154, 166, 167, 168, 172, 173, 174, 175, 176, 178, 179, 181, 182, 186, 190	Inappropriate handling and disposal of spent water resulting in soil, surface water and groundwater impacts with potential migration to Darwin Harbour and deterioration of aquatic environmental health.	Nutrients, metals, hydrocarbons and physico-chemical parameters – with trigger values. Biocides, corrosion inhibitors and oxygen scavengers.	Soil, groundwater and surface water.	Infiltration and groundwater expression to near shore environment. Surface water migration to the marine environment.	Landward mangrove habitat. Seaward mangrove habitat. Intertidal benthic. Soft bottom benthic. Water column.	Construction, Pre-Commissioning, Commissioning and Demobilisation.
Liquid waste - storage, transport or disposal of hazardous and non-hazardous waste (including domestic waste).	88, 89, 90, 129, 136b, 137, 142, 145, 149, 150, 171, 188	Accidental spill and release of liquid waste resulting in pollution of the marine environment.	Nutrients, metals, hydrocarbons and physico-chemical parameters – with trigger values.	Soil, groundwater and surface water.	Infiltration and groundwater expression to near shore environment. Surface water migration to the marine environment.	Landward mangrove habitat. Seaward mangrove habitat. Intertidal benthic. Soft bottom benthic. Water column.	Construction, Pre-Commissioning, Commissioning and Demobilisation.
Decommissioning activities - waste management, spills, handling/transfer/storage of chemicals/interface.	192	Uncontrolled release of dangerous goods or hazardous substances resulting in: • Release of dust to the environment; • Potential contamination of soil, surface water and groundwater following contact with water; and • Potential eventual migration of contaminants to Darwin Harbour.	Metals and nutrients – with trigger values.	Soil, groundwater, surface water and air.	Infiltration and groundwater expression to near shore environment, inhalation, respiration, photosynthesis.	Landward mangrove habitat. Seaward mangrove habitat. Intertidal benthic. Soft bottom benthic. Water column.	Demobilisation.



APPENDIX C

Conceptual Site Models Diagrams

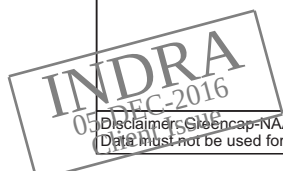


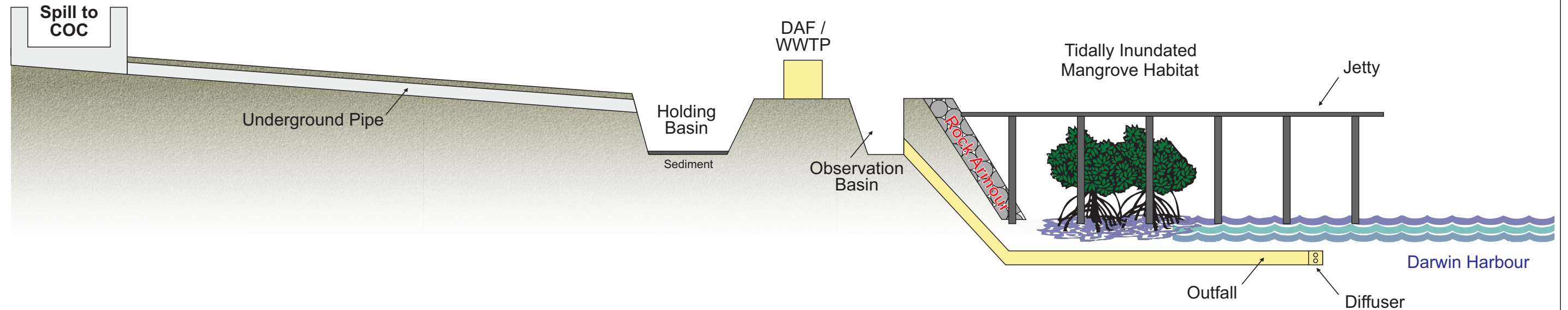
*Potential for direct exposure of mangrove habitate to waters, precipitation of contaminants into the sediments and bioaccumulation into mud whelks.



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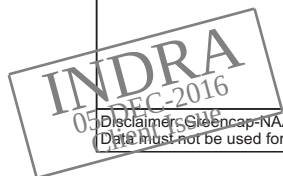
	Client Name:		JKC Australia LNG Pty Ltd				
	Client Number:		C110043		Project Number:		J140153
	Project Description:		2015-16 INPEX EIMP Project				
d	Address:		Inpex - Darwin, NT				
	Prepared:	JG	Reviewed:	SS	Date:	17/03/2016	
	Figure 3.0	Conceptual Site Model - Spill to NCW (Non-Contaminated Water)					

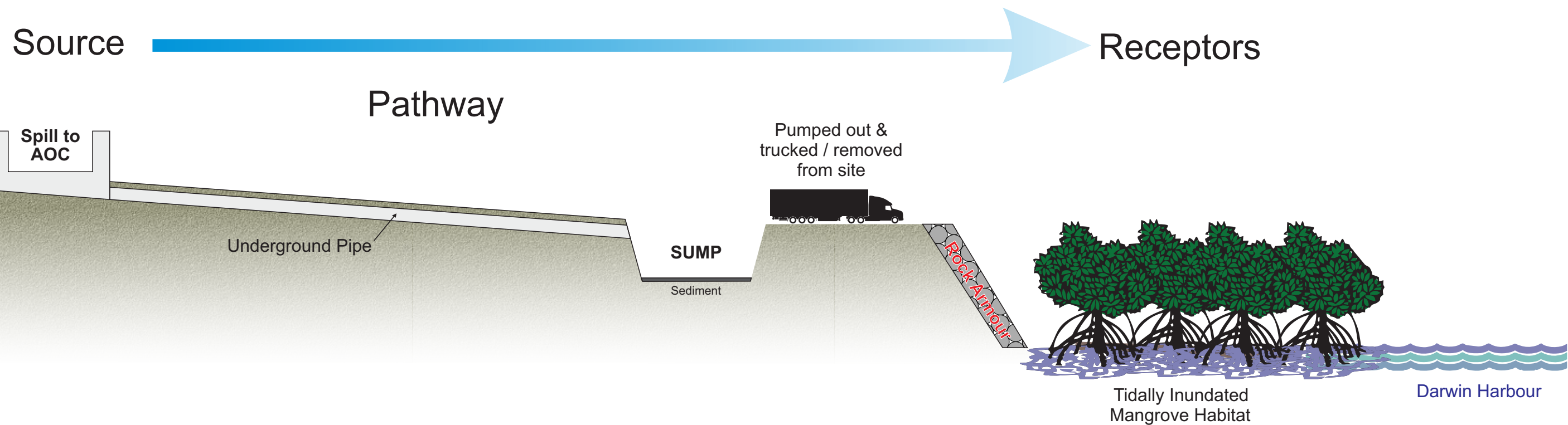




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Project Description:		2015-16 INPEX EIMP Project			
Address:		Inpex - Darwin, NT			
Prepared:	JG	Reviewed:	SS	Date:	17/03/2016
Figure 3.1	Conceptual Site Model - Spill to COC (Continuously Oil Contaminated)				





Wastewater Management Systems (Commissioning Phase)

Legend

