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DOCUMENT TITLE:	EPA7 ANNUAL REPORT 2017 - ENVIRONMENTAL IMPACT MONITORING PROGRAM
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ICHTHYS ONSHORE LNG FACILITIES

JKC AUSTRALIA LNG PTY LTD

Darwin, Australia

Subcontractor ISSUE PURPOSE	☐ FA ☐FR ☐FI X FC ☐AB ☐CA
CTR RESULT CODE	☐A ☐B ☐ N ☐F
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Approval or review hereunder shall not be construed to relieve Vendor / Subcontractor of his responsibilities and liability under the Contract.	

CTR ORGANIZATION	DEPT. NAME	SIGNATURE
PJ DEPT.	DOC-EIMP Code A Approved. A. Black 27/07/17	
RESPONSIBLE DEPT.		
RELATED DEPT.		

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EPA7 Annual Report 2017
Environmental Impact Monitoring Program

Ichthys On-Shore LNG Facilities

Bladin Point

Prepared for:
JKC Australia LNG Pty Ltd

Date: 24 July 2017

Prepared by:

GREENCAP

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EPA7 Annual Report 2017 – Environmental Impact Monitoring Program

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ABBREVIATIONS

Abbreviation	Description
AEMR	Annual Environmental Monitoring Report
AOC	Accidentally Oil Contaminated
ASS	Acid Sulphate Soil
BOM	Bureau of Meteorology
BTEXN	Benzene, toluene, ethylbenzene, xylene and naphthalene
CEMP	Construction Environmental Management Plan (INPEX document L092-AH-PLN-10001)
Cth	Commonwealth
dB(A)	A-weighted Decibel
DGPS	Differential Global Positioning System
DO	Dissolved Oxygen
EC	Electrical Conductivity
E. coli	*Escherichia coli*
EIMP	Environmental Impact Monitoring Program (Rev 6)
EIS	Environmental Impact Statement
EPA7	Environment Protection Approval 7 (as amended)
ERR	Environmental Risk Register
FRP	Filterable Reactive Phosphorus
g/L	Grams per litre
GEP	Gas Export Pipeline
ha	Hectare
HAT	Highest Astronomical Tide
ISQG	Interim Sediment Quality Guideline
Jetty	Product Loading Jetty
km	Kilometre
L	Litre
LNG	Liquefied Natural Gas
LOR	Limit of Reporting
mg	Milligram
mm	Millimetre
MOF	Module Offloading Facility
m/s	Metres per second
NATA	National Association of Testing Authorities
NEPM	National Environment Protection Measure

Abbreviation	Description
NRETAS	Department of Natural Resources, Environment, the Arts and Sport
NSW	New South Wales
NT	Northern Territory
NT EPA	Northern Territory Environment Protection Authority
NTU	Nephelometric Turbidity Units
ORP	Oxidation reduction potential
Palmerston	City of Palmerston
PASS	Potential acid sulphate soils
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
Site	The boundary of Contractor's scope of work as defined in Figure 1.2 of CEMP
SE	Standard error
TDS	Total Dissolved Solids
TPWC Act	*Territory Parks and Wildlife Conservation Act* (NT)
TRH	Total Recoverable Hydrocarbons
TSS	Total Suspended Solids
µg/L	Micrograms per litre
WDL	Waste Discharge Licence
WDL 192	Waste Discharge Licence 192
WDL 211	Waste Discharge Licence 211
WONS	Weeds of National Significance
WQOs	Water Quality Objectives

1. INTRODUCTION

1.1 Background

INPEX Operations Australia Pty Ltd (INPEX), 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 and Chiyoda Corporation, has been appointed by INPEX as the engineering, procurement and construction Contractor for development of the following:

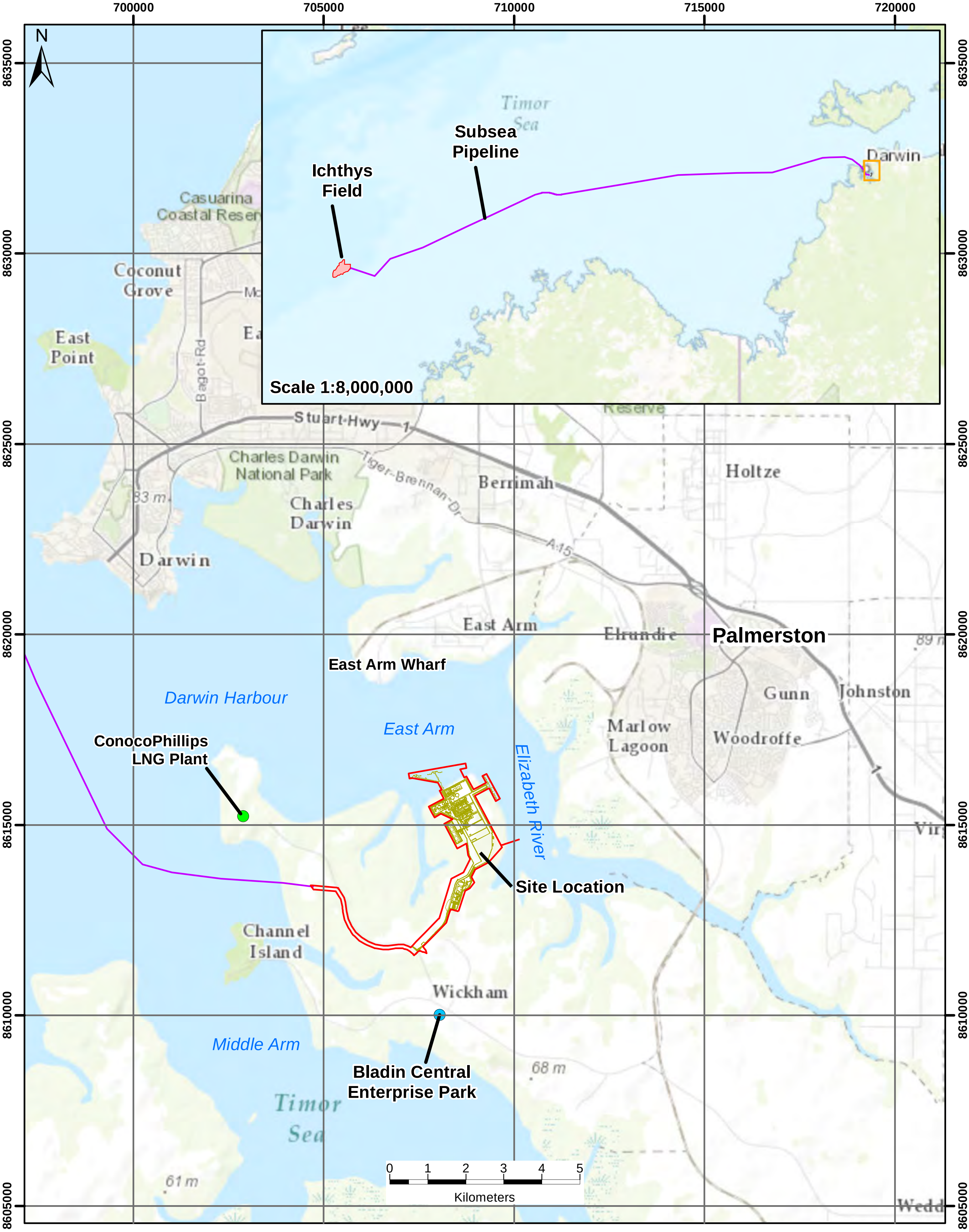
- Ichthys Onshore Liquefied Natural Gas (LNG) Facilities and its supporting infrastructure at Bladin Point; and
- Manigurr-ma Village at Howard Springs.

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 but excludes the Manigurr-ma Village and offshore infrastructure (see **Figure 1-2**).

This document is the *EPA7 Annual Report 2017 – Environmental Impact Monitoring Program* (EPA7 Report [2017]), that reflects the environmental monitoring carried out from 1 May 2016 to 30 April 2017 (the annual monitoring period).

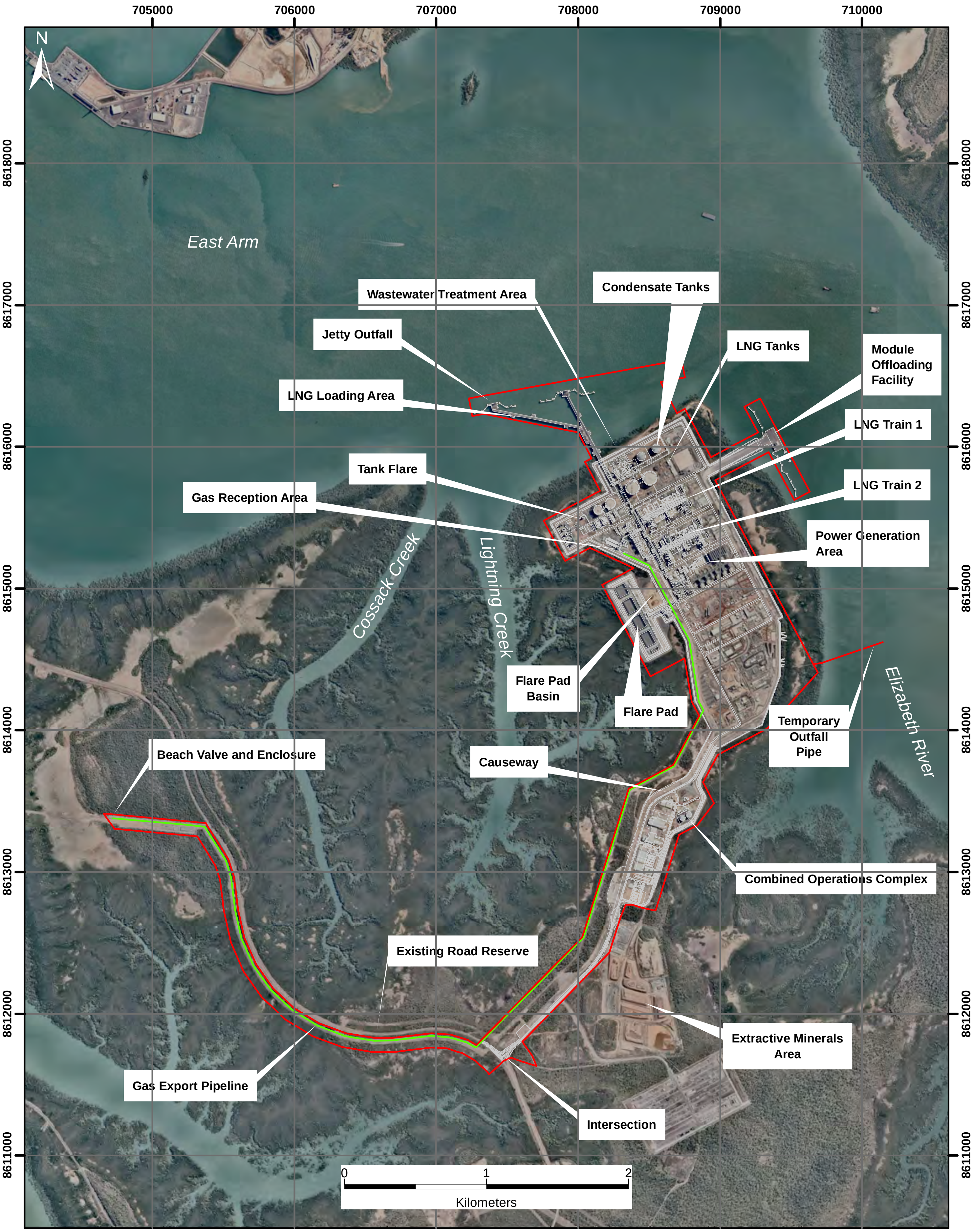
1.2 Purpose

This EPA7 Report has been prepared to comply with Condition 28 of the Environment Protection Approval (EPA7 [as amended]) for the Project and provides a synopsis of the monitoring undertaken during the annual monitoring period.



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

Project Location		
Figure 1-1	INPEX Bladin Point	GREENCAP
Date: *14/07/2017*	**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**	GREENCAP
Date: *14/07/2017*	**Author:** malcolm.nunn **Map Scale (@A4):** 1:35,000	
Revision: A	**Coordinate System:** GDA 1994 MGA Zone 52	

2. ENVIRONMENTAL STRATEGY

2.1 Construction Environmental Management Plan

The *Ichthys Onshore LNG Facilities - Construction Environmental Management Plan* (INPEX Operations Australia Pty Ltd, 2017) (L092-AH-PLN-10001) (hereafter referred to as the CEMP) was developed for the onshore LNG facilities at Bladin Point, in accordance with the requirements of EPA7 (as amended) and the Development Permit (DP12/0065) for 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, commissioning and demobilisation phases of the Project.

2.2 Environmental Impact Monitoring Program

An *Environmental Impact Monitoring Program* (AEC Environmental Pty Ltd, 2015) (L290-AH-PLN-10013) (EIMP [Rev 6]) was prepared to meet Condition 21 of EPA7 (as amended). The document establishes the monitoring framework for the detection of potential impacts associated with the construction of the Project. A revised EIMP was approved by the Northern Territory Environment Protection Authority (NT EPA) on 9 June 2017 and will govern the monitoring framework for the 2017/18 annual monitoring period.

The monitoring programs for the following aspects were undertaken as part of EIMP (Rev 6):

- Surface water monitoring;
- Groundwater quality monitoring;
- Mangrove community health, sediments and bio-indicator monitoring;
- Air quality (dust) monitoring;
- Airborne noise monitoring;
- Weed monitoring; and
- Adaptive response monitoring.

In addition to the results of the monitoring programs listed above, flora and fauna reporting was included in EIMP (Rev 6).

Table 2-1 summarises the aims and objectives of each monitoring strategy.

Table 2-1 CEMP Objectives and Targets Relevant to EIMP (Rev 6)

Management Strategy	Objectives	Performance Criteria
Surface Water Management	To protect surface water quality from Project-related activities	No detectable changes in surface water quality in the receiving environment above relevant water quality parameters listed in Table 6-14 of the CEMP and in excess of 10% of concurrently measured background concentrations (defined as the 80th percentile of the reference site database).
		Stormwater actively discharged from Site does not exceed the relevant discharge trigger values listed in Table 6-14 of the CEMP.
		Construction water discharged from Site does not exceed the relevant discharge trigger values listed in Table 6-14 of the CEMP.
		Treated effluent discharged from Site does not exceed the water quality criteria listed in WDL 192 (as amended).
		Surface water reused on Site is compliant with the criteria for reuse in Table 6-14.
		Spent hydrotest water discharged from Site via the regulating drain is compliant with WDL 211 (as amended).
		Spent hydrotest water discharged via the temporary MOF outfall is compliant with WDL 211 (as amended).
		Treated effluent discharged from the permanent jetty outfall does not exceed water quality criteria as specified in EPA7 (as amended).
Groundwater Management	To minimise changes in groundwater levels and/or quality resulting from construction activities	No statistically significant trend showing a deterioration of groundwater levels outside of historical background seasonal fluctuations and that is attributable to construction activities.
	To minimise changes in groundwater levels and/or quality resulting from construction activities	No statistically significant trend showing a deterioration of groundwater quality listed in Table 6-29 of the CEMP and in excess of 10% of seasonal background concentrations and no plume trend that is attributable to construction activities.
Acid Sulphate Soil (ASS) Management	To minimise the impacts of ASS resulting from construction activities on sediments and bio-indicators	Zero incidents of exceedances in the intertidal sediment quality criteria listed in Table 6-22 of the CEMP attributed to Project activities.
		Zero incidents of exceedances in the bioavailability of heavy metals in bio-indicators criteria in Table 6-23 attributed to Project activities.
Erosion and Sedimentation Management	To minimise transport of sediment from the Site into immediate surroundings including adjacent land, intertidal areas and receiving surface waters	Stormwater actively discharged from a controlled sediment basin to receiving waters complies with the water quality criteria in Table 6-14 of the CEMP.
Dust and Air Quality Management	To minimise impacts of dust generation on the nearby receptors (mangroves and adjacent communities) during construction	No significant visible dust attributable to the Project outside the Site.
		Compliance with the air quality criteria listed in Table 6-37 of the CEMP.

Management Strategy	Objectives	Performance Criteria
Dust and Air Quality Management (cont.)		No deterioration of greater than 30% in mangrove community health.
		No increase beyond 5 cm in ground level, averaged over 1 m^2 and a 12 month period attributed to sediment (veneer deposition in comparison to reference sites).
Noise and Vibration Management	To minimise the impacts of construction noise, including from commissioning, and vibration on local communities (nearest sensitive receptors).	No environmental nuisance infringements as a result of construction activities.
		No exceedance of the noise limits defined in Table 6-43 of the CEMP which correlate with noise complaints.
Flora and Fauna Management	To minimise disturbance to flora and alteration of mangrove communities outside the Site boundary due to Project activity.	Vegetation clearing within the approved clearing boundary.
		No detected impact to mangroves outside the Site boundary attributable to the works (acceptable change in mangrove canopy cover is <30% reduction in canopy cover and in tree condition, including pneumatophores).
	To avoid injury or death to native terrestrial fauna related to Project activities.	Zero incidents of death or injury to native fauna attributable to Project activities.
Weed and Pest Management	To prevent the 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.
		Effective and strategic control of weeds.

3. SITE INFORMATION

3.1 Site Identification

The Site is located at Bladin Point on Middle Arm Peninsula in Darwin Harbour approximately 16 km south-east of the City of Darwin and occupies an area of 348 hectares[1] (ha) (excluding the Extractive Minerals Area) (**Figure 1-1**). 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 surrounded by the following land uses:

- North – Darwin Harbour and East Arm Peninsula (approximately 2.5 km to the north-west);
- East – Elizabeth River;
- West – Lightning Creek and Wickham Point beyond; and
- South – Bladin Central Enterprise Park (approximately 2 km to the south).

The City of Palmerston (Palmerston) is located approximately 4 km to the north-east and the existing Darwin Liquefied Natural Gas Plant is located approximately 2 km to the west of the Site.

3.2 Surrounding Environment

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.

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.

Bladin Point is located in the upper estuary area of Darwin Harbour. 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 Water Quality Objectives [WQOs]) (NRETAS, 2010a), which states the following:

> *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.*

Bladin Point is considered to be part of the Darwin Coastal Bioregion. The flora of Bladin Point, prior to clearing, was dominated by woodland and monsoon vine forest with fringing patches of mixed low woodland species and *Melaleuca* forest. The woodland community mostly consisted of *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.

[1] This value was reported as 406 ha in AEMR (2016), which was an error. The terrestrial footprint for the onshore development area is 413 ha (including the Extractive Minerals Area) and includes the land that has already been cleared or modified.

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 (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 schultzii* (Brocklehurst *et al.*, 1996).

3.3 Geology and Hydrogeology

Aquifers within the Site occur within the Cretaceous and Proterozoic sediments and rocks (URS, 2009 and Appendix 18, *Ichthys Project Environmental Impact Statement* [INPEX Browse, Ltd, 2010] [EIS]). The uppermost aquifer at Bladin Point occurs in the clayey sand/gravel horizons of the Cretaceous Darwin Formation. The Darwin Formation is underlain by weathered Proterozoic rocks represented by a cemented gravel horizon. Cretaceous sediments covering the gravel horizon comprise sand, clay and silt.

Groundwater quality assessments have previously been undertaken on the aquifers in the Darwin rural area. Regionally, the aquifer is included in the Cretaceous rock/sediments, which are present beneath the Site as part of the Cretaceous Darwin Member of the Bathurst Island formation. The formations are reported to have acidic conditions, i.e. groundwater within this aquifer is typically of low pH, as presented in Radke *et. al.* (1998), which states:

"*Darwin rural groundwater have a wide range of pH (4.1 to 7.6), within which acidity is the main problem. 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 <10 mg/L), acidic (approximately pH 5 at the borehead) and very corrosive (Jolly, 1983).*"

Within the Darwin Region, the regional groundwater are known to contain arsenic and other metals. NRETAS (2008) refers to the following:

"*On the basis of geological formation, three main zones were defined with two zones of elevated risk of bores producing groundwater with arsenic concentrations above the Australian Drinking Water Guidelines. Zones with high risk consists of four formations (Burrell Creek Formation, Mount Bonnie Formation, Acacia Gap Member, Wildman Siltstone) with a high possibility of mineralization as the source of elevated arsenic concentrations in groundwater.*"

The Burrell Creek Formation is one of the key formations which underlays the Site. The report indicates that arsenic concentrations may vary seasonally as a result of groundwater level fluctuations. Also noted is the increase in arsenic concentrations by the oxidation of sulfidic minerals in the aquifer. A review of the NRETAS dataset has indicated that the groundwater from the Burrell Creek formation contained elevated levels of aluminium, cadmium, iron, manganese, lead and zinc. Baseline monitoring undertaken for the EIS (INPEX Browse Ltd, 2010) reported elevated concentrations of aluminium, cadmium, copper, manganese, nickel and zinc in groundwater at the Site before the commencement of the Project. This information indicates that naturally acidic groundwater with the presence of the above dissolved metals has a wide distribution in the Darwin Region and in the groundwater from the Burrell Creek Formation in particular.

3.4 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.

Climatic data has been recorded at the onsite weather station since October 2012 and collects data on rainfall, temperature, humidity, wind speed and wind direction.

During the annual monitoring period, the Site received 3,024.0 mm of rainfall, with rain falling on 145 days, mainly in the wet season. October was the hottest month with a temperature range of 23.4°C minimum to 38.0°C maximum. A summary of the climatic data collected during the annual monitoring period is presented in **Figure 3-1**.

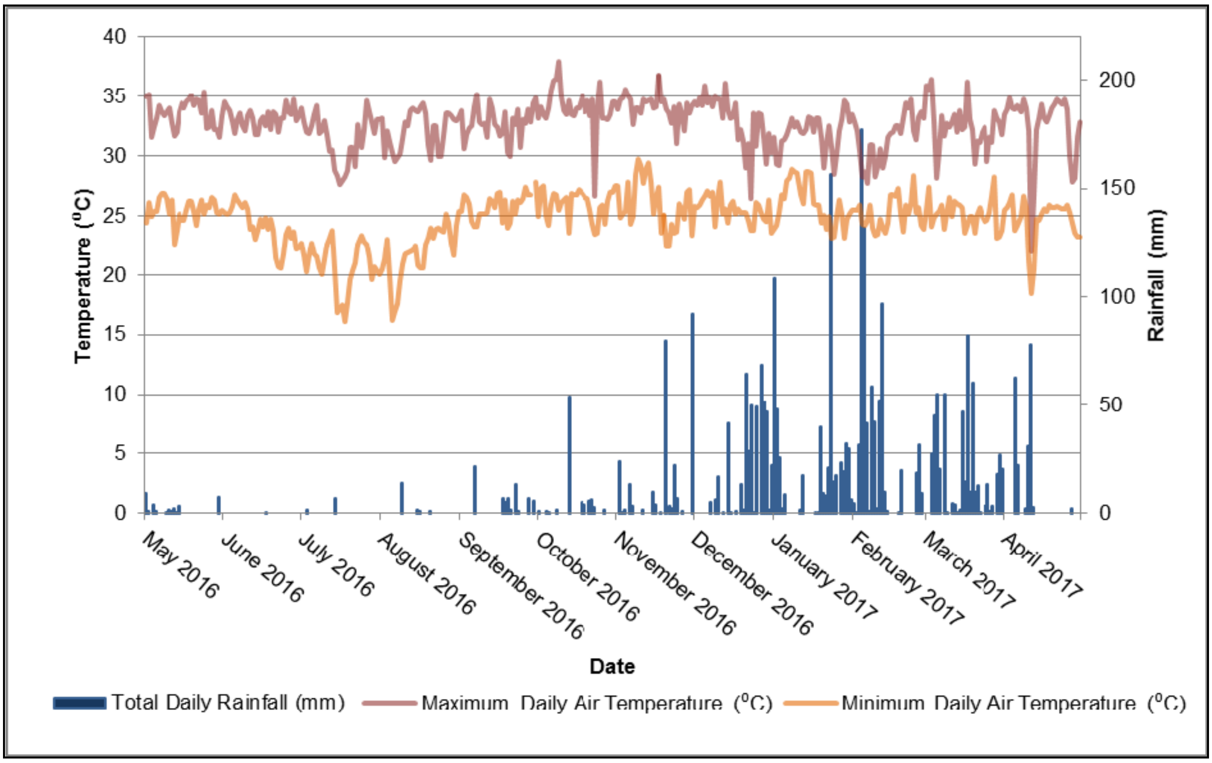


Figure 3-1 Summary of Climatic Data, May 2016 – April 2017

Rainfall recorded during the annual monitoring period was substantially higher than the historical average for Darwin (1,728.2 mm) and the average rainfall for all previous annual monitoring periods (1,815.9 mm). The 2016 dry season had unusually high rainfall with 70.4 mm of rainfall in September 2016, and a dry season total of 119.6 mm compared to an onsite historical average of 41.4 mm.

During the dry season, the prevailing wind direction was easterly to south-easterly while in the wet season the prevailing wind direction was westerly to north-westerly.

Wind speeds during the annual monitoring period ranged between 2 and 10 metres per second (m/s) and the average maximum wind speed was 8.2 m/s.

3.5 Site Construction Activities – May 2016 to April 2017

Construction activities undertaken on Site during the annual monitoring period are summarised in **Table 3-1** below.

Table 3-1 Summary of Construction Activities, May 2016 to April 2017

Type of Activity	Additional Details
Earthworks	• Excavation to expose tie-ins and backfilling at the Combined Cycle Power Plant in B200; • Excavation and backfilling of the northern trench in B100; • Tie in between the offshore and onshore pipeline at the GEP beach valve and reinstatement; • Street lighting with excavation of coil pits and installation of footings for junction boxes at E300; • High voltage trench excavation and backfilling at B100; • Excavation and backfilling for 132 kV cable replacement for the gas turbine generators 1 and 2 (GTG1 and 2) in B200; and • Excavation and recovery of cables under buildings in B100.
Facilities	• Installation and testing of the laboratory gases and equipment at Building Works in E300; • Closeout of punch-list items for the handover of Area SP-1A buildings in Area E300; • Distribution Board terminations were energised and commissioning was underway at the Area SP-1C warehouse in Area E300; • Closeout of punch-list items at the Operations Office, Operations Training and Canteen Building in E300; • Closeout of demise premise punch-list items and installation of furniture, fixtures and equipment at the Central Control Building and Fire Station in E300; • Installation of plywood lining, sprinkler fire piping and fit offs, epoxy flooring, racking installation, distribution of board terminations and sprinkler fire piping and fit offs at the Warehouse in E300; • Services rough-in and fit offs and installation of pallet racking, epoxy flooring and slabs in refuelling area, and fit-out of telecoms equipment and distribution board terminations at the Hazardous Materials Warehouse and Dangerous Goods Stores in E300; • Landscaping with hydro mulching in Area E300; • Heating, ventilation and air conditioning commissioning activities and closeout of punch-list items at the gatehouse in E300; • Lighting and piping works and electrical commissioning was underway at the Operations Training and Canteen Building in E300; • The Southern Carpark was almost complete and awaiting the delivery of the shade structures in E300; • Distribution board terminations, pre-commissioning checks, grid ceilings closed out, whilst partition framing and interior painting, exterior doors and hardware installation, distribution board terminations and instrument/plant air installations, vinyl flooring installation, workshop equipment final placements and connections and welding gas installation at the Main Workshop, Tools Room, Crib Room and Main Administration Building in E300; • Commissioning of distribution boards, Workshop equipment and overhead crane and fire systems at the Main Workshop and Tools, Crib and Admin Buildings in E300; • Heating, ventilation and air conditioning rough-in, closeout punch-list items, commissioning at the Field Workshop/Amenities and services and finishes in the Toilet Block in E300;

Type of Activity	Additional Details
	• Aboveground electrical cable pulling and installation of fire and gas instruments and the installation of the firewall in E300; • Module-to-module hook-ups in Area 200, wi-fi access points and telephone handsets in Area 300, and installation of the firewall and punch list clearing work at Areas B100, B300 and E300; • Acoustic insulation on the Area 200 demethaniser and installation of insulation on nitrogen package valves and flange boxes; • Pressure testing and flushing, lube oil strainer inspection, lube oil skid, LNG loading arm hydraulic lines at the Jetty and installation of Area D100 form generator skids; • Insulation work and painting on the main pipe-rack and fuel gas line at Gas Turbine Generator 5 in B200; • Motor water cooler system bundles were removed for chemical cleaning and preparation for filter house internal cleaning in B200; • All the punch-list items for the nitrogen and demineralised packages in B100; • Pressure testing of the cold flare gas header, which is connected from the plant north to the ground flare area, blowing and reinstatement in B300; • Installation of telecom devices in the Central Control Building, pulling cables in the Operations Training Building and in the Workshop building in E300; • Fire water drain piping installation across Site; • Area E300 sanitary drain line underground tie-in modification; • Installation of the fuel tank and other equipment at the refuelling facility in E300; • Installation of lighting in the compressor areas in Areas 100 and 200; • Module welding at LNG, Propane and Butane Tanks in Areas C100 and C200; • Mechanical works trains hook-up welding work fronts in A100 and A200; • Stabiliser recycle pumps construction and tube testing for feed gas preheater in A100 and A200; • Installation of auxiliary skids for the Compressor Area in A100 and A200; • Compressor piping and compressor piping pneumatic tests in A100 and A200; Overhead crane commissioning and final lube oil flushing at Jetty; • Electrical and instrumentation works in Areas 100, 200, 300, B100, C000, E600; • Installation of aboveground electrical cables in Area 100 and 200; and • Installation of insulation in confined space in Area 100 and 200.
Civil Works	• Earthing, installation of cable trays and bracket fabrication in Area C300; • Workshop wash-down bay civil works in E300; • Civil and landscaping works were progressing well across the Operations Complex with only small areas of pavement left to be installed in E300; • Light poles, luminaires and underground services to re-fuelling facility in E300; • The concrete u-ditch in Area E600; • Pouring of beads concrete, inner tank shell course erection and welding application of mesh lining and the bottom plate at the Propane/Butane Tanks in C200; • Hydrotest water discharge from the Butane Tank in C200; • Hydrotesting of LNG Tank-1 and water transfer to LNG Tank-2 in C100; • Hydrotesting of LNG Tank-2 and hydrotest water discharge in C100; • Pavements, finishing grading and chip sealing for permanent roads in C100; • Light pole/luminaire installation was complete and street lights are progressively being energised; • Seal welding the roof rafter and roof plate LNG Tank-1 and Tank-2 in C100; and • Street light pole and junction box installations to the slug catcher and impoundment pond pump in A300.

4. RESULTS AND DISCUSSION

4.1 Surface Water

4.1.1 Monitoring Methodology

The surface water management objectives for the Site seek to minimise changes in receiving water quality resulting from the disturbance or dewatering of acid sulphate soils (ASS) and discharges offsite of water containing nutrients, dissolved metals, hydrocarbons or any other contaminants. In accordance with EIMP (Rev 6) and EPA7 (as amended), surface water monitoring during the annual monitoring period was undertaken at[2]:

- Fifteen offsite marine impact sites located in Darwin Harbour around the Site;
- Four reference sites located in Darwin Harbour near East Arm;
- Five telemetered marine buoy monitoring sites located in Darwin Harbour around the Site;
- Five monitoring locations at the edge of the mixing zone around the Jetty outfall; and
- Four auto-samplers situated within drainage outfalls at strategic locations in the drainage structures to monitor stormwater passively discharging from Site.

Figure 4-1, Figure 4-2 and **Figure 4-3** present the surface water monitoring locations.

The following analytes were recorded in situ:

- Electrical conductivity (EC);
- Dissolved oxygen (DO);
- Oxidation reduction potential (ORP);
- pH;
- Temperature;
- Salinity;
- Turbidity; and
- Total dissolved solids (TDS).

Electrical conductivity, ORP, pH, salinity and turbidity concentrations were also recorded by the auto-samplers.

Each of the surface water samples collected at onsite and offsite locations were analysed for:

- Total and dissolved metals;
- Total suspended solids (TSS);
- Alkalinity;
- Nutrients (ammonia, oxides of nitrogen, total kjeldahl nitrogen, total nitrogen, filterable reactive phosphorus [FRP] and total phosphorus); and
- Major ions and hardness.

Surface water locations were also analysed for the following additional parameters, as required:

- Total recoverable hydrocarbons (TRH);
- Benzene, toluene, ethylbenzene, xylenes, and naphthalene (BTEXN); and
- Biological indicators (*E. coli,* Enterococci, and chlorophyll-a).

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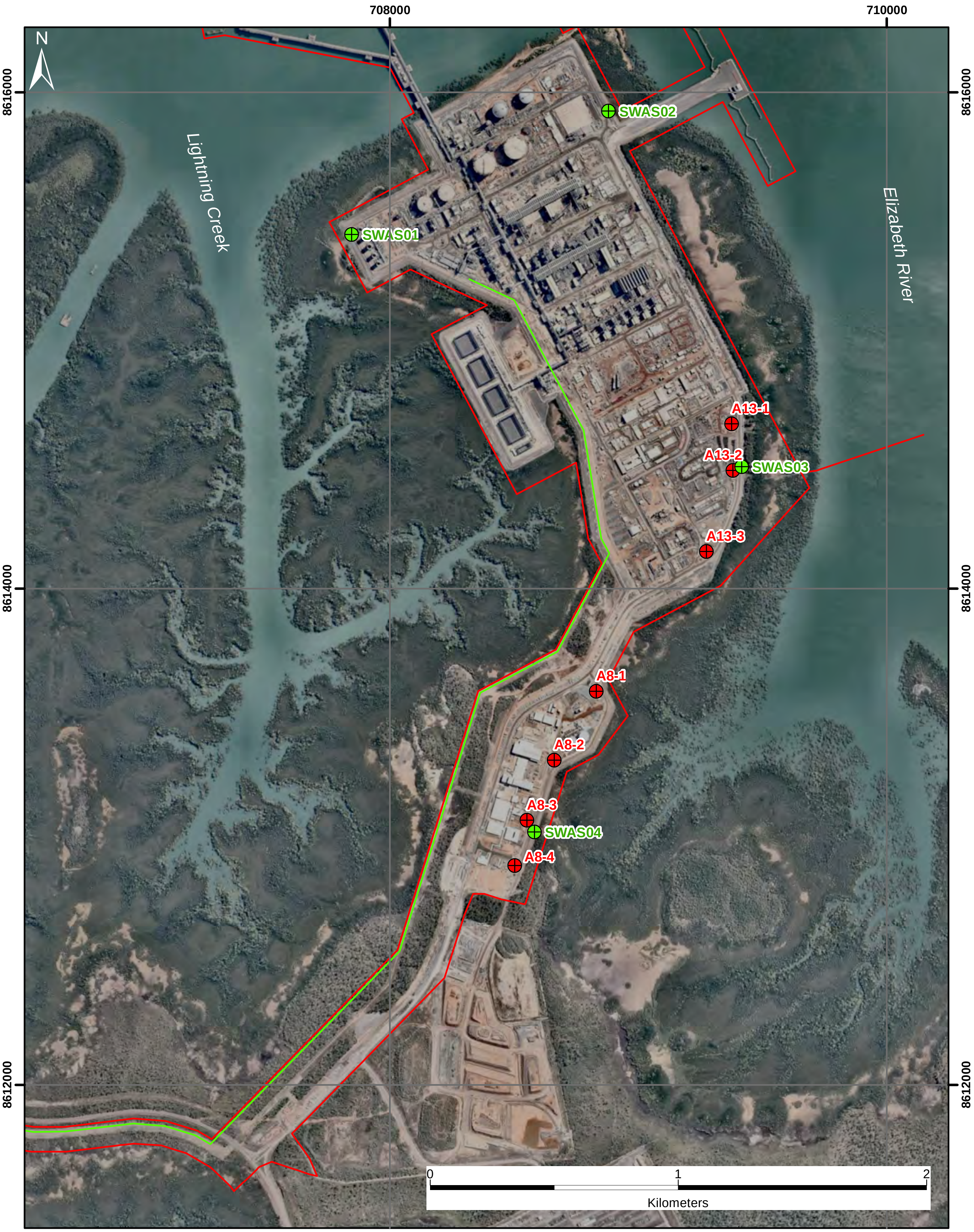
[2] Waste Discharge Licences 192 and 211 (as amended) do not form part of the requirements of EIMP (Rev 6) or EPA7 (as amended) but for the purposes of understanding all potential impacts of Site discharges on the marine receiving environment, these programs are discussed in this EPA7 Report.



Site Boundary

Gas Export Pipeline

Surface Water Monitoring Locations

Auto-Sampler

Onsite Basin

Onsite Surface Water Monitoring Locations

Figure 4-1	INPEX Bladin Point	GREENCAP
Date: *14/07/2017*	**Author:** malcolm.nunn	
	Map Scale (@A4): 1:20,000	
Revision: A	**Coordinate System:** GDA 1994 MGA Zone 52	

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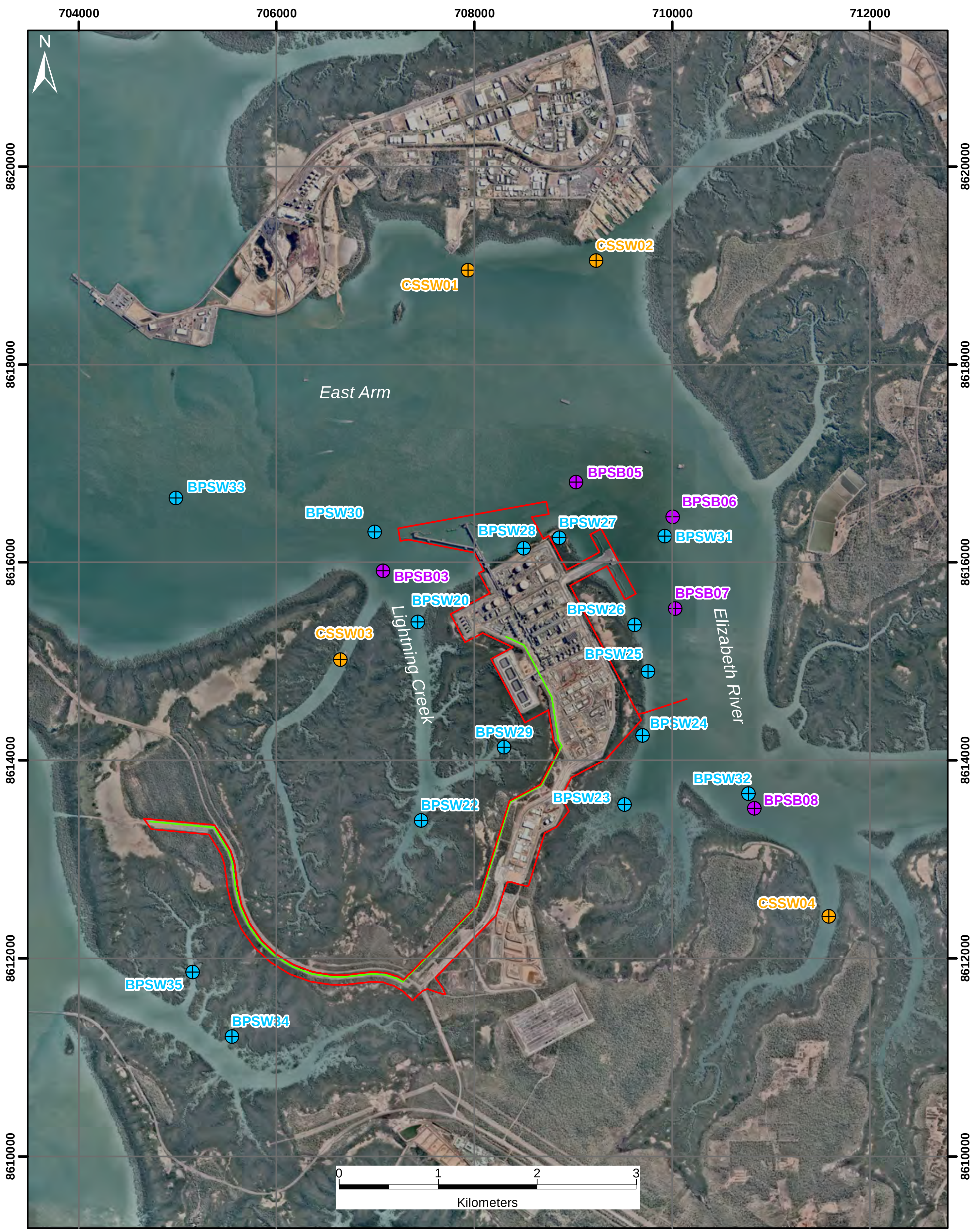


Site Boundary

Gas Export Pipeline

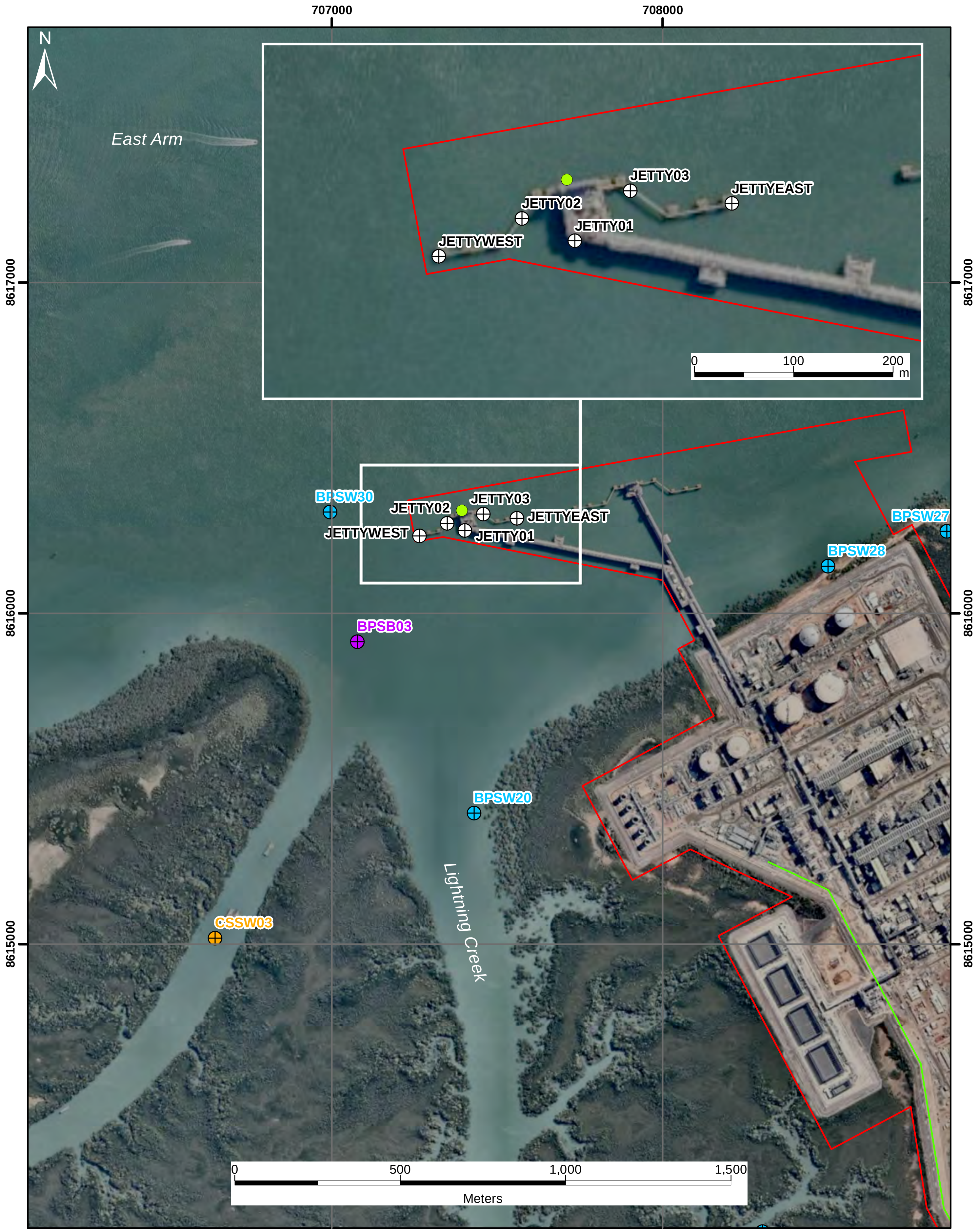
Surface Water Monitoring Locations

Offsite Marine Sampling Locations

Reference Sites

Marine Buoy Locations

Offsite Surface Water Monitoring Locations		
Figure 4-2	**INPEX Bladin Point**	GREENCAP
Date: *14/07/2017*	**Author:** malcolm.nunn	
	Map Scale (@A4): 1:50,000	
Revision: A	**Coordinate System:** GDA 1994 MGA Zone 52	



Site Boundary

Gas Export Pipeline

Surface Water Monitoring Locations

Jetty Outfall Monitoring Location

Jetty Outfall Diffuser

Offsite Marine Sampling Locations

Reference Sites

Marine Buoy Locations

Jetty Outfall Monitoring Locations		
Figure 4-3	**INPEX Bladin Point**	GREENCAP
Date: *21/07/2017*	**Author:** Malcolm.Nunn **Map Scale (@A4):** 1:15,000	
Revision: A	**Coordinate System:** GDA 1994 MGA Zone 52	

4.1.2 Field and Analytical Results

4.1.2.1 Marine Surface Water Quality

Salinity

The salinity recorded at the marine surface water locations ranged from 8.74 to 39.00 g/L with a median of 35.35 g/L during the annual monitoring period.

Further analysis of the salinity data revealed the following:

- During the dry season, salinity remained relatively stable with values ranging between 33.89 and 39.00 g/L with a median of 35.83 g/L;
- Median salinity was highest in November 2016 with a value of 38.18 g/L;
- From December 2016 onwards, salinity decreased (median of 35.73 g/L) as a result of dilution associated with a number of heavy rainfall events;
- The wet season salinity in this annual monitoring period (median of 32.37 g/L) was marginally lower than the 2015/16 wet season (median of 34.00 g/L) but significantly higher than the 2014/15 wet season (median of 24.30 g/L). This result is unusual given the fact that the 2016/17 wet season was the wettest since monitoring began on the Project; and
- Salinity during the dry season (median 35.83 g/L) was higher than the salinity during the 2014 and 2015 dry seasons (33.00 and 33.10 g/L, respectively).

Figure 4-4 presents the salinity data trends from May 2015 to April 2017.

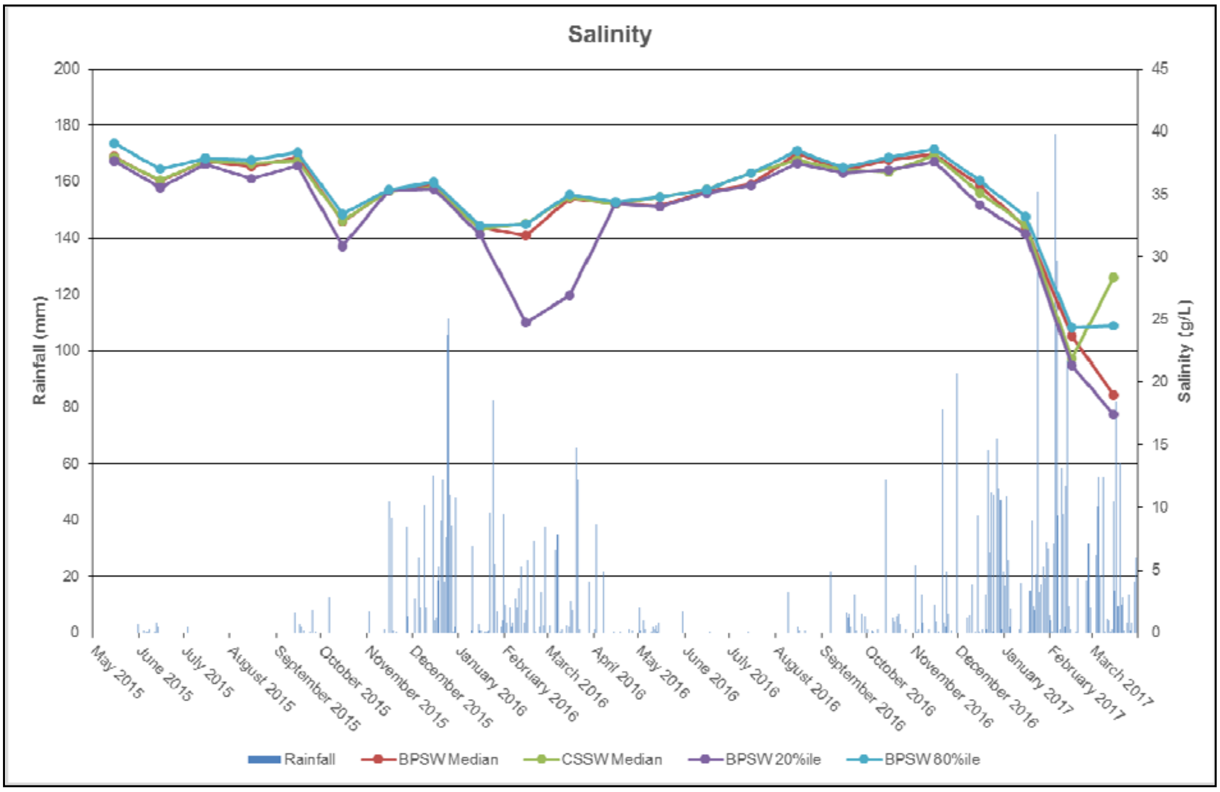


Figure 4-4 Marine Surface Water Salinity vs Daily Rainfall, May 2015 to April 2017

Dissolved Oxygen

The DO at marine surface water locations ranged from 53.9 to 103.0% saturation with a median of 84.1% saturation during the annual monitoring period. Results for DO were lowest in February 2017 with a median of 75.9% saturation and the highest values were recorded in July 2016 with a median of 88.3% saturation.

Fewer DO exceedances were recorded at impact sites in the 2016/17 wet season compared to the 2014/15 and 2015/16 wet seasons (38 in 2016/17 versus 39 in 2014/15 and 54 in 2015/16). During the 2016 dry season, 11 exceedances were recorded at impact sites, compared to 38 in 2014 and 16 in 2015.

The monitoring results were consistent across impact sites and reference sites, which indicated that DO patterns in the marine receiving environment were not impacted by Site activities or discharges.

pH

The pH at the marine surface water locations ranged from 6.89 to 8.67 pH units with a median of 7.85 pH units during the annual monitoring period. Further analysis of the pH data revealed the following:

- The pH remained relatively stable between the wet and dry season. During the dry season, the pH ranged from 6.92 to 8.20 pH units with a median of 7.91 pH units. During the wet season, the pH ranged from 6.89 to 8.67 pH units with a median of 7.77 pH units;
- The highest single pH reading, and only exceedance, was recorded in February 2017 with a value of 8.67 pH units, and only marginally exceeded the trigger value;
- The highest pH readings were observed in May 2016, with a median of 8.04 pH units;
- The lowest pH readings were observed in June, with a median of 7.56 pH units; and
- pH results did not correlate with DO and ORP during the annual monitoring period.

pH was influenced by rainfall events, with a decrease of up to 0.9 pH units generally associated with heavy rainfall events. The greatest pH range was recorded at marine buoy BPSB08, ranging from 6.2 to 8.1 pH units during the annual monitoring period.

The monitoring results for pH were consistent across impact sites and reference sites, which indicated that pH patterns in the marine receiving environment were not impacted by Site activities or discharges.

Turbidity

Based on the monthly surface water monitoring data, turbidity at marine surface water locations ranged from 0.09 to 20.90 NTU during the annual monitoring period with a median of 3.60 NTU. During the dry season, turbidity ranged from 0.70 to 10.82, with a median of 3.07 NTU. During the wet season, turbidity ranged from 0.09 to 20.90 NTU, with a median of 4.45 NTU. There was one turbidity exceedance recorded during the annual monitoring period, in March 2017 (20.90 NTU).

The data collected to date indicates that turbidity in Darwin Harbour is primarily driven by tides, however, there is some influence from rainfall, particularly high rainfall events and the subsequent sediment runoff from the upstream catchment areas.

Based on the continuous data collected at the marine buoys, turbidity trends showed daily tidal influence, with two peaks and two troughs per 24 hour period. The peaks coincided with both the high and low tides within a 24 hour period and the turbidity range due to tidal influence was between 1 and 50 NTU. The number of exceedances recorded in the annual monitoring period was lower than that recorded in previous Annual Environmental Monitoring Reports (AEMR), namely AEMR (2013), AEMR (2014), AEMR (2015) and AEMR (2016).

The monitoring results for turbidity were consistent across impact sites and reference sites which indicated that turbidity patterns in the marine receiving environment were not impacted by Site activities or discharges.

Total Suspended Solids

The TSS at the marine surface water locations ranged from <1 to 55.0 mg/L with a median of 8.8 mg/L during the annual monitoring period. Further analysis of the TSS data revealed the following:

- During the dry season, TSS ranged from <1 to 48.0 mg/L, with a median of 6.1 mg/L;
- During the dry season, TSS was highest in August 2016 with a median value of 15.0 mg/L;
- During the wet season, TSS ranged from <1 to 55.0 mg/L, with a median of 11.0 mg/L;
- During the wet season, TSS was lowest in October with a median value of 3.8 mg/L and highest in January 2017 with a median value of 22.0 mg/L; and
- During the monitoring period, TSS was lowest in July 2016, with a median of 3.5 mg/L.

This annual monitoring period presented a different TSS trend to that reported in AEMR (2015) and AEMR (2016) with fewer exceedances recorded during the dry season and more exceedances during the wet season. However, these results were more consistent with those recorded in AEMR (2013) and AEMR (2014).

The monitoring results for TSS were consistent across impact sites and reference sites, which indicated that TSS patterns in the marine receiving environment were not impacted by Site activities or discharges.

Surface water monitoring undertaken as part of WDL 211 recorded three reportable TSS exceedances in October 2016. These were separate, single exceedances and were not indicative of a TSS plume from Site.

Nutrients

Ammonia

Ammonia results ranged from <5 to 180 µg/L with a median of 12 µg/L in the annual monitoring period. Further analysis of the ammonia data revealed the following:

- The highest ammonia concentrations were recorded in March 2017 with a median of 18 µg/L;
- The lowest concentrations were recorded in December 2016, with a median of 6 µg/L;
- The median was 13 µg/L during the dry season and 12 µg/L during the wet season; and
- There was no apparent correlation between rainfall and ammonia concentrations in the annual monitoring period.

Insufficient knowledge of seasonal ammonia cycling in Darwin Harbour exists to relate the current monitoring results, although previous studies consider that ammonia concentrations in the Harbour do not vary remarkably from 10 µg/L (Butler *et al.*, 2013), which was comparable to the median reported here. These authors do concede that ammonia concentrations may be higher in creek arms due to mineralisation, presumably through the lower oxygen environments that exist in the dry season. Alternatively, increased water input through the wet season may reduce ammonia by flushing and/or advection through the same environments.

The dry season isopleth showed relatively stable ammonia results across all reference sites and impact sites with one exceedance recorded at an impact site and one at a reference site. The wet season isopleth showed exceedances at three impact sites.

A comparison of ammonia exceedances between AEMR (2013), AEMR (2014), AEMR (2015) and AEMR (2016) demonstrated that fewer ammonia exceedances were recorded during this annual monitoring period compared to previous monitoring periods.

Surface water monitoring undertaken as part of WDL 192 detected a reportable ammonia exceedance in October 2016 with a value of 24 µg/L. Ammonia was reported at 81 µg/L at the STP Tank outlet. Following dilution through the diffuser, the ammonia concentration in the discharge water at the end of pipe was not sufficient to be the source of the exceedance detected at the mixing zone location. The risk of potential environmental harm via algal blooms was also considered low, as evidenced by low chlorophyll-a concentrations (<5 µg/L) and aerobic conditions.

Surface water monitoring undertaken as part of WDL 211 detected a reportable ammonia exceedance of more than double the trigger value in April 2017. There were no ammonia exceedances at the end of pipe, a trigger value exceedance was also reported at a reference site in the month, there were no chlorophyll-a detections and the DO results indicated an aerobic environment. As a result the signatures detected in the mixing zone were not attributed to the discharge event and the risk of environmental harm via algal blooms was assessed to be low.

Oxides of Nitrogen

Results for oxides of nitrogen ranged from <5 to 57 µg/L, with a median of 13 µg/L during the annual monitoring period. Further analysis of the oxides of nitrogen data revealed the following:

- The median was 13 µg/L during the dry season and the wet season;
- The median oxides of nitrogen concentrations decreased from 17 µg/L in June 2016 to 11 µg/L in July 2016;
- Median concentrations increased from September 2016 (7 µg/L) to November 2016 (22 µg/L), and dropped in December 2016 (7 µg/L). Median concentrations then increased from December 2016 to February 2017 (21 µg/L);
- Concentrations were highest in February 2017 with a median of 24 µg/L;
- Concentrations were lowest in September and December 2016 both with a median of 7 µg/L; and
- Oxides of nitrogen results did not correlate with the rainfall recorded during each month.

Insufficient knowledge of seasonal oxides of nitrogen cycling in Darwin Harbour exists to relate the current monitoring results. The dry season isopleth showed one exceedance at a reference site in the creek to the west of the Site. The wet season isopleth showed no trigger value exceedances.

Overall, fewer exceedances were recorded in this annual monitoring period compared to all previous monitoring periods. This was particularly evident during the wet season which had substantially fewer exceedances compared to all other annual monitoring periods.

Surface water monitoring undertaken as part of WDL 211 detected an oxides of nitrogen exceedance in August 2016 with a value of 110 µg/L. This was a single exceedance and monitoring of discharge water at the end of pipe did not report elevated oxides of nitrogen concentrations prior to discharge. As a result, the signatures detected in the mixing zone were not attributed to the discharge events.

There was an oxides of nitrogen exceedance, with a median concentration equal to twice the trigger value (40 µg/L), detected at the WDL 211 impact sites in March 2017. The end of pipe oxides of nitrogen concentration was reported as being below the limit of detection at <5 µg/L. Monitoring of discharge source water did not report elevated oxides of nitrogen concentrations prior to discharge. As a result, the signatures detected in the mixing zone were not attributed to the discharge events and the risk of environmental harm via algal blooms was low, as evidenced by the low chlorophyll-a concentrations.

There was a reportable oxides of nitrogen exceedance, with three consecutive values above the median, detected in WDL 211 monitoring in April 2017. There were no exceedances at the end of pipe and no chlorophyll-a detections during the reportable exceedance events. Furthermore DO results indicated an aerobic environment. As a result, the signatures detected in the mixing zone were not attributed to the discharge events and the risk of environmental harm via algal blooms was low.

Total Nitrogen

Results for total nitrogen ranged from 14 to 2,600 µg/L with a median of 160 µg/L during the annual monitoring period. Further analysis of the total nitrogen data revealed the following:

- The median was 165 µg/L during the dry season, with median concentrations ranging from 110 µg/L (May 2016) to 240 µg/L (July 2016);
- The median was 165 µg/L during the wet season, with median concentrations ranging from 100 µg/L (January 2017) to 2,300 µg/L (April 2017);
- An increasing trend was observed from May to July 2016 (median concentrations 110 and 190 µg/L respectively), before dropping to 110 µg/L in August 2016; and
- A decreasing trend was observed from November to December 2016 (median of 270 and 250 µg/L respectively), which decreased further to 110 µg/L in January 2017 before slowly increasing to 300 µg/L in April 2017.

Total nitrogen is mostly comprised of organic nitrogen, either attached to sediment or (more commonly) as part of the natural degradation processes of organic material. Its generation, therefore, is independent of wet and dry season cycles (Butler *et al*., 2013) and thus, unlike dissolved forms such as ammonia or oxides of nitrogen, it may not have a stronger signal due to runoff associated with the wet season.

In previous monitoring periods, exceedances mostly occurred in the months of October, November and December. During this monitoring period, there were 14 exceedances during the dry season and 23 during the wet season. This was attributed to the relatively wet dry season. Total nitrogen can correlate with increased sediment levels, and the rainfall during the dry season could have increased the amount of sediment flowing into Darwin Harbour. There were more exceedances during this annual monitoring period compared to AEMR (2014) and AEMR (2015).

Total Phosphorus

Results for total phosphorus ranged from <5 to 230 µg/L, with a median of 28 µg/L during the annual monitoring period. Further analysis of the total phosphorus data revealed the following:

- The median was 230 µg/L during the dry season and 200 µg/L during the wet season;
- Elevated total phosphorus concentrations were recorded in November 2016 (median of 190 µg/L) and in July and August 2016 (medians of 120 µg/L);
- Concentrations were low in May 2016 (median of 26 µg/L) and increased to a median of 120 µg/L in August 2016;
- Concentrations decreased in September 2016 (median of 28 µg/L) and steadily increased towards November 2016;
- Concentrations remained relatively stable during the wet season with medians between 19 and 23 µg/L between December 2016 and April 2017; and
- Results across the annual monitoring period could not be correlated with rainfall.

Total phosphorus concentrations displayed a different seasonal pattern to previous monitoring periods, in that the median concentrations were higher in the dry season compared to the wet season. During the 2016 dry season, concentrations exceeded the trigger value at impact sites and reference sites and concentrations were higher than those observed in previous dry seasons.

In previous annual monitoring periods, total phosphorus was observed at higher concentrations during the wet season compared to the dry season and was assessed to be related to organic material washed from the upstream Elizabeth River catchment area.

During the annual reporting period, the highest total phosphorus concentrations were associated with more saline water and were not significantly influenced by wet season runoff. In addition, the total phosphorus concentrations were not significantly influenced by TSS concentrations which confirmed that seasonal rainfall events were not the primary load for total phosphorus.

Similar to the nitrogen cycle the phosphorus cycle is strongly regulated by the activity of micro-organisms (Dyhrman *et al.* 2007) but it differs from nitrogen in also being highly particle-reactive (Butler *et al.* 2013). Given that total phosphorus exceedances were also observed at reference sites during the dry season it was assessed that they were related to harbour-wide effects of the phosphorus cycle and the resuspension of marine sediments.

There were fewer exceedances recorded during the wet season compared to AEMR (2013), AEMR (2014) and AEMR (2015). More exceedances were recorded during the dry season compared to AEMR (2013), AEMR (2014), and AEMR (2016), but were comparable to AEMR (2015).

There was a total phosphorus exceedance that was twice the trigger value detected at one of the WDL 211 impact sites in July 2016 (100 µg/L). This was a single exceedance and monitoring of discharge water at the end of pipe did not report elevated total phosphorus concentrations prior to discharge. As a result, the signatures detected in the mixing zone were not attributed to the discharge events.

Surface water monitoring undertaken as part of WDL 211 recorded a reportable total phosphorus exceedance in October. Elevated total phosphorus concentrations were ubiquitous in Darwin Harbour during October with exceedances recorded at 11 EIMP (Rev 6) monitoring locations, including one reference site. Following dilution through the diffuser, the total phosphorus concentration in the discharge water at the end of pipe was not sufficient to be the source of the exceedance detected at the mixing zone location. It was also concluded that the risk of environmental harm via algal blooms was low, as evidenced by the by low chlorophyll-a concentrations in October.

Filterable Reactive Phosphorus

The results for FRP ranged from <1 to 25 µg/L, with a median of 2 µg/L during the annual monitoring period. Further analysis of the FRP data revealed the following:

- Elevated FRP concentrations were recorded in November (median of 4 µg/L). These elevated results did not correlate with any rainfall events; and
- Results were consistent throughout the remainder of the annual monitoring period with medians ranging from <1 to 3 µg/L.

Filterable reactive phosphorus is the reactive form of this nutrient and is readily available for uptake by plants. Its generation would occur from degradation processes acting on the organic phosphorus (a major component of total phosphorus) in Darwin Harbour which would have been delivered from the catchment. Phosphorus cycling within Darwin Harbour is not a well understood process.

A single exceedance was recorded in August 2016 in a creek south-west of the GEP corridor at impact site BPSW34 and a review of Site activities did not identify a potential source of this exceedance. The number of exceedances in the annual monitoring period were consistent with previous annual monitoring periods.

Nutrient Summary

The results at the majority of the surface water monitoring locations did not exceed the adopted trigger values for nutrients and overall the number of exceedances and analyte concentrations deceased in comparison to previous annual monitoring periods. There were fewer ammonia, oxides of nitrogen and total phosphorus exceedances, but more total nitrogen exceedances, recorded in the annual monitoring period compared to previous monitoring periods.

The months in which multiple nutrient exceedances were typically recorded in the marine receiving environment were in the wet season.

Where nutrient exceedances were recorded in the marine receiving environment during the annual monitoring period, these were demonstrated to be single exceedances or where they were ubiquitous (e.g. total phosphorus) they were related to harbour-wide events. A review of construction activities did not identify a potential source(s) of the single exceedances and where the exceedances were recorded at both impact sites and reference sites, these were not related to Site activities or discharges.

There were instances where reportable exceedances with the WDL 192 and WDL 211 Licence conditions were recorded. Investigations concluded that these exceedances were either single exceedances or were also recorded at EIMP (Rev 6) and WDL reference sites and were therefore not related to Site activities or discharges. It was assessed that the risk of environmental harm from these exceedances was low.

Metals and Metalloids

Marine field and analytical metal and metalloid results obtained during the annual monitoring period were reflective of seasonal trends and historical values based on the extended dataset now collected for the Project.

Filtered Aluminium

The results for filtered aluminium ranged from <10 to 210 µg/L with the majority of the results below the limit of reporting (LOR). Trigger value exceedances for filtered aluminium were recorded at three impact sites and one reference site in January 2017; at one impact site in February 2017; at two impact sites and one reference site in March 2017; and, at one impact site in April 2017. A review of construction activities did not identify a potential source(s) of these exceedances. The number of filtered aluminium exceedances in this annual monitoring period were consistent with all previous monitoring periods.

Filtered Copper

The results for filtered copper ranged from <1 to 2.0 µg/L. There was a single filtered copper exceedance at an impact site in the annual monitoring period. A review of construction activities did not identify a potential source of this exceedance. There were fewer copper exceedances compared to all previous monitoring periods.

Other Parameters

Chlorophyll-a

The majority of chlorophyll-a results reported values below the LOR with two exceedances recorded at single impact sites in November 2016 and December 2016. When these exceedances were recorded, there was no evidence of any algal blooms in the visual observations in the field records for these sampling rounds. The single chlorophyll-a exceedances did not overlap with any of the total nitrogen, total phosphorus and FRP exceedances in these months. Furthermore, a review of construction activities in November and December 2016 did not identify a potential source of these exceedances.

Surface water monitoring undertaken as part of WDL 211 detected a reportable chlorophyll-a exceedance in October. This was a single exceedance and no exceedances were recorded in the discharge water or at any of the EIMP (Rev 6) monitoring locations in the month of October. It was therefore assessed that the potential for environmental harm was low.

Total Recoverable Hydrocarbons

Total recoverable hydrocarbon detections were recorded at three impact sites in December 2016. Following silica gel clean-up, there were no TRH detections, indicating that these hydrocarbons were from a natural source. Furthermore, a review of construction activities in December 2016 did not identify a potential source of these exceedances.

Biological Parameters

An *E. coli* exceedance was recorded at one impact site in February 2017, and at six impact sites and one reference site in March 2017. The dry season isopleth showed no elevated *E. coli* concentrations at any monitoring locations while the wet season isopleth showed exceedances east of the Site.

An Enterococci exceedance was recorded at one impact site in February 2017, and at nine impact sites and one reference site in March 2017. The dry season isopleth showed no elevated Enterococci concentrations at any monitoring locations while the wet season isopleth showed exceedances east of the Site.

The *E. coli* and Enterococci exceedances recorded in February 2017 were single exceedances and a review of construction activities did not identify a source of these exceedances. In March 2017, the exceedances were recorded at both impact sites and reference sites, and were therefore unrelated to Site activities and discharges.

Monitoring at the WWTP consistently showed low levels of the above bacteria indicating these discharges were not the source of the above exceedances.

Chloride/Sulphate Ratio

Chloride/sulphate ratios can be used to determine whether there has been discharge from ASS-impacted streams into marine receptors. Chloride/sulphate ratios are often <3 in ASS-impacted streams, whereas ratios between ~5 and 7 are expected in estuarine streams (Sammut *et al.,* 1996). A chloride/sulphate ratio of less than four and certainly a ratio less than two, is a strong indication of an extra source of sulphate from previous sulphide oxidation (Mulvey, 1993). Salinity results from the surface water monitoring program, while slightly higher than previous annual monitoring periods, remained consistent with seawater with a number of exceptions that were indicative slightly fresher water (**Figure 4-5**) and it can be concluded that there have not been discharges from ASS-impacted streams into the marine receiving environment. In addition, the data that were collected during this annual monitoring period were similar to all previous annual monitoring periods.

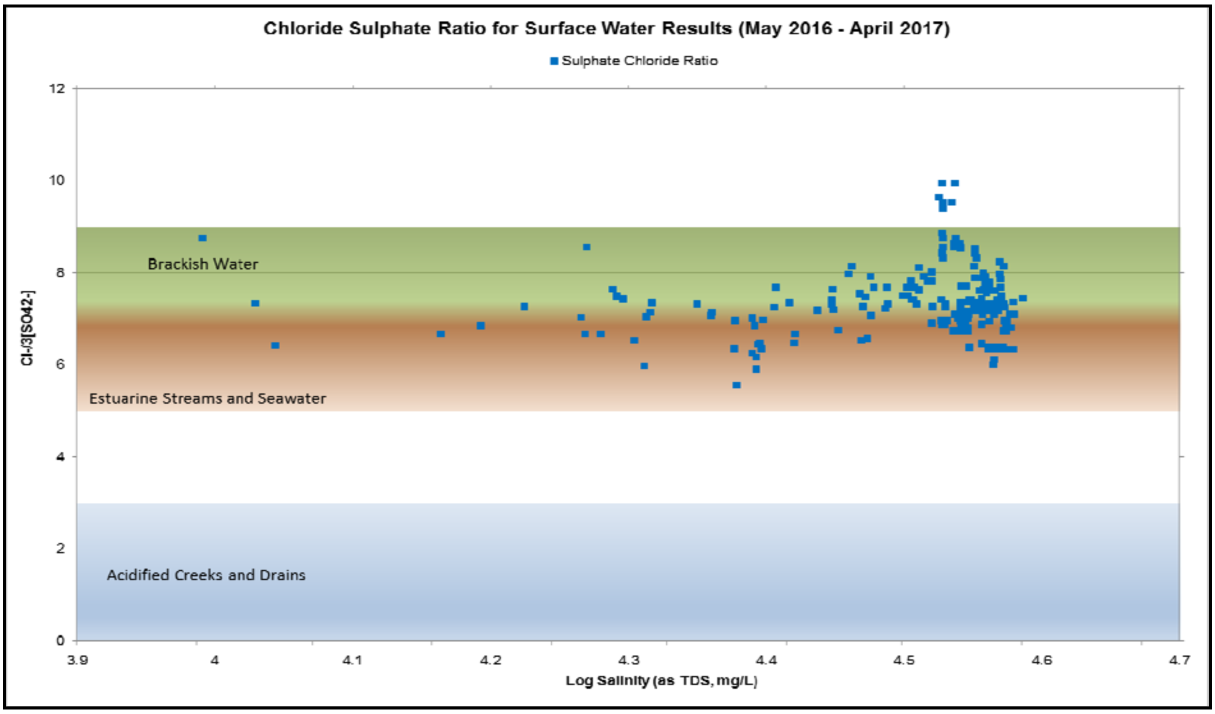


Figure 4-5 **Surface Water Chloride/Sulphate Ratio**

4.1.2.2 Terrestrial Surface Water Quality

The auto-sampler results were representative of terrestrial surface waters passively discharging from Site. The auto-samplers were installed in outfall locations, including basin outfalls previously used as part of the Site erosion and sedimentation controls. These basins are not free flowing. Auto-samplers are not compliance points for stormwater discharge.

Samples collected from the auto-samplers correlated with rain events and the turbidity results were representative of surface flow and sediment loads from unsealed surfaces. It has been assessed that the source of the elevated concentrations of the metals (i.e. aluminium, arsenic, cadmium, cobalt, copper, manganese, nickel and zinc) and nutrients (i.e. ammonia, oxides of nitrogen, total nitrogen and total phosphorus) is the soils that wash-off the auto-sampler catchment areas during rain events and passively discharge from Site.

Results for auto-samplers were compared with sediments and bio-indicators to determine if analytes in the passive Site discharges were accumulating in the downstream sediments or receptors in the mangrove environment fringing the Site (see **Section 4.3.2.5**).

4.1.2.3 Jetty Outfall Water Quality

One Jetty outfall monitoring event was undertaken in April 2017 and no reportable exceedances were recorded.

4.2 Groundwater

4.2.1 Monitoring Methodology

The groundwater management objectives for the Site seek to minimise changes in groundwater levels and quality which may be arising from construction activities. This includes impacts associated with the possible oxidation of ASS, which may lead to disturbance of the mangrove communities fringing the Site where groundwater may discharge. Monitoring also aims to assess potential impacts resulting from onsite spills and leaks at the nominated higher risk locations as identified via environmental incident reporting.

The current bore network comprises 44 monitoring locations, identified on **Figure 4-6**. Data loggers were used to continuously monitor standing water level, pH, ORP, DO, TDS, turbidity and temperature at selected bores during the annual monitoring period. Samples were collected from the monitoring bores on a monthly basis.

The following analytes were recorded in situ:

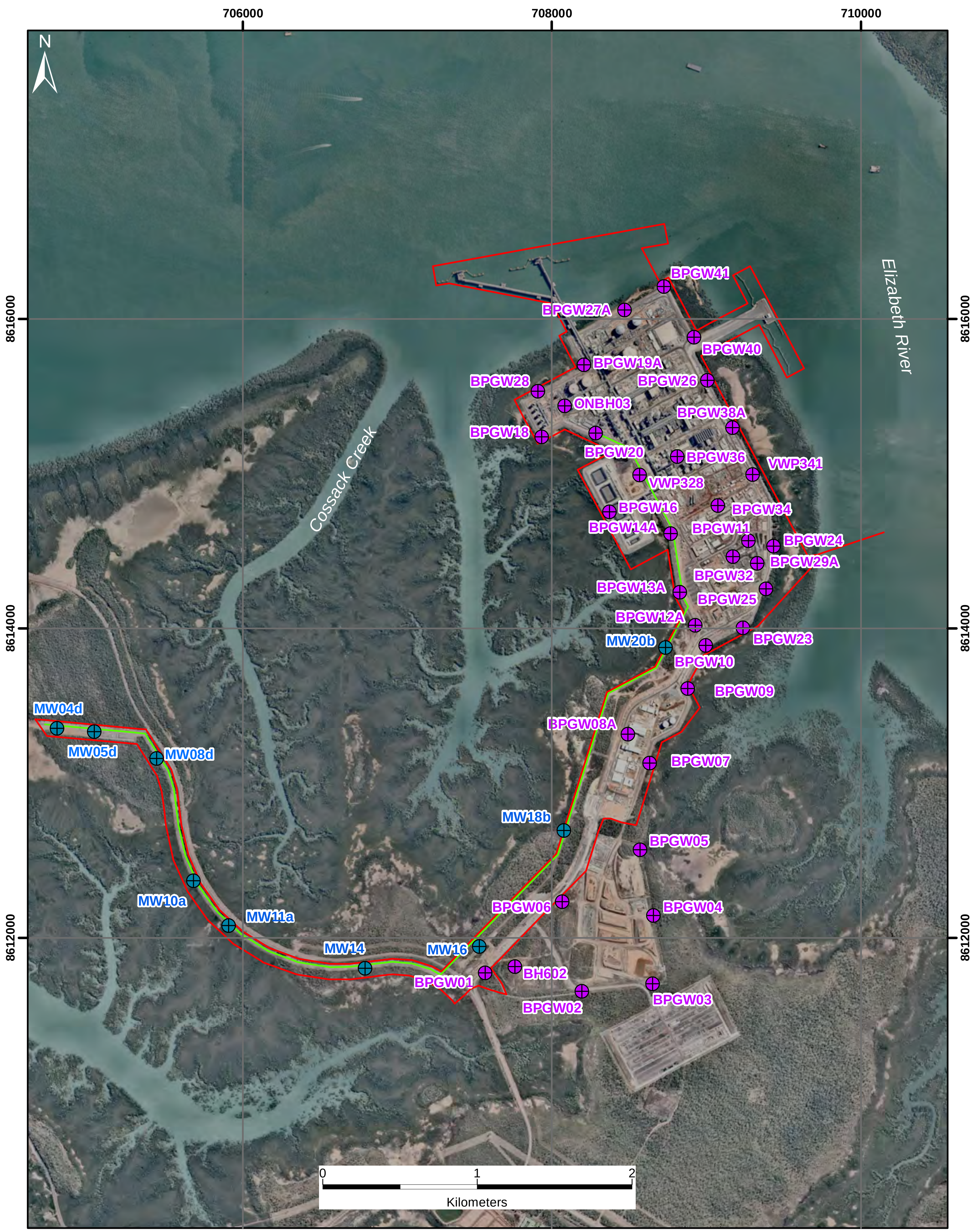
- Temperature;
- Electrical conductivity;
- pH;
- Turbidity;
- Total dissolved solids;
- Dissolved oxygen;
- Oxidation reduction potential; and
- Salinity.

Each of the collected groundwater samples were analysed for:

- Total and dissolved metals;
- Total suspended solids;
- Alkalinity;
- Nutrients (ammonia, oxides of nitrogen, total kjeldahl nitrogen, total nitrogen, FRP and total phosphorus); and
- Major ions and hardness.

Specifically identified groundwater monitoring bores were also analysed for the following additional parameters:

- Total recoverable hydrocarbons and BTEXN.



Gas Export Pipeline
Site Boundary

Monitoring Locations

Groundwater Sampling Locations

EIMP (Rev 6) GEP Groundwater Sampling Locations

Groundwater Sampling Locations		
Figure 4-6	**INPEX Bladin Point**	GREENCAP
Date: *14/07/2017*	**Author:** malcolm.nunn	
	Map Scale: 1:32,000	
Revision: A	**Coordinate System:** GDA 1994 MGA Zone 52	

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4.2.2 Field and Analytical Results

4.2.2.1 Groundwater Elevation

Groundwater levels were highest south of the isthmus where typically the underlying soils are less compacted and covered in a more permeable layer allowing increased recharge compared to the north of the isthmus were the soils are typically more compacted and covered in more impermeable surface materials. Groundwater bores have been grouped within two main zones, namely: areas above the high water mark i.e. above the highest astronomical tide (HAT) and those below the HAT which are periodically inundated by tidal waters. Bores above the HAT exhibit seasonal variation in water levels and are more influenced by rainfall recharge while bores below the HAT are influenced by tidal movements. Groundwater levels may also be influenced by the amount of hard stand areas on Site limiting recharge during the wet season.

Analysis of groundwater level patterns on Site for the period between 2012 and 2017 indicated the following:

- Direct comparison of groundwater level contours in eight bores over multiple years was not possible due to their reinstatement in different positions following damage during construction;
- Groundwater levels were higher in the wet season within the central parts of the Site where groundwater levels changed more in response to rainfall;
- Groundwater levels appeared to be lower around the coastal (intertidal) areas where the rainwater recharge was less influential;
- The groundwater level seasonal fluctuation pattern indicated that the highest water levels were observed during the wet seasons (typically between October and April) and the lowest water levels were observed during the dry season (typically between May and September) during all annual monitoring periods;
- The overall seasonal fluctuation amplitude of groundwater levels appeared to be similar over the annual monitoring period; and
- The groundwater level rises were relatively proportional to the amount of rain recorded each year, i.e. the 2016/17 wet season had the highest rainfall compared to the 2012/13, 2013/15, 2014/15 and 2015/16 wet seasons, and consequently recorded the highest groundwater levels since monitoring began.

Based on the historical background data and results from the groundwater monitoring program that was undertaken during the annual monitoring period, there were no observed increasing or decreasing trends outside normal seasonal variations in groundwater levels on Site and along the GEP corridor.

4.2.2.2 Salinity

Field measured salinity ranged from 0.0 g/L to 94.35 g/L. The results confirmed that groundwater salinity varies seasonally and increases depending on proximity to the coastal margins, with varying degrees of rainfall or tidal influence on the groundwater at each bore location. Areas of hypersalinity (with groundwater salinities greater than seawater) were centred on four nodes (i.e. points) located along the coastal margins of the Site, around the isthmus, along the western side of the Site (along the Flare Pad) and in the north-western corner of the Site.

Groundwater salinity along the GEP corridor followed a similar pattern where salinity varied seasonally in bores installed above the HAT and was generally consistent in the bores installed below the HAT. Areas of hypersalinity occurred at the bores located below the HAT along the coastal margins of the GEP and in the areas dominated by mangrove forests. Comparison of the collected data with baseline monitoring data indicated that the groundwater salinity values along the GEP corridor were not notably modified by the Site activities or discharges.

4.2.2.3 pH

Data from the EIS (INPEX Browse, Ltd, 2010) indicated that groundwater pH levels were substantially below the lower limit of the trigger value range (pH 6) prior to the commencement of the Project and were representative of the natural background quality of the groundwater on Site.

Seventy-two percent of the pH values recorded during the annual monitoring period were below the lower limit of the pH trigger value range (pH 6.0), indicating groundwater acidity, and this was consistent with results from the previous annual monitoring periods and natural background levels measured during the EIS.

There were two large nodes of low pH observed on Site during the dry and wet seasons, as follows (**Figure 4-7** and **Figure 4-8**):

- The southern portion of the Site centred on bores BH602 and BPGW06; and
- The central portion of the Site centred on bore BPGW34.

There were several seasonal nodes of low pH which typically developed towards the end of the dry season, as follows:

- Areas within the northern portion of the Site in the vicinity of ONBH03 and BPGW27A;
- Areas within the south-eastern portion of the Site in the vicinity of BPGW23;
- The area to the west of the Operations Complex at BPGW08A;
- The central portion of the extractive minerals area in the vicinity of BPGW06; and
- The south-eastern portion of the extractive minerals area in the vicinity of BPGW02 and BPGW04.

It should be noted that the observed seasonal and long-term low pH nodes did not correlate with onsite major ground improvement works or other Site activities or discharges.

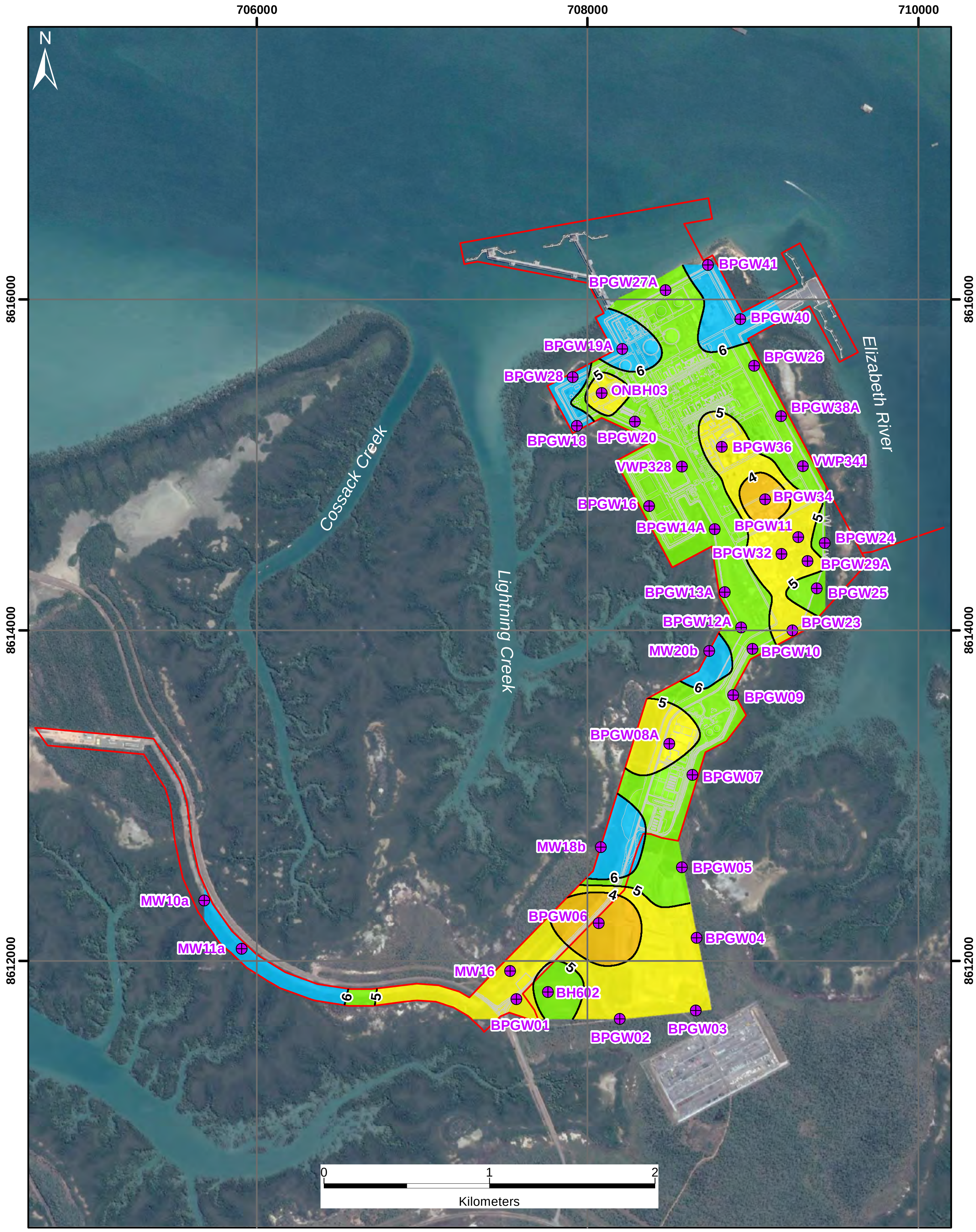
There were four primary zones of near neutral pH that were observed on Site, as follows:

- The central western area around BPGW16;
- The north-western areas around bores BPGW18, BPGW19A and BPGW28;
- The north-eastern area around BPGW40 and BPGW41; and
- Along parts of the GEP corridor.

The near neutral pH areas were generally associated with the high salinity groundwater zones along the coastal fringes of the Site.

Groundwater acidity was not related to Site activities or discharges for the following reasons:

- Background data indicated it was present prior to the commencement of construction;
- It is a known characteristic of the saline aquifer and is a result of natural processes historically occurring in the area (see **Section 3.3**) ; and
- The last ASS management was completed in August 2015, all major earthworks packages have finished, no groundwater extraction has taken place and all analytical testing undertaken to date has not identified any ASS-related geochemical changes in the groundwater.



- Site Boundary
- Construction Footprint
- Groundwater Sampling Locations
- pH Level Contours

pH

<4.0	6.0 - 7.0
4.0 - 5.0	7.0 - 8.0
5.0 - 6.0	8.0 - 8.5
	>8.5

pH Level Contours, October 2016

Figure 4-7	INPEX Bladin Point	GREENCAP
Date: 14/07/2017	**Author:** malcolm.nunn	
	Map Scale: 1:30,000	
Revision: A	**Coordinate System:** GDA 1994 MGA Zone 52	

No warranty is given in relation to the 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 breach of privacy laws. Imagery (16th May 2016) © Google, DigitalGlobe (2016).
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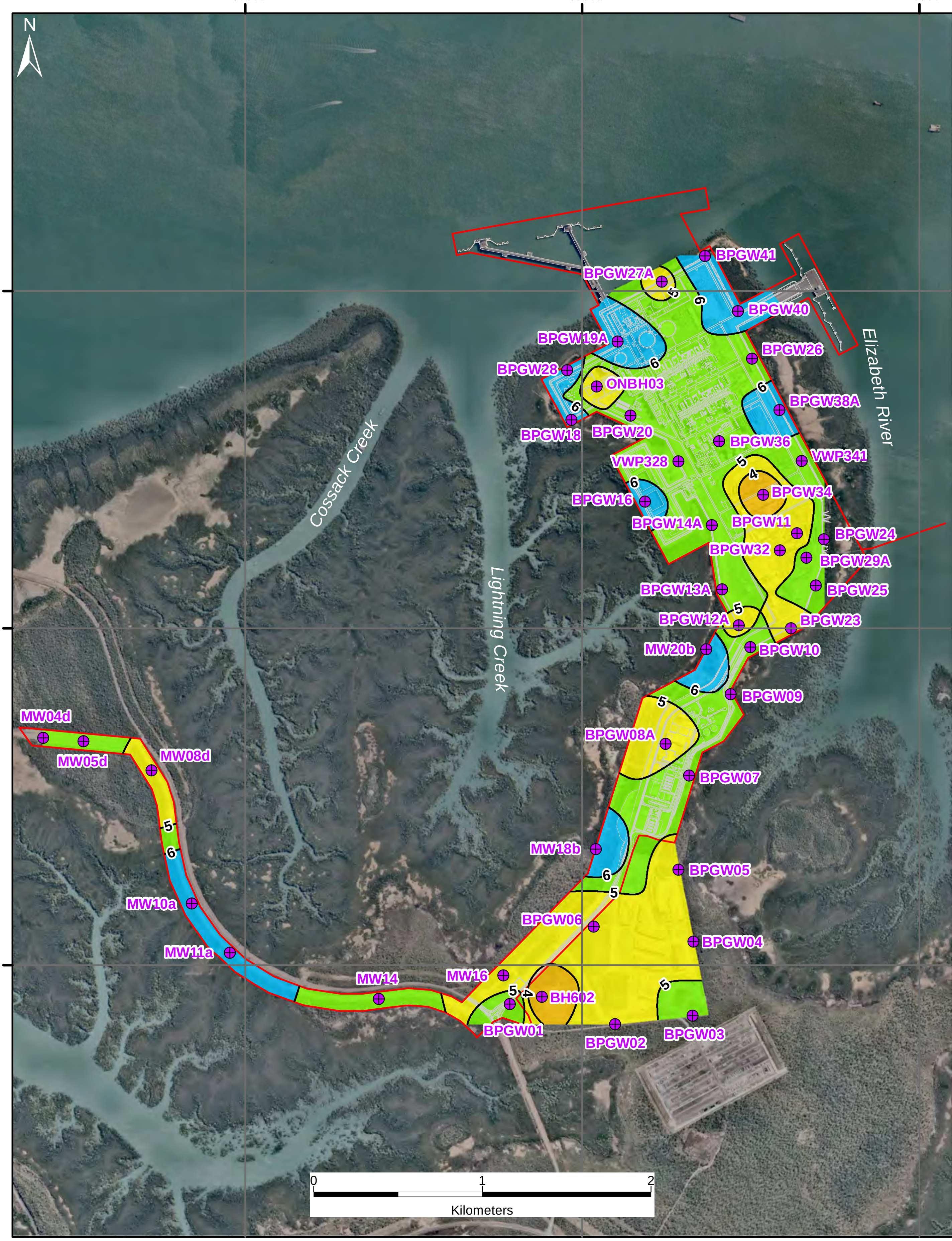

- Site Boundary
- Construction Footprint
- Groundwater Sampling Locations
- pH Level Contours

pH

- <4.0
- 4.0 - 5.0
- 5.0 - 6.0
- 6.0 - 7.0
- 7.0 - 8.0
- 8.0 - 8.5
- >8.5

pH Level Contours, March 2017

Figure 4-8	INPEX Bladin Point	GREENCAP
Date: 14/07/2017	Author: malcolm.nunn	
	Map Scale: 1:30,000	
Revision: A	Coordinate System: GDA 1994 MGA Zone 52	

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4.2.2.4 Groundwater Acidification

The *Acid Sulphate Soils Assessment Guidelines* (Acid Sulphate Soil Management Committee NSW, 1998) states the following:

> *The potential influence from ASS on groundwater quality was assessed using sulphate/chloride ratios. A typical sulphate-chloride ratio for seawater is 0.14 (19,400 mg/L chloride and 2,700 mg/L of sulphate). As the ratios of the dominant ions in saline water remains approximately the same when diluted with rainwater, estuaries, coastal saline creeks and associated groundwater can be expected to have similar ratios to the dominant ions in seawater (Mulvey, 1993). Where the analysis indicates that there is an elevated level of sulphate ions relative to the chloride ions, these results provide a good indication of the presence of acid sulphate soils in the landscape. A $Cl^-:SO4_{2-}$ ratio of less than four and certainly a ratio less than two, is a strong indication of an extra source of sulphate from previous sulphide oxidation (Mulvey, 1993).*

A low chloride/sulphate ratio would indicate a potential influence from a sulphate-containing source e.g. ASS oxidation. A higher ratio would typically indicate a sulphate salt precipitation or dilution with water, with minor sulphate content, e.g. rainwater. Groundwater was consistent with the typical seawater ratio (**Figure 4-9**), indicating a negligible influence from sulphate generation sources and some influence from dilution.

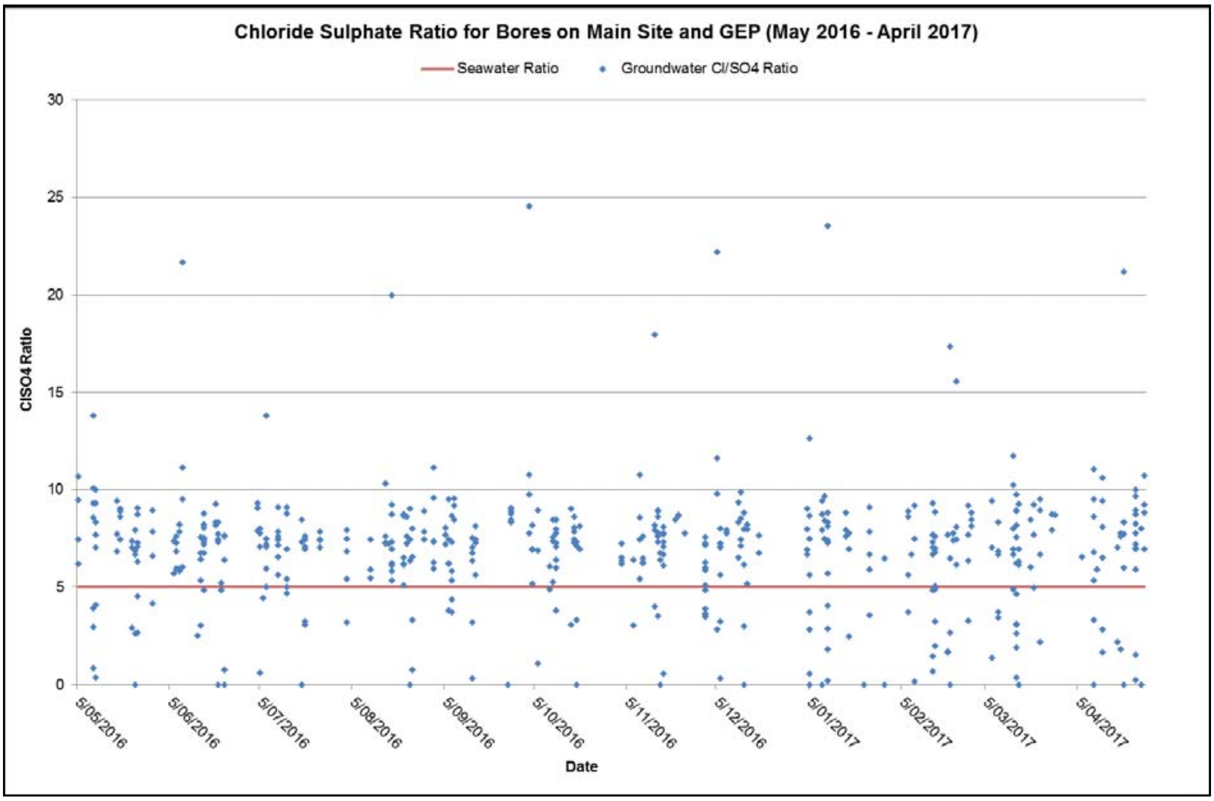


Figure 4-9 Chloride/Sulphate Ratio for Bores on Site and GEP

A lower chloride/sulphate ratio was noted in specific bores located to the south of the isthmus (e.g. BPGW01, BPGW03, BPGW04 and BPGW05) during the wet season. This was assessed to be related to significant, seasonal freshwater recharge in these bores and the natural presence of sulphate salts in the soils, and was not a result of any ASS impacts. This was further evidenced by the fact that these bores are not located in potential PASS/ASS areas and Mann-Kendall statistical analysis did not indicate any decreasing trends in chloride/sulphate ratios in these bores.

In order to assess whether any potential groundwater acidification had arisen from previous ASS disturbance on Site, an analysis of the sulphate/chloride ratios was carried out for all the bores on Site and along the GEP using the Mann-Kendall statistical trend analysis tool.

No increasing or decreasing trends were observed, with the exception of one bore on Site, namely BPGW06, which displayed an increasing trend. A review of the data indicated that the sulphate concentrations were below the LOR on all occasions at BPGW06 since monitoring began. This indicated that the overall increasing trend reported by Mann-Kendall for BPGW06 was a false positive and no impacts associated with ASS occurred at this bore location.

A comparison of the Mann-Kendall classic trend against the seasonal trend technique indicated that the majority of the bores displayed a strong seasonal influence in the sulphate/chloride ratios associated with the wet and dry seasons and in response to groundwater recharge rates. Exceptions to this included some of the bores located near the coastal margins, which are more influenced by tidal movement than rainfall recharge.

4.2.2.5 Metals

A review of the available baseline data indicated that the metal species exceeding the trigger values in the EIS (INPEX Browse, Ltd, 2010) were similar to those identified in this annual monitoring period. Also, the observed lateral distribution of metals did not identify any plume-like extents indicative of metal contamination sources on Site. Based on the information reported in the EIS (Appendix 17) the natural onsite soils contain metals which can be mobilised into solution under acidic conditions. Groundwater beneath the Site may contain metals resulting from natural processes involving groundwater interaction with acidic soils which contain acid-extractable metals (Radke *et. al.*, 1998; URS, 2009; NRETAS, 2008).

The metals that exceeded their adopted trigger values on one or more occasion during the annual monitoring period included (all filtered) aluminium, arsenic, cadmium, cobalt, copper, lead, manganese, nickel, silver and zinc. Mercury recorded exceedances during the annual monitoring but these were only detected occasionally. The following observations from the metals results were made:

- The majority of the elevated metals were found in brackish to saline groundwater;
- The magnitude of some metal concentrations tended to decrease during the wet season when freshwater infiltration reduced the groundwater salinity and diluted the concentrations of these metals;
- The reduction in some metals concentrations during the wet season also indicated that no additional metals infiltrated groundwater from the surface, which indicated that the source of the metals observed in the groundwater was likely to be from in situ soils naturally found on Site, rather than a release and subsequent plume associated with ASS, spills or leaks; and
- There were no increasing trends in metals concentrations in the bores on Site and along the GEP, with the exception of those metals/bores outlined in **Section 4.2.2.7** below.

Metal concentrations followed typical seasonal patterns during the annual monitoring period by increasing in the dry season and decreasing in the wet season, and were largely influenced by resulting changes in pH and salinity levels. After a number of high rainfall events from mid-December onwards, metals concentrations decreased quite rapidly as a result of the rainfall and recharge.

A review of the 80th percentile statistical analysis tool, which provides a temporal assessment of metal exceedances, indicated exceedances of the trigger values and 80th percentiles during the monitoring period for (all filtered) aluminium, cadmium, cobalt, copper, lead, manganese, nickel, silver and zinc. These results were then compared with isopleths to provide a spatial assessment of metal concentrations. A comparison of the temporal and spatial tools indicated that the 80th percentile exceedances correlated with areas of higher salinity and lower pH and did not correspond with known spills. Both the total number and magnitude of the metal exceedances decreased with both the onset and progression of the wet season and was indicative of rainfall recharge and subsequent groundwater recharge.

Based on statistical analysis of the dataset, baseline data and the results from the annual monitoring period at construction activity locations, it was assessed that those elevated metals concentrations detected in the groundwater on Site and along the GEP corridor were not related to Site activities.

4.2.2.6 Nutrients

The nutrients that exceeded the adopted trigger values in the bores on Site and along the GEP corridor during the annual monitoring period were ammonia, oxides of nitrogen, FRP, total nitrogen and total phosphorus. The following observations from the nutrient results were made:

- There were no continuous increasing trends in nutrient concentrations in the bores on Site and along the GEP corridor, with the exception of ammonia and total nitrogen in two bores (see **Section 4.2.2.7**);
- Elevated ammonia concentrations were noted in saline and hypersaline groundwater (with the exception of BH602). Concentrations varied seasonally and the following trends were noted:
    - Slight seasonal variations in the bores below the HAT where groundwater levels were not heavily influenced by rainwater infiltration
    - Decreases in concentrations in the bores above the HAT during the wet season as a result of freshwater recharge and subsequent dilution
- Filterable reactive phosphorus concentrations occasionally exceeded the trigger levels during the wet season in the areas where rainwater infiltrated through natural soils; and
- A seasonal increase in oxides of nitrogen concentrations was noted mainly during the wet season in areas where groundwater had high ORP levels, which supported conversion of natural ammonia into nitrite and nitrate.

A review of the 80th percentile statistical analysis tool during the annual monitoring indicated some exceedances of the 80th percentile for all of the analysed nutrients. A comparison of the temporal and spatial tools indicated that the 80th percentile exceedances corresponded with areas of mangrove muds and did not correspond with known spills. The number of exceedances and nutrient concentrations in groundwater decreased with the onset and progression of the wet season and was indicative of rainfall recharge and subsequent groundwater recharge.

Based on statistical analysis of the dataset, baseline data and the results from the annual monitoring period at construction activity locations, it was assessed that those elevated nutrient concentrations detected in the groundwater on Site and along the GEP corridor were not related to Site activities.

4.2.2.7 Metals and Nutrients on Watch List

In AEMR (2016), a small number of bores were observed to have potentially increasing trends in metals and nutrients concentrations. During this annual monitoring period, these bores were placed on a watch list for additional investigation. Mann-Kendall trend analysis was used to assess metals and nutrients concentrations and sulphate/chloride ratios at each of the bores on the AEMR (2016) watch list. Based on a seasonal analysis, there were no overall increasing trends for sulphate/chloride ratios at any of the bores on the watch list, however, there were increasing metals trends in bores BPGW05 (zinc), BPGW08a (aluminium) and BPGW11 (aluminium, cadmium, cobalt, nickel and zinc), and increasing nutrient trends in BPGW24 and BPGW32 (both ammonia).

A review of environmental incidents was undertaken to determine whether any spillages had occurred in the vicinity of the AEMR (2016) watch list bores that might account for these trends. The outcome of this review was that there were no spills that could explain these trends and therefore spills were discounted as a potential source. Furthermore, a review of construction activities did not identify a potential source of these exceedances.

In this annual monitoring period a new 2017 watch list was established based on the results of the April 2017 80th percentile statistical results. Groundwater monitoring parameters that exceeded the adopted trigger value and 80th percentile were assessed for trends using the same Mann-Kendall analysis techniques.

In addition, bores and parameters on both the AEMR (2016) watch list and 2017 watch list that had pH values that exceeded the trigger value and 80th percentile in April 2017 were further analysed using Mann-Kendall. This was done because decreasing pH concentrations is a fundamental indicator of potential ASS/PASS impacts.

Only two bores, namely BPGW11 and BPGW23 were found to exceed the pH trigger value and 80th percentile in April 2017 i.e. they were outside natural seasonal variation, and displayed increasing metal and decreasing pH trends. A review of the historical data for BPGW11 and BPGW23 indicated that these bores have similar pH trends, in that the pH concentrations decreased in April to June 2013 and have since remained relatively constant. A slight increasing trend in salinity has also been noted at these locations which may be a result of the relatively impermeable construction platform and reduced groundwater recharge at these locations. Given that there were no increasing trends in sulphate/chloride ratios, it was assessed that these increasing metals trends were not associated with ASS mobilisation and Site activities because a review of construction activities did not identify a source.

Two bores demonstrated increasing nutrient trends namely BPGW28 (ammonia) and BPSW24 (total nitrogen), however, these trends were not related to Site activities because a review of construction activities did not identify a potential source.

4.3 Mangrove Community Health, Sediments and Bio-Indicators

4.3.1 Monitoring Methodology

Monitoring of mangrove community health, sediments and bio-indicators was undertaken to assess potential impacts from the Site activities on mangrove communities fringing the Site.

During the annual monitoring period, mangrove monitoring occurred at the locations identified on **Figure 4-10**.

During the annual monitoring period, impact sites BPMC05, BPMC06 and BPMC07 were retained to monitor mangrove recovery in an area where construction activities had previously caused a mud wave and water ponding (AEMR [2014], AEMR [2015] and AEMR [2016]).

The parameters used to monitor mangrove community health were seedling density and species composition, canopy cover, tree condition and benthic community health. These were monitored on a quarterly basis. To complement the collection of this data, photographs were taken of mangroves within the monitoring plots from standard reference points.

To monitor for potential sedimentation and erosion effects, surveying of ground level profiles (annually) through tidal flat and mangroves areas and the monitoring of relative sediment heights (quarterly) from within the monitoring plots using fixed marker stakes were used.

Within each mangrove monitoring plot, a sample of sediment from the surface was collected for metal and hydrocarbon analysis within an area of 1 x 1 m. Using a sterile wooden spatula, the sediment surface (top 1 to 5 cm) was scraped and the material directly transferred into a WhirlpakTM bag.

High concentrations of metals and hydrocarbons are potentially toxic to benthic macro-fauna that live within the sediment or at the sediment-water interface (Clark, 2001). Additionally, many organisms that live in or on the sediment are known to accumulate metals and hydrocarbons in their tissue (bioaccumulation) which may cause a threat to human health if consumed. The measurement of metals and hydrocarbons in the tissue of organisms can therefore be used as an indicator for bioavailability of contaminants in the environment (Gay *et al*., 2003). For this particular assessment, a large snail, the mud whelk (*Telescopium telescopium*), was selected as an indicator of bioaccumulation. These bio-indicators were sampled on a quarterly basis to account for seasonal variation.

4.3.2 Results

4.3.2.1 Mangrove Community Health

There were no exceedances of the 30% trigger value for canopy cover, which increased in the majority of survey plots in the annual monitoring period. The largest overall increase was recorded at impact sites (+8.1% ± 2.0 SE) compared to reference sites (+3.6% ± 2.4 SE), which was consistent with the AEMR (2016), AEMR (2015) and AEMR (2014). Overall, mean canopy cover was the same at impact sites (86.0 ± 2.2 SE) and reference sites (86.0 ± 4.1 SE) during the annual monitoring period.

Canopy cover data has been summarised in **Figure 4-11** by comparing mean canopy cover for the three mangrove assemblages monitored, namely:

- *Rhizophora* forest zone;
- *Ceriops* dominated tidal flat zone; and
- Hinterland margin zone.

The results recorded during the annual monitoring period indicated that canopy cover had generally increased at all sites in comparison to background data, with the largest overall increase recorded at impact sites within the Tidal Flat *Ceriops* assemblage which was consistent with previous annual monitoring periods.

Tree condition did not exceed the 30% trigger value (with the exception of one impact site, BPMC06) and remained high at the majority of survey plots with the average percentage of healthy trees marginally higher at reference sites compared to impact sites. Impact site BPMC06 is located within an area previously impacted by a known mud wave and water ponding, remained consistent with previous data and appears to have stabilised as the forest adapts to the new soil and hydrological conditions.

The majority of impact and reference sites contained seedlings (75% and 92% respectively) and although there was a slight overall decline in mean seedling density at impact and reference sites, regeneration rates remained high at survey plots.

Pneumatophore density exceeded the 30% trigger value at one impact site and two reference sites, and crab burrow density at fifteen impacts and eight reference sites during the annual monitoring period. However, these exceedances did not cause deleterious impacts on mangroves fringing the Site.

Dust was not evident on the leaves of mangrove trees at impact and reference sites during the quarterly surveys undertaken during the annual monitoring period. This represented a decrease in dust levels in comparison to AEMR (2016), which recorded light dust levels in June 2015 and light to medium dust levels in September 2015.

The mangrove community health results in this annual monitoring period were largely consistent with the June 2012 survey, and background data collected in March 2015, June 2015, September 2015, December 2015 and June 2016, with the exception of the limited number of pneumatophore and crab burrow density exceedances and a decrease in the proportion of healthy trees at impact sites BPMC06 and BPMC07.

No ecologically significant decline in mangrove community health was detected at the 20 impact sites surveyed during the annual monitoring period and this indicated that the mangrove communities located close to the Site have remained in a healthy condition. The exceptions were impact sites BPMC06 and BPMC07, however the decline in tree condition at these locations was associated with a known mud wave and ponding adjacent to the Flare Pad and was not considered representative of the overall health of fringing mangrove communities. These sites also appeared to be stabilising after the mud wave impacts in this area which occurred three years ago.

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

Mangrove Monitoring Locations

Figure 4-10	INPEX Bladin Point	GREENCAP

Date: *14/07/2017*

Author: malcolm.nunn

Map Scale: 1:35,000

Revision: A

Coordinate System: GDA 1994 MGA Zone 52

R:_Projects\C110043_Inpex\GIS\Maps\BP_EPA7_Report\2017\FIG_4_10_Mangroves_170506.mxd

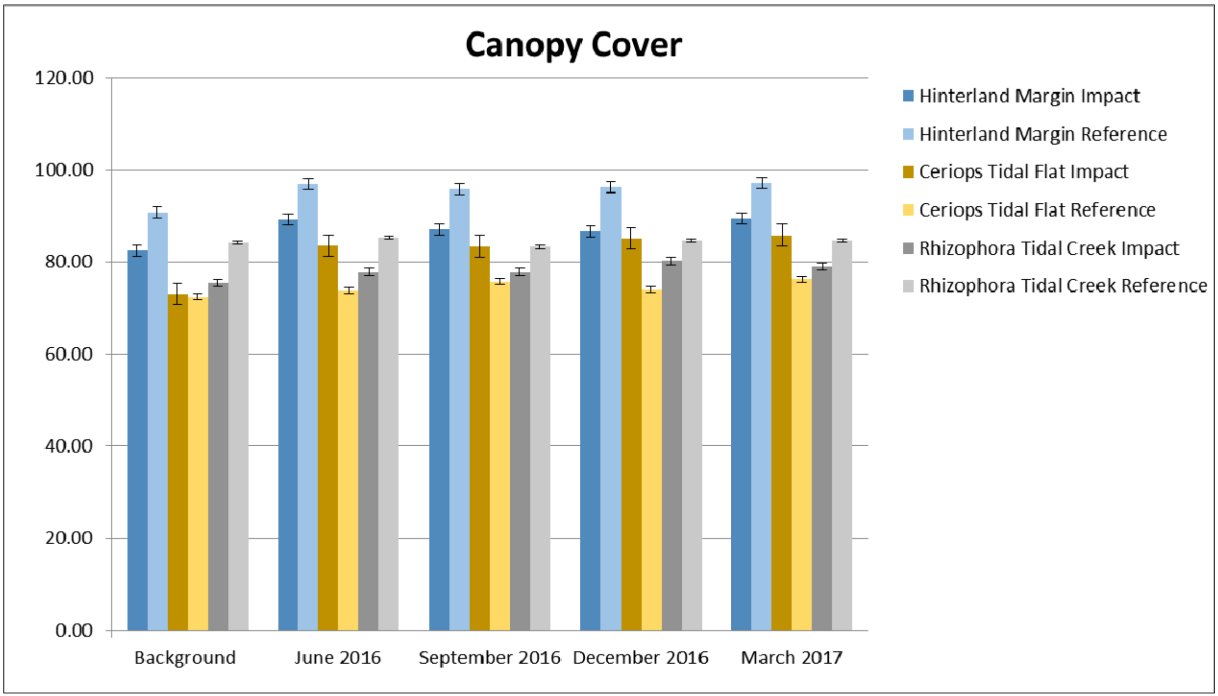


Figure 4-11 Mean Canopy Cover Summarised for each Mangrove Assemblage

4.3.2.2 Sedimentation and Erosion

The quarterly relative sediment height results indicated that there were no exceedances of the sedimentation and erosion trigger value and relative sediment heights remained stable in the annual monitoring period.

The annual DGPS survey recorded ten impact sites and five reference sites that exceeded the 5 cm (± 2 cm) trigger value for ground level variation during the annual monitoring. The largest variations were along BPMC07, however these changes were attributed to the mangrove ponding remediation excavation and infill works that were undertaken from late 2014 to June 2015 within the Flare Pad causeway mangrove drainage areas. Mangroves at BPMC07 did not record any ecologically significant decline in mangrove community health parameters in the annual monitoring period.

The mangrove sediment data collected during the annual monitoring period indicated that there had not been any broad-scale sediment accumulation or erosion that had impacted mangrove communities fringing the Site. Within the mangrove environment, there is a dynamic relationship between erosion and sediment deposition resulting from tidal, surface and stormwater runoff including cyclones. Furthermore, most mangroves are tolerant of moderate (i.e. up to 10 mm per year) rates of sediment accretion (Ellison, 1998). Hence, small scale changes in sediment deposition or erosion are not necessarily deleterious to the mangrove environment and should be seen as part of long-term processes driving mangrove habitat development.

4.3.2.3 Sediment Quality

Total metals in sediments were within the adopted trigger values with the exception of total arsenic (15 exceedances recorded at impact sites), chromium (two recorded at impact sites) and antimony (seven recorded at reference sites). Twelve hydrocarbon detections were recorded in the mangrove sediments at BPMC17, BPMC20, BPMC22 and BPMC26 during the annual monitoring period. However, there were no TRH detections after silica gel clean-up, indicating a natural source.

A more detailed assessment of the potential source(s) of those metals that recorded exceedances in the mangrove sediments in the annual monitoring period is outlined in **Section 4.3.2.5** below.

The presence of veneers at impacts sites and reference sites indicated that terrestrial sediment deposition was not related to Site activities or discharges. Sediment grain size and moisture content analysis did not show any trend towards increasing or decreasing grain size or composition across the impact and reference sites.

4.3.2.4 Bio-indicators

Metals and semi-metals in mud whelk tissue were within the adopted trigger values during the annual monitoring period with the exception of copper and mercury. The number of mercury exceedances that were recorded during the annual monitoring period decreased in comparison to AEMR (2016) and AEMR (2015) at impact and reference sites.

Similarly, the number of copper exceedances that were recorded during the annual monitoring period decreased in comparison to AEMR (2016) and remained generally consistent with AEMR (2015). There were no hydrocarbons detected in mud whelk tissue during the annual monitoring period.

A more detailed assessment of the potential source(s) of those metals that recorded exceedances in the bio-indicators in the annual monitoring period is outlined in **Section 4.3.2.5** below.

Since June 2014, when the frequency of bio-indicator monitoring was revised to quarterly, there has been substantial variability in the data between monitoring periods and between impact sites and reference sites. Some of this variability may be attributed to sample size variation, location, tides, and climatic and seasonal changes.

4.3.2.5 Metals in Sediments and Bio-indicators

During the annual monitoring period, arsenic, antimony and chromium exceedances were detected in mangrove sediments, and copper and mercury exceedances were detected in bio-indicators.

Mann-Kendall statistical analysis was undertaken on the following metals in mangrove sediments and bio-indicators: aluminium, arsenic, cadmium, cobalt, copper, manganese, mercury, nickel and zinc to determine the significance of any potential trends and the outcomes are discussed below.

Terrestrial surface water quality results (from auto-samplers, denoted with the prefix SWAS) were compared to mangrove sediment and bio-indicator results because terrestrial surface waters passively discharging from Site are a potential, cumulative source of sediments (and metals) in the mangrove environment fringing the Site.

Results from auto-samplers were compared to results at nearby mangrove monitoring sites as follows:

- BPMC08 and BPMC09 were compared to SWAS01 (250 m and 75 m away, respectively);
- BPMC26 was compared to SWAS02 (125 m away);
- BPMC17 and BPMC20 were compared to SWAS03 (500 m and 750 m away, respectively);
- BPMC22 was compared to SWAS04 (125 m away).

Total Arsenic in Sediments

Total arsenic and filtered arsenic exceedances were recorded at both BPMC17 and SWAS03 and BPMC22 and SWAS04 in December 2016 and at four impact locations (BPMC01, BPMC24, BPMC27 and BPMC28) in June, September and December 2016 (which are not located close to auto-sampler locations). Mann-Kendall statistical analysis indicated there were no increasing trends for arsenic in mangrove sediments (or bio-indicators) during the annual monitoring period, and there was no decline in mangrove community health parameters during the annual monitoring period.

Furthermore, total arsenic exceedances in sediments were typically present at, and south of the isthmus, at impact sites BPMC01, BPMC22, BPMC24, BPMC17 and at two GEP sites, BPMC27 and BPMC28. Sites BPMC01, BPMC22 and BPMC24 are located in close proximity to the isthmus and groundwater bores BPGW09, BPGW10, BPGW13A and MW20b. The most likely reason for the consistently elevated arsenic concentrations at these locations may be their proximity to the isthmus, an area of known groundwater expression.

Groundwater is known to historically egress at the isthmus during periods of higher groundwater elevation as a result of recharge following rain events. With the exception of BPMC17 and BPMC24, there were no exceedances north of the isthmus where the major portion of the construction works were occurring.

Total Antimony in Sediments

Total antimony results in the sediment exceeded the trigger value at six reference site locations in June and September 2016. As no impact site exceedances were recorded, no further assessment was required.

Total Chromium in Sediments

Total chromium results in the sediment exceeded the trigger value at BPMC17 and BPMC24 in December 2016. There were no filtered chromium exceedances detected at any of the auto-sampler locations during the annual monitoring period and all bio-indicator chromium results were below the LOR. Mann-Kendall statistical analysis indicated there were no increasing trends for chromium in the mangrove sediments (or bio-indicators) during the annual monitoring period.

Copper in Bio-indicators

Copper concentrations in mud whelk tissue exceeded the trigger value at BPMC09 in June 2016. The closest auto-sampler monitoring location to BPMC09 was SWAS01 and this location did not record any filtered copper exceedances during the annual monitoring period. Additionally, there was no corresponding total or bio-available copper elevated concentration in the sediments and a review of construction activities in the areas adjacent to BPMC09 in June did not identify any potential source. Mann-Kendall statistical analysis indicated there were no increasing trends for copper in bio-indicators during the annual monitoring period. There were increasing trends recorded for copper in mangrove sediments at BPMC09 and BPMC22 but assessment of the data collected at the corresponding auto-sampler locations SWAS01 and SWAS04 did not indicate any link between copper concentrations in the mangrove sediments and the auto-samplers.

Mercury in Bio-indicators

Mercury concentrations in mud whelk tissue exceeded the trigger value at two impact locations (BPMC01 and BPMC27) in September and December 2016 (which are not located close to auto-samplers). Exceedances were also detected at reference site locations, deeming these attributable to a source other than Site activities. Results indicated a mercury exceedance in bio-indicator tissue at BPMC01 in March 2017, with no reference site exceedances. However there were no corresponding elevated, total or bio-available mercury concentrations in the mangrove sediments and a review of construction activities in the area adjacent to BPMC01 in March did not identify any potential source.

Furthermore, there was no decline in mangrove community health parameters during the annual monitoring period and nearby groundwater wells MW20b, BPGW09, BPGW10 and BPGW12A did not record any filtered mercury trigger value and 80th percentile exceedances during the annual monitoring period. Therefore, after the assessment of multiple lines of evidence, it was concluded that the mercury exceedance recorded in bio-indicator tissue at BPMC01 in March 2017 was not related to Site activities. In addition, Mann-Kendall statistical analysis indicated there were no increasing trends for mercury in bio-indicators (or mangrove sediments) during the annual monitoring period.

Aluminium, Cobalt, Manganese, Nickel and Zinc in Sediments and Bio-indicators

The Mann-Kendall statistical analysis and assessment of the above metals indicated the following:

- No increasing trends for aluminium in sediments and bio-indicators;
- Increasing trends for cobalt in bio-indicators at impact sites BPMC08 and BPMC09, and reference plots CSMC01-3, CSMC02-5 and CSMC02-6. These increasing trends were not related to Site activities or discharges because they were recorded at both impact sites and reference sites;
- An increasing trend for manganese in bio-indicators at impact site BPMC22, which was not related to Site activities or discharges because there were no manganese exceedances recorded at the corresponding auto-sampler SWAS04 during the annual monitoring period;
- Increasing trends for nickel in bio-indicators at impact sites BPMC08, BPMC09, BPMC10 and BPMC22, and reference plots CSMC01-2 and CSMC02-5. Increasing trends for nickel in sediments were also noted at BPMC08 and BPMC09. The increasing trends in bio-indicators were not related to Site activities or discharges because they were recorded at both impact sites and reference sites. The increasing trends in sediments at the two impact sites were not related to Site activities or discharges because there were no nickel exceedances recorded at the corresponding auto-samplers SWAS01 and SWAS04 during the annual monitoring period; and
- An increasing trend for zinc at impact site BPMC08, which was not related to Site activities or discharges because there were no zinc exceedances recorded at the corresponding auto-sampler SWAS01 during the annual monitoring period.

Summary

There was no evidence of a direct link between the metals exceedances in the mangrove sediments and bio-indicators and the stormwater passively discharging from Site. There was also no evidence of increasing metals trends in the mangrove sediments and bio-indicators that were related to Site activities and discharges.

Based on the above analysis, the risk of passive Site discharges resulting in the accumulation of metals in mangrove sediments or bio-indicators was assessed to be low.

4.4 Air Quality (Dust)

4.4.1 Monitoring Methodology

The objective of the dust monitoring program is to assess whether Site dust is giving rise to exceedances of the approved trigger values at identified sensitive receptors.

The dust monitoring program comprises the collection of particulate matter of 10 micrometres or less in size (PM_{10}) and particulate matter of 2.5 micrometres or less in size ($PM_{2.5}$) as well as dust deposition rates at the Site and the nearby City of Palmerston. The data are used to inform Site activities so that impacts from dust on the environment and nearby sensitive receptors are minimised.

During the annual monitoring period, air quality monitoring occurred at the locations set out in **Figure 4-12**.

Fifteen dust deposition locations (BPDD01 to BPDD14 and PADD01) have been installed. Sample bottles were retrieved from the dust deposition gauges on a monthly basis and submitted to the laboratory for analysis.

Five E-Samplers (BPPM01 to BPPM04 and PAPM01) have been installed. BPPM01, BPPM04 and PAPM01 monitor both $PM_{2.5}$ and PM_{10} whilst BPPM02 and BPPM03 solely monitor PM_{10}.

4.4.2 Results

4.4.2.1 PM_{10} and $PM_{2.5}$

During the annual monitoring period, there were ten PM_{10} exceedances and one $PM_{2.5}$ exceedance at PAPM01. No PM_{10} or $PM_{2.5}$ exceedances were recorded at PAPM01 during 24-hour vector-averaged south-westerly winds (i.e. along the impact pathway) and therefore, it was assessed that Site activities had not resulted in dust impacts at sensitive receptors located in Palmerston.

There were 80 PM_{10} and 22 $PM_{2.5}$ exceedances at BPPM04 during the annual monitoring period. Four PM_{10} exceedances and one $PM_{2.5}$ exceedance were recorded at BPPM04 during 24-hour vector-averaged northerly winds (i.e. along the impact pathway). Further assessment identified there were two days during the annual monitoring period when the Bladin Central Enterprise Park was potentially impacted by dust levels exceeding the air quality criteria from the direction of the Site. However no reports of dust complaints were received on these two occasions or during the annual monitoring period.

4.4.2.2 Dust Deposition

There were no exceedances of the dust deposition trigger value recorded at PADD01 or BPDD14 and no records of dust complaints were received during the annual monitoring period.

Dust deposition gauges on Site provided data on potential impacts on the mangrove communities fringing the Site. The trigger value was exceeded 22% of the time on Site during the monitoring period. Mangrove communities fringing the Site remained in a healthy condition during the annual monitoring period and were not affected by dust deposition.

4.5 Airborne Noise

4.5.1 Monitoring Methodology

The objective of the airborne noise monitoring program is to assess whether Site noise is giving rise to exceedances of the adopted noise trigger values at identified sensitive receptors

Monitoring occurred at three locations during the annual monitoring period (BPAN01, BPAN02 and PAAN01) (**Figure 4-13**).

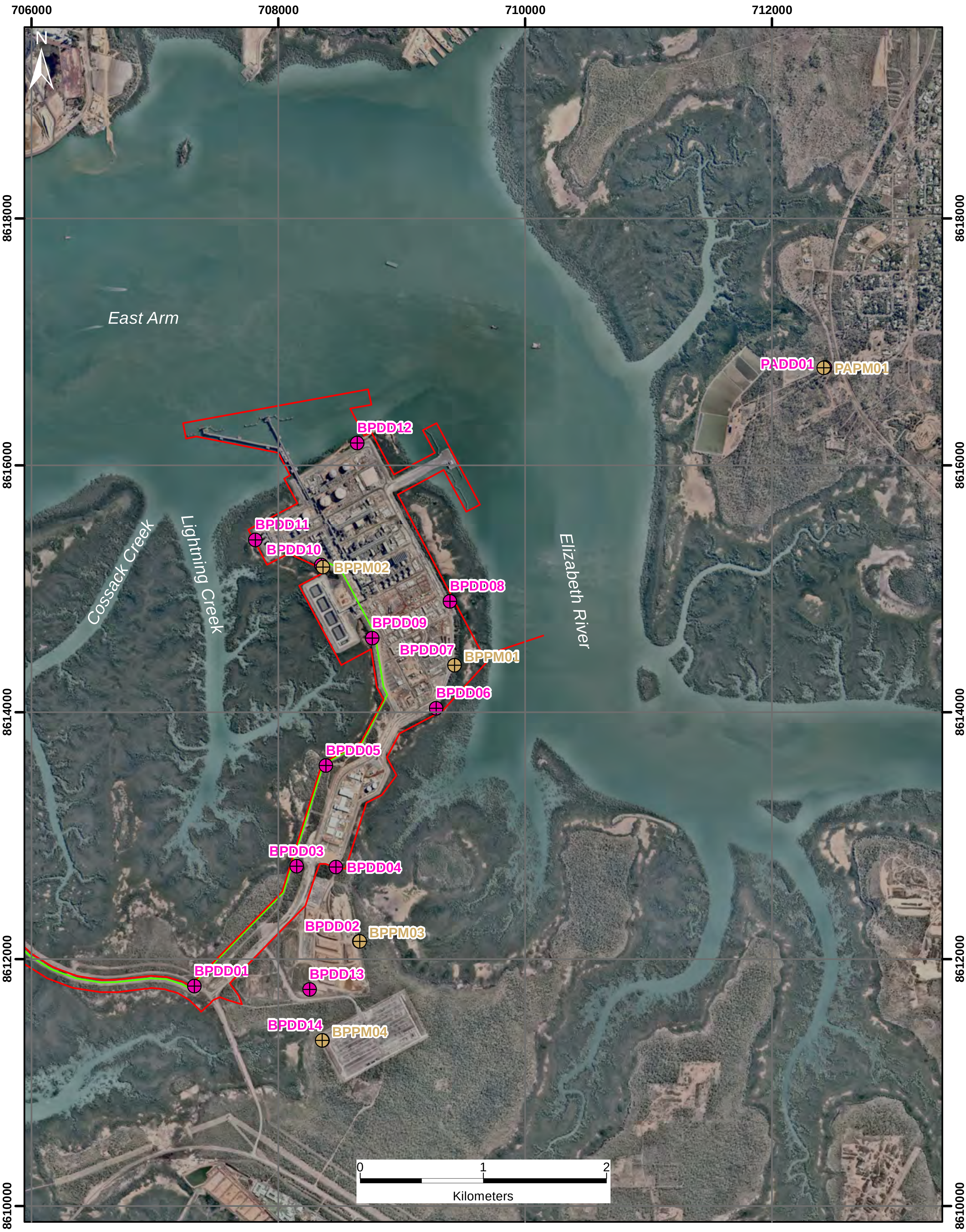
4.5.2 Results

No noise complaints were received during the annual monitoring period.

Audio files analysed from PAAN01 indicated that the day-time and night-time exceedances recorded during the annual monitoring period were unrelated to Site activities and were caused by local activities (e.g. motor vehicles, passing trains) and natural noise sources (e.g. insects, frogs and birdsong). The Palmerston noise monitor PAAN01 remains a suitable reference site with its location next to the residents of Marlows Lagoon.

The dominant sound source contributing to exceedances at PAAN01 was vehicle movements along the nearby Catalina Road. The second most dominant sound source was birdsong. During site visits for calibration and data collection purposes, it was observed that the Turf Farm acted as a suitable nesting ground for plovers and cockatoos, and other birds in the overhead power lines above the noise monitor.

Audio analysis of sound files from BPAN02 confirmed that the predominant causes of exceedances were vehicle reversing alarms and heavy vehicle movements that were operating in the laydown area. Exceedances also occurred during the wet season as a result of thunder storms passing over Site. Based on noise attenuation monitoring undertaken previously, in order for there to be an exceedance of the trigger value at Bladin Central Enterprise Park there would need to be a noise level of 109 dB(A) in the day-time and 99 dB(A) in the night-time at noise monitoring location (BPAN02). The data collected during the annual monitoring period indicated that there were no noise levels of this magnitude at BPAN02.



Site Boundary

Gas Export Pipeline

Dust Monitoring Location (Dust Deposition Sample)

Dust Monitoring Location (Particulate Matter Sample)

Dust Monitoring Locations		
Figure 4-12	INPEX Bladin Point	GREENCAP
Date: *14/07/2017*	**Author:** malcolm.nunn	
	Map Scale: 1:40,000	
Revision: A	**Coordinate System:** GDA 1994 MGA Zone 52	

No warranty is given in relation to the 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 breach of privacy laws. Imagery (10th June 2016) © Nearmap (2017).
R:_Projects\C110043_Inpex\GIS\Maps\BP_EPA7_Report\2017\FIG_4_12_Dust_170506.mxd

Site Boundary

Gas Export Pipeline

Noise Monitoring Locations

Noise Monitoring Locations

Figure 4-13	INPEX Bladin Point	GREENCAP
Date: *14/07/2017*	**Author:** malcolm.nunn	
	Map Scale: 1:40,000	
Revision: A	**Coordinate System:** GDA 1994 MGA Zone 52	

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4.6 Flora and Fauna

The flora management objectives identified in the CEMP were to minimise disturbance to flora and alteration of mangrove communities outside the Site boundary due to Site activities. The fauna management objective was to avoid injury or death to native terrestrial fauna as a result of Site activities or discharges from Site.

No vegetation was cleared during the annual monitoring period.

The majority of fauna interactions reported related to observations of fauna that were active on Site. Common species recorded in the fauna interactions register were birds, flying foxes, wallabies, snakes, wild dogs and cats and crocodiles. Where required, fauna species such as snakes and birds were relocated away from Site activities using an approved fauna handler. A small proportion of reported fauna interactions related to fauna injury or death and the most common cause was entanglement in the perimeter fencing.

Flying foxes became entangled in the perimeter fence on 15 occasions in the annual monitoring period. The immediate response was the rescue of live animals by an approved fauna handler for transport to the veterinary hospital for treatment. Additional fauna deterrent tape and steel protection plates were installed on Site fencing and has been completed. Following implementation of these measures in January 2017, no flying foxes have been entangled in any areas of the Site where both the tape and plates have been installed. The last reported flying fox entanglement was reported on 19 January 2017 which indicates that the controls have been effective to date.

4.7 Weeds

The objective identified in the CEMP is to prevent the introduction of new weed species to the Site and the spread of declared weed species and WONS within the Site.

The Site has mostly been cleared of vegetation and is heavily compacted and stabilised to allow for construction operations. The compaction of the soil minimises the opportunity and potential for weed species to become established. Additionally the northern section of the Site is completely surrounded by intertidal mangrove habitats and associated salt flats which has historically acted as a barrier to weed invasion.

Two new Class B declared species, Sicklepod and Mimosa, were recorded during the annual monitoring period.

The declared weed species with the highest recorded abundance in the annual monitoring period was Perennial Mission Grass (including *Cenchrus spp.*) followed by Horehound and Gamba Grass. Sicklepod and Mimosa were recorded in small, isolated patches.

A targeted and strategic weed control program was implemented during the annual monitoring period, which aimed to control all target weeds (Class B declared weeds and Annual Mission Grass) during their active growing stage and before viable seed formation.

Weed control measures were implemented during the last quarter of the previous annual monitoring period (February and March 2016). This treatment period was ideal as most targeted weeds had germinated, were in an active growing stage and were not mature with seeds. These measures were effective in spot-spraying patches, however, during the May 2016 weed survey, it was noted that the remnant areas of weed incursion had consolidated and further treatment was required.

Further weed control measures were undertaken in December 2016 to coincide with the commencement of the wet season (Round 1), when plants start to germinate and actively re-grow. All weeds marked in the survey reports were treated and some successful control outcomes were achieved, however, the herbicide was not wholly effective in killing all mature plants.

During the January 2017 weed survey, it was identified that weed control measures undertaken in December 2016 (Round 1) were approximately 90% effective in the northern portion of the Site and 50% effective in the southern portion of the Site.

Weed control measures undertaken in March 2017 (Round 2 - mid wet season) constituted the major part of the control program and 90% of the years' control occurred in this period, which was ideal as most targeted weeds had germinated and were in their active growing stage. Several areas of effective weed control were observed during the April 2017 survey. Although spraying was evident it was not fully effective in killing entire plants in a few isolated locations, and therefore follow up control will be required in July-September 2017 (Round 3 - late wet season).

Although declared weed median densities and total area have increased during the annual monitoring period, it is important to note that the total area of weed patches is still very small compared to the total area occupied by the Site (1.2 ha of weeds compared to the 348 ha Site; ~0.4%).

As per NT guidance for management of Class B weeds, reasonable effort must be made to control the growth and spread of these weeds. It is therefore recommended that the targeted and strategic weed control program is continued to prevent the spread of weeds, particularly along the GEP corridor and along highly trafficked areas adjacent to the Haul Road and near storm water outlets.

Implementing control measures at an early stage, while densities of declared species are still low will help prevent further infestation and spread. It is recommended that the next spraying event includes foot-based spraying along the GEP corridor in areas where vehicular access is restricted during times of seasonal inundation (the peak weed growth and treatment period).

The success of future weed control on Site will depend on timing of control which must aim to control all target weeds during their active growing stage and before viable seed formation. To ensure that the control of all weeds is carried out before seed set, the ideal timing of the weed control program is as follows:

- Round 1: Early wet season – December. To control all early germinations;
- Round 2: Mid wet season – February. This is the major control program and 90% of the years control will occur in this period; and
- Round 3: Late wet season – April. To control all the germinations and any weeds that may have been missed in earlier control as well as areas previously inaccessible in the wet season.

The next weed survey will be conducted from July to September 2017 in order to effectively inform the weed control program and coincide with the weed growth period, and will advise the follow up process.

5. RISK ASSESSMENT

The risk assessment is aligned with the environmental risk identification process contained in the CEMP and the risk rankings contained in the Environmental Risk Register (ERR) (Appendix C of the CEMP). The Risk Register is a collation of the Projects risks generated from the various Environmental Risk Assessments that have been undertaken.

A detailed Conceptual Site Model was prepared for Site which outlines the sources, pathways and receptors that the EIMP (Rev 6) is designed to monitor and provides data to assess the relevant lines of evidence. Impacts are assessed using spatial, temporal and statistical assessment of data points and are investigated using the key inter-relationships between the environmental parameters and the source-pathway-receptor linkages. The risk assessment adopts a multiple lines of evidence approach to determine if the signal detected is attributable to construction activities, or by other factors not associated with the Project.

The data collected were also used to inform management plans and tools that included the CEMP and the ERR to support the mitigation of the major environmental risks posed by Site activities or discharges. The risk assessment has been updated to reflect Project staging and emerging risks as identified from updates to the Risk Register and monitoring data collected.

5.1 National Environmental Protection Measure Requirement

In accordance with the NEPM (2013), environmental risk assessment is based on identifying plausible source-pathway-receptor linkages and then assessing the magnitude of the risk of an adverse effect. If there is no linkage between a source and a receptor (i.e. no pathway), then there is no inherent risk.

The estimate of risk is qualitative (e.g. low, moderate, high and critical) and is based on the potential for exposure (likelihood) and the potential magnitude of environmental impacts (consequences) which results in changes in the risk profile. These risk factors are described further in Table 5-1 of CEMP.

This risk assessment makes a qualitative assessment of risk via comparison with environmental criteria for potential source-pathway-receptor linkages in the CEMP and the ERR. The best application of these criteria for beneficial use is specific to surface water and groundwater, as opposed to other environmental parameters considered in accordance with the Darwin Harbour WQOs. However, the groundwater and surface water beneficial use criteria apply to the broader environment including ecotoxicology, flora and fauna protection, commercial use relating to primary and secondary use of waters and agricultural purposes for marine and surface activities (DLRM, 2010a; DLRM, 2010b).

It should be noted that a beneficial use assessment was undertaken in AEMR (2014) that is still applicable, and assessed that the only applicable beneficial use at the present time for groundwater at the Site was for environmental purposes. Other potential future uses not applicable to the Site included agriculture, public water supply, rural stock and domestic supply.

5.1 Surface Water Monitoring Program

5.1.1 Qualitative Risk Assessment

According to the risk assessment approach the potential sources of impacts were noted as construction activities generating surface water and sediment discharges. The potential impact pathways include mobilisation of contamination to groundwater or surface waters and discharge into the receiving environment. Receptors include: the landward mangrove habitat; seaward mangrove habitat; intertidal and soft bottom benthic habitats and ecosystem; the water column; and, the aquatic megafauna in Darwin Harbour.

5.1.2 Surface Water Contamination

Results from the majority of the marine surface water monitoring locations did not exceed the adopted trigger values for metals and nutrients during the annual monitoring period. The exceedances that were recorded were either single exceedances at impact sites, and a review of construction activities did not identify a potential source, or occurred at both impact sites and references, and were hence not related to Site activities. There were instances where reportable exceedances with the WDL 192 and WDL 211 Licence conditions were recorded during the annual monitoring period. Investigations concluded that the risk of environmental harm related to these exceedances was low.

The risk ranking remained moderate for surface water contamination and the monitoring program objectives were achieved.

5.1.3 Sediment Transport

The objective of the erosion and sediment controls was to minimise the transport of sediment from the Site into the immediate surroundings including adjacent land, intertidal areas and receiving surface waters.

Terrestrial surface water results from auto-samplers were compared to mangrove sediment results because terrestrial surface waters passively discharging from Site are a potential, cumulative source of sediments in the mangrove environment fringing the Site. The results of this analysis indicated that stormwater passively discharging from the Site did not result in sedimentation or erosion in the surrounding mangrove communities during the annual monitoring period.

The risk ranking remained low and the monitoring program objectives were achieved.

5.2 Groundwater Monitoring Program

5.2.1 Qualitative Risk Assessment

According to the risk assessment approach the potential sources of impact to groundwater were earthworks, ground improvement works, ASS and spills. The impact pathway is ingress/inflow of contaminated water into groundwater and migration offsite. Receptors include the mangrove habitats and other ecosystems in Darwin Harbour.

5.2.2 Groundwater Levels and Quality

The objectives of the groundwater monitoring program were to minimise changes in groundwater levels and quality as a result of Site activities and/or discharges.

Groundwater level fluctuations in bores located in the centre of the Site were attributed to seasonal rainfall and recharge, while bores located along the perimeter of the Site were more influenced by tides.

Based on the historical background data and results from the groundwater monitoring program that was undertaken during the annual monitoring period, there were no observed increasing or decreasing trends in groundwater levels along the GEP and on Site.

Mann-Kendall statistical trend analysis was conducted to assess any overall trends in the sulphate/chloride ratios in the bores on Site and along the GEP corridor. No increasing trends in sulphate/chloride ratios were observed in the bores on Site or along the GEP corridor, with the exception of one bore, namely BPGW06. A review of the data indicated that the sulphate concentrations have been below the LOR on all occasions at BPGW06 since monitoring began. This indicated that the overall increasing trend reported by Mann-Kendall for BPGW06 was a false positive result and no impacts associated with ASS were evident at this bore location.

A comparison of the Mann-Kendall classic trend against the seasonal trend technique indicated that the bores displayed a strong seasonal influence in the sulphate/chloride ratios associated with the wet and dry seasons and in response to groundwater recharge rates.

In AEMR (2016), a small number of bores were observed to have a potentially increasing trend in metals and nutrients concentrations. During this annual monitoring period, these bores were placed on a watch list for additional investigation. Mann-Kendall trend analysis was used to assess for any trends in metals and nutrients concentrations, and sulphate/chloride ratios at each of the bores on the AEMR (2016) watch list. Based on this analysis, there were no overall increasing trends for sulphate/chloride ratios at any of the bores on the watch list, however, there were increasing metals and nutrients trends in certain bores on the AEMR (2016) watch list.

In this annual monitoring period a new watch list was established based on the results of the April 2017 80th percentile statistical results. Groundwater monitoring parameters that exceeded the adopted trigger value and 80th percentile were assessed for trends using the same Mann-Kendall analysis techniques as specified above. Groundwater monitoring parameters that did not exceed the trigger values and 80th percentile were considered to be within normal seasonal variation and were not assessed using Mann-Kendall.

pH trends were analysed using Mann-Kendall in groundwater bores that were observed to exceed the trigger value and 80th percentile in April 2017 and that displayed an increasing trend following the Mann-Kendall Analysis in both the AEMR (2016) and 2017 watch list.

Only two bores, namely BPGW11 and BPGW23 were found to exceed the trigger value and the 80th percentile in April 2017 i.e. were outside natural seasonal variation, and displayed increasing metal and decreasing pH trends. A review of the historical data for BPGW11 and BPGW23 indicated that these bores have similar pH trends, in that the pH concentrations decreased in April to June 2013 and have since remained relatively constant. A slight increasing trend in salinity has also been noted at these locations which may be a result of the relatively impermeable construction platform and reduced groundwater recharge at these locations. Given that there were no increasing trends in sulphate/chloride ratios, it was assessed that these increasing metals trends were not associated with ASS mobilisation and Site activities because a review of construction activities did not identify a potential source(s).

The risk ranking has remained moderate for concentrations of metals and nutrients in soils and groundwater and the monitoring program objectives were achieved. Any effects observed on the surrounding environment during the annual monitoring period were localised and minor.

5.2.3 Mangrove Community Impacts

The mangrove objective for the groundwater monitoring program was to minimise disturbance to and alteration of mangrove communities as a result of changes to groundwater levels or quality arising from Site activities and/or discharges.

No ASS impacts on mangroves were observed during the annual monitoring period. The mangrove systems adjacent to the Site were in a healthy condition and relatively undisturbed by Site activities and discharges. The data collected were broadly consistent with data collected during previous annual monitoring periods.

The risk ranking remained moderate for ASS impacts on mangroves surrounding the Site and the monitoring program objectives were achieved.

5.3 Mangrove, Sediments and Bio-indicator Monitoring Program

5.3.1 Qualitative Risk Assessment

Objectives of the mangrove community health, sediment and bio-indicator monitoring program include minimising the disturbance to, and alteration of, mangrove communities outside the Site boundary due to Project activities.

5.3.2 Mangrove Community Health

The trigger value for tree condition was not exceeded at 19 out of 20 impact sites and the only exceedance was recorded at impact site BPMC06, which was previously impacted by a known mud wave and water ponding. The proportion of healthy trees at BPMC06 showed no variation during the annual monitoring period, which indicated that this site may have stabilised as the forest adapts to the new soil and hydrological conditions.

Impact and reference sites contained seedlings (75% and 92% respectively) and regeneration rates remained high.

There were no exceedances of the canopy cover trigger value during the annual monitoring period and canopy cover remained high at the survey plots. These results are similar to those recorded in previous monitoring periods.

Changes in pneumatophore density were very similar at impact and reference sites compared to the June 2016 background data and pneumatophore density increased at the majority of impact and reference sites. Overall, there was a high level of variability in crab burrow density during the annual monitoring period, however, crab burrow density remained high at the survey plots.

Dust was not evident on the leaves of mangrove trees at impact and reference sites during the annual monitoring period. This represented a decrease in dust levels in comparison to AEMR (2016), which recorded light dust levels in June 2015 and light to medium dust levels in September 2015.

The risk ranking for loss of mangrove habitat and loss of biodiversity around the Site remained moderate and the monitoring program objectives were achieved.

5.3.3 Sedimentation and Erosion

The quarterly relative sediment height results indicated that there were no exceedances of the sedimentation and erosion trigger values and relative sediment heights remained stable in the annual monitoring period.

The annual DGPS survey indicated an overall increase in the number of ground level exceedances in comparison to AEMR (2016) and AEMR (2015), with the largest variations recorded along BPMC07. These changes were attributed to the mangrove ponding remediation excavation and infill works that were undertaken from late 2014 to June 2015 within the Flare Pad causeway mangrove drainage areas. Mangroves at BPMC07 did not record any ecologically significant decline in mangrove community health parameters in the annual monitoring period.

Survey point 6001 (located along BPMC06) recorded an increase of 2 cm (± 2 cm) during 2012-2013, 25 cm (± 2 cm) during 2013-2014, and a decrease of 20 cm (± 2 cm) during 2014-2015. An increase of 17.3 cm was recorded in June 2016, representing a total nett increase of 24.0 cm since May 2012. The June 2016 result was interpreted to demonstrate that the previous, known mud wave in this area was not increasing and appeared to have stabilised. The proportion of healthy trees at BPMC06 showed no variation during the annual monitoring period, which indicated that this site may have stabilised as the forest adapts to the new soil and hydrological conditions.

The risk ranking for sedimentation and erosion remained low and the monitoring program objectives were achieved.

5.3.4 Sediment Quality

Total metals in sediments were within the adopted trigger values with the exception of total arsenic, total antimony and total chromium, which was consistent with AEMR (2016). After consideration of bio-availability, the exceedances dropped below the ISQG-Low trigger value, with exception of a single trigger value exceedance of total antimony at one reference site in September 2016. These results were characterised as low risk and no further action was required.

As outlined in **Section 4.3.2.5**, Mann-Kendall statistical analysis of metals in mangrove sediments (and bio-indicators), and an assessment of the water quality of stormwater passively discharging from Site indicated that any observed, increasing metals trends in mangrove sediments were not related to Site activities and discharges. Based on the analysis, the risk of passive Site discharges resulting in the accumulation of metals in mangrove sediments was assessed to be low.

The risk ranking for sediment quality remained low and the monitoring program objectives were achieved.

5.3.5 Bio-indicators

Since June 2014, when the frequency of bio-indicator monitoring was revised to quarterly, there has been substantial variability in the data between monitoring periods and between impact sites and reference sites. Some of this variability may be attributed to sample size variation, location, tides, and climatic and seasonal changes.

During the annual monitoring period, metals in mud whelk tissue were within the adopted trigger values with the exception of copper and mercury. The number of mercury exceedances recorded during the annual monitoring period decreased compared to AEMR (2016) and AEMR (2015) at impact and reference sites. Similarly, the number of copper exceedances that were recorded during the annual monitoring period decreased in comparison to AEMR (2016) and remained consistent with AEMR (2015) at impact and reference sites.

Similar seasonal patterns of mercury concentrations were observed at the three impact locations (BPMC01, BPMC08 and BPMC27) and four reference locations (CSMC01-3, CSMC02-5, CSM02-6 and CSMC4-11) which recorded mercury exceedances. There were no sources of mercury on Site that would be discharged to the Darwin Harbour.

Mann-Kendall statistical analysis of metals in bio-indicators indicated that any observed, increasing metals trends in bio-indicators were not related to Site activities and discharges, and the risk of passive Site discharges resulting in the accumulation of metals in bio-indicators was low.

The risk ranking for bio-indicator impacts remained low and the monitoring program objectives were achieved.

5.4 Dust Monitoring Program

5.4.1 Qualitative Risk Assessment

According to the risk assessment approach the potential sources of impact were earthworks and general construction activities, the impact pathway is winds blowing from Site and the receptors were mangroves fringing the Site and community sensitive receptors located in Palmerston and Bladin Central Enterprise Park.

5.4.2 Dust Impacts on the Environment

No PM_{10} or $PM_{2.5}$ exceedances were recorded at Palmerston (PAPM01) during 24-hour vector averaged south-westerly winds (i.e. along the impact pathway) and therefore, it was assessed that Site activities had not resulted in dust impacts at sensitive receptors located in Palmerston.

Four PM_{10} exceedances and one $PM_{2.5}$ exceedance were recorded at the dust monitor (BPPM04) closest to the Bladin Central Enterprise Park during 24-hour vector averaged northerly winds (i.e. along the impact pathway).

Further assessment identified there were two days during the annual monitoring period when the Bladin Central Enterprise Park could potentially have been impacted by dust levels. However, no reports of dust complaints were received on these two occasions or during the annual monitoring period.

The risk ranking for dust impacts on community sensitive receptors remained low and the monitoring program objectives were achieved. The reason why this ranking applies to the Bladin Central Enterprise Park is because the BPPM04 dust monitor is not located at the sensitive receptor location itself but is positioned at the Site boundary adjacent to the active lay-down area which is 1.28 km away. In addition, the winds speeds were relatively low (2-10 m/s) on the two occasions where vector averaged, northerly wind exceedances were detected at the BPPM04 monitor during the annual monitoring period. As such, it is very unlikely that dust exceedances at the monitor location would have resulted in nuisance dust or health impacts at the sensitive receptor located this far away.

There were no exceedances of the dust deposition trigger value recorded at PADD01 or BPDD14. Dust deposition gauges on Site provided data on potential impacts on the mangrove communities fringing the Site. Based on the fact that the mangroves remained in a healthy condition during the annual monitoring period, it was assessed that any dust deposition that did occur, did not adversely affect the mangrove community surrounding the Site. The risk ranking for dust impacts on surrounding mangrove vegetation resulting in smothering and reduced growth remained low, and the monitoring program objectives were achieved.

5.5 Airborne Noise Monitoring Program

5.5.1 Qualitative Risk Assessment

According to the risk assessment approach the potential source of impact was general construction activities, the impact pathway was sound propagation through air (as a longitudinal wave) and sensitive receptors are in Palmerston and Bladin Central Enterprise Park.

5.5.2 Noise Impacts to Local Community

No noise complaints were received during the annual monitoring period.

Noise audio file analysis of the day-time and night-time exceedances recorded at PAAN01 indicated that noise exceedances at this monitor were caused by local activities (e.g. motor vehicles, passing trains and aircraft) and natural noise sources (e.g. insects, frogs and birdsong).

Assessment of available audio files collected from BPAN02 indicated that the vast majority of exceedances at this noise monitoring location were caused by Site activities within the Area 1888 Laydown Area, however, noise attenuation analysis undertaken previously indicated that these events would not have caused an exceedance of the residential trigger values at the Bladin Central Enterprise Park. The remaining exceedances were caused by natural noise sources like insect and bird sounds.

The risk ranking for noise impacts (nuisance and health impacts) remained low and the monitoring program objectives were achieved.

5.6 Flora and Fauna Monitoring Program

5.6.1 Qualitative Risk Assessment

According to the risk assessment approach, the potential sources of impact were vegetation clearing and ponding water (specific to mangroves). The receptors were mangrove fauna and flora at the Site.

5.6.2 Flora and Fauna

No vegetation clearing occurred during the annual monitoring period.

Flying foxes became entangled in the perimeter fencing on 15 occasions during the annual monitoring period. The immediate response was the rescue of live animals under the direction of a NT Parks and Wildlife permitted fauna handler for transport to a veterinary hospital for treatment and the installation of visible tape to avoid collisions.

Additional fauna deterrent tape and steel protection plates were installed on the Site fencing in January 2017 and following implementation of these measures, no further incidents were reported.

The risk ranking related to fauna and flora impacts was low and any effects on the surrounding environment were localised and minor. This will continue to be monitored during seasonal changes to flying fox movements, to confirm the additional deterrents remain effective.

5.7 Weed Monitoring Program

5.7.1 Qualitative Risk Assessment

According to the risk assessment approach the potential sources of impact were general site activities, vehicles and clearing activities. The pathway is the movement of weed/pest species and the receptors were natural vegetation communities surrounding the Site.

5.7.2 Weed Management

The Site has mostly been cleared of vegetation and is heavily compacted and stabilised to allow for construction operations. The compaction of the soil minimises the opportunity and potential for weed species to become established. Additionally the northern section of the Site is completely surrounded by intertidal mangrove habitats and associated salt flats which has historically acted as a barrier to weed invasion.

Two new Class B declared species, Sicklepod and Mimosa, were recorded during the annual monitoring period. The declared weed species with the highest recorded abundance in the annual monitoring period was Perennial Mission Grass (including *Cenchrus spp.*) followed by Horehound and Gamba Grass. Sicklepod and Mimosa were recorded in small, isolated patches.

Declared weed densities increased during the annual monitoring period, however, it is important to note that the total area of weed patches is still very small compared to the total area occupied by the Site (~0.4%).

Targeted and strategic weed controls on Site should continue in order to prevent the spread of weeds, particularly along the GEP corridor and along highly trafficked areas adjacent to the Haul Road and near storm water outlets. Implementing control measures at an early stage, while densities are still low will help prevent the spread of declared weeds. It is recommended the next spraying event includes foot-based spraying along the GEP corridor in areas where vehicular access is restricted during times of seasonal inundation.

The success of future weed control on Site will depend on the timing of controls which must aim to control all target weeds during their active growing stage and before viable seed formation. To ensure that the control of all weeds is carried out before seed set, the ideal timing of the weed control program is as follows:

- Round 1: Early wet season – December. To control all early germinations;
- Round 2: Mid wet season – February. This is the major control program and 90% of the years control will occur in this period; and
- Round 3: Late wet season – April. To control all the germinations and any weeds that may have been missed in earlier control as well as areas previously inaccessible in the wet season.

The weed monitoring program was implemented as planned but the objective of no new declared weed species was not met, however, it was not clear whether this was due to a pre-existing seed bank in the soils or construction activities.

5.8 Adaptive Response Monitoring

5.8.1 Hydrotest Discharge Line Leak

Discharge of spent hydrotest waters from the Butane/Propane storage tanks via the MOF outfall to Darwin Harbour was being carried out on 27 February 2017. During a site inspection on 28 February it was found that a washer coupling in the hydrotest discharge line had lost a seal which resulted in a leak of hydrotest water to authorised discharge location DL1 (regulating reservoir in the north-eastern corner of the Site).

Following the detection of the hydrotest line leak, adaptive response monitoring was carried out downstream in the regulating reservoir. The leak was then isolated by the construction of barricading dams both upstream and downstream of the leak in order to impede surface water flow to the regulating reservoir and minimise the quantity discharged to the receiving environment. The seal was repaired after the discharge had finished.

<u>Surface Water</u>

The adaptive response monitoring included the collection of two downstream surface water samples from the hydrotest line leak entering the regulating reservoir. Additional response monitoring was conducted in the receiving environment downstream of the leak and included the collection of three marine water quality samples.

Characterisation sampling of the water collected from the discharge line indicated oxides of nitrogen concentrations of 60 µg/L and 190 µg/L, which exceeded the WDL 211 limit for discharge to the regulating reservoir by 17 µg/L and 147 µg/L respectively, but were below the end of pipe water quality criteria for the MOF of 300 µg/L. Sampling of the water collected from the regulating reservoir downstream of the leak and one out of three locations in the receiving marine environment also reported slight exceedances of the trigger value for oxides of nitrogen.

Exceedances of oxides of nitrogen are not uncommon in Darwin Harbour and testing undertaken as part of the EIMP (Rev 6) regularly detects oxides of nitrogen concentrations in excess of 500 µg/L. As such the oxides of nitrogen exceedances observed during receiving environment monitoring were not considered representative of a contamination event and were not attributed to the line leak. Therefore the risk of environmental harm to marine surface waters as a result of this spill was considered to be low.

<u>Mangroves</u>

Three response monitoring mangrove sediment samples were collected downstream of the regulating reservoir outfall. All oxides of nitrogen concentrations in the sediment samples were reported below the LOR. Therefore, the risk of environmental harm to the downstream mangrove community as a result of this spill was considered to be low.

5.8.2 Area B300 Oil and Diesel Spill

On 6 December 2016, a generator leaked oil into the Common Flare Knockout Drum bund in Area B300 on Site. The generator was repaired the same day; however, on 7 December 2016, the same generator suffered a secondary fault and diesel subsequently leaked into the bund. As a result of the two leaks, the AOC drainage and pit system became contaminated with approximately 85 L of oil and diesel. Following the spills, remediation works were undertaken by a subcontractor in the bund and AOC system from 6 December 2016 to 20 January 2017. Validation sampling demonstrated that the source of the spill was successfully cleaned up and as such no future impacts from the spill were considered likely.

During the remedial works, a significant rainfall event (approximately 185.6 mm) occurred on 23 and 24 January 2017 causing the AOC in Area B300 to overtop at pit MH309 into the regulating reservoir. As a result, approximately 160 KL of stormwater that was potentially contaminated with hydrocarbons was unintentionally released into the regulating reservoir and was discharged from Site.

Surface Water

Four surface water samples were collected downstream of Pit MH309 (#7) from the following locations on 24 January 2017 and during the AOC overtopping event into the regulating reservoir: Pit MH309 (#8); Pit MH309 (#9); and, the regulating reservoir and outfall immediately downstream of Pit MH309. All four samples were submitted to a NATA-accredited laboratory for TRH and BTEXN analysis.

All results were less than the trigger criteria for discharge to the regulating reservoir as per the waste discharge permits, which indicated that potentially contaminated water was not being discharged at the time of sampling. The risk of environmental harm to the marine receiving environment as a result of this spill was considered to be low.

5.8.3 Area E600 Acid Spill

On 19 October 2016, approximately 1,000 L of 25% hydrochloric acid leaked from a dangerous goods container onto the surrounding compacted fill along the northern perimeter of Area E600 on Site.

Soil, Groundwater and Surface Water

Remedial excavation works were supervised by Greencap and were guided by using a field screening method utilising pH data collected from reference soils located in areas of the Site not impacted by the acid spill. Six reference soil samples were collected from surface soils located up to a distance of approximately 1 km away from the spill in areas that could not be affected by the spilled acid. The maximum depth of the excavation for the investigation and remediation works was 0.13 m at which point soil screening in the field indicted that the soil had returned to a normal pH which was confirmed via subsequent submission of collected samples to a NATA accredited laboratory.

Once the soils had been removed, soil validation and reference samples were collected and sent to a NATA-accredited laboratory for pH analysis.

Laboratory and visual evidence of the spill area indicated that the remedial excavation works were successful and that no further excavation was required. The excavation was then backfilled with suitably uncontaminated fill.

Remediation works and validation sampling demonstrated that the source of the spill was successfully removed and as such no future impacts from this spill are considered likely.

No groundwater or surface water impacts were detected, indicating that the risk of environmental harm to the groundwater and marine receiving environment sensitive receptors was low.

6. CHANGES TO EIMP (REV 6)

The Project is entering the closing stages of construction/commissioning and is approaching the operations phase. As a result, the risk sources, pathways and the potential for environmental harm have changed, and the monitoring program has been reviewed to remove surplus components.

The remaining phases of the Project currently include:

- Final construction activities;
- Pre-commissioning and commissioning; and
- Removal of temporary facilities and demobilisation.

AEMR (2016) recommended that specific components of the GEP surface water and groundwater monitoring programs could be changed where a detailed risk assessment concluded that no adverse impacts had occurred after consideration of the 2016 dry season and the 2016/17 wet season data. Construction activities and reinstatement works along the GEP were completed in October 2016 and therefore the main risk source(s) have been removed.

Based on the detailed assessment outlined in AEMR (2017), and in accordance with the adaptive monitoring process outlined in Chapter 5 of the revised EIMP, the following recommendations are made:

- The frequency of GEP surface water monitoring is changed from monthly to quarterly because this frequency will be sufficient to monitor any potential impacts related to ASS mobilisation through the groundwater expression pathway. The monitoring should continue until the end of the 2017/18 wet season in order to provide further evidence of whether any construction or reinstatement impacts have been detected; and
- Monitoring at GEP bores MW04d, MW05d, MW08d, MW10a, MW11a and MW14 can cease and these bores can be removed from EIMP (Rev 6).

7. CONCLUSIONS

In conclusion, the EPA7 Annual Report provides a clear understanding of the Project's potential impacts on the adjacent receiving environment and broader Darwin Harbour. While there were exceedances across a small range of the total number of parameters measured during the annual monitoring period, it was assessed that these did not result in environmental harm in the receiving environment.

The environmental impacts and risks associated with the Project are adequately managed through the provisions, procedures and mitigation measures outlined in the CEMP.

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9. STATEMENT OF LIMITATIONS

This report was prepared for Contractor and INPEX in accordance with industry recognised standards and procedures recognised at the time of the work.

The report presents the results of the assessment based on the quoted Scope of Services (unless otherwise agreed in writing) for the specific purposes of the commission. No warranties expressed or implied are offered to any third parties and no liability will be accepted for use of this report by any third parties.

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