APPENDIX Q

Draft Water and Sediment Monitoring Program

PowerWater

Report

East Point Outfall Water, Sediment and Biota Monitoring Program

26 OCTOBER 2011

Prepared for

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Introduction

Treated effluent from the Ludmilla Wastewater Treatment Plant (LWWTP) is discharged to the waters of Darwin Harbour through the East Point Outfall (EPO) (Site 0 on Figure 1-1). The present outfall pipe extends approximately 350 m offshore in a north-westerly direction across an intertidal mudflat and discharges in the intertidal zone. The outfall at the end of the pipeline is a vertical discharge at approximately neap tide low water level and 2.2 m below mean sea level (Plate 1-1). The rate of discharge averages 7.65 ML/day in the dry season and up to 30 ML/day in the wet season (2006 figures). During periods of excess flow in the wet season, and as a result of fault and maintenance shutdowns, wastewater may be diverted to Ludmilla Creek from where it discharges to the Harbour.

Plate 1-1 East Point Outfall on low tide

Source: HydroSurvey Australia (2008)

Power and Water Corporation (PWC) has committed to improvements in water quality in discharges from its sewage treatment plants (Power and Water Environment Report 2007, Power and Water Annual Report 2009). As part of that process PWC is currently considering options to extend the EPO and to augment the existing Effluent Rising Main (ERM) as part of a wider review covering the upgrade and expansion in capacity of the Ludmilla WWTP. The upgrade process will include:

- augmentation of the East Point ERM
- extension of the East Point Outfall
- diversion works to deliver sewage from the Larrakeyah catchment to the Dinah Beach trunk sewer
- upgrades to the Ludmilla WWTP to increase hydraulic capacity and to deliver performance improvements.

As acknowledged by PWC in its 2007 Environment Report, the introduction of water quality objectives for Darwin Harbour by the Department of Natural Resources, Environment and The Arts (NRETA) is likely to impact on future water quality targets required for wastewater discharge.

1 Introduction

A monthly water quality monitoring program addressing physical, chemical and biological parameters at the harbour outlet location and environs was implemented by PWC in February 2011. This programme considerably exceeds the monitoring requirements as set out in the Ludmilla WWTP Waste Discharge Licence, Licence Number 150 (refer to Section 2 of this report). Prior to 2011, the monitoring of additional harbour sites was largely undertaken on an ad-hoc basis in response to identified concerns. The principal issue addressed has been unsatisfactory bacteria levels within Darwin Harbour which have resulted in beaches being closed on a number of occasions, although in many cases the specific causes are uncertain due to multiple potential sources. More recently, the use of chlorine for odour control with the additional benefit of disinfection of the wastewater discharged from the Ludmilla WWTP, has seen bacteria levels reduced to extremely low levels, in most cases meeting environmental health guidelines at the point of discharge.

Recognising that there are multiple potential sources of bacteria in the harbour environment, the Department of Natural Resources, Environment, The Arts and Sport (NRETAS) also undertakes a harbour-wide recreational (bacteriological) monitoring program which monitors bacterial levels at recreational beaches.

Monitoring of other water quality parameters is also undertaken by NRETAS at various sites within the Harbour and historically there have been a number of short-term and project specific water quality studies undertaken at various times and locations within the Harbour which provide background information on water quality.

There is no routine monitoring of harbour sediments in the vicinity of the outfall, but some background information is available from other studies (e.g. NRETAS, ConocoPhillips, INPEX, Darwin Waterfront).

The purpose of the current Water and Sediment Quality Monitoring Program is to address issues of concern arising from the proposed relocation and increased capacity of the EPO. These have been identified by NRETAS as: future and cumulative increases in nutrients, turbidity, fine sediment and heavy metals entering the marine environment of Darwin Harbour causing impacts to fauna and flora at both the pollution point source and harbour-wide scale.

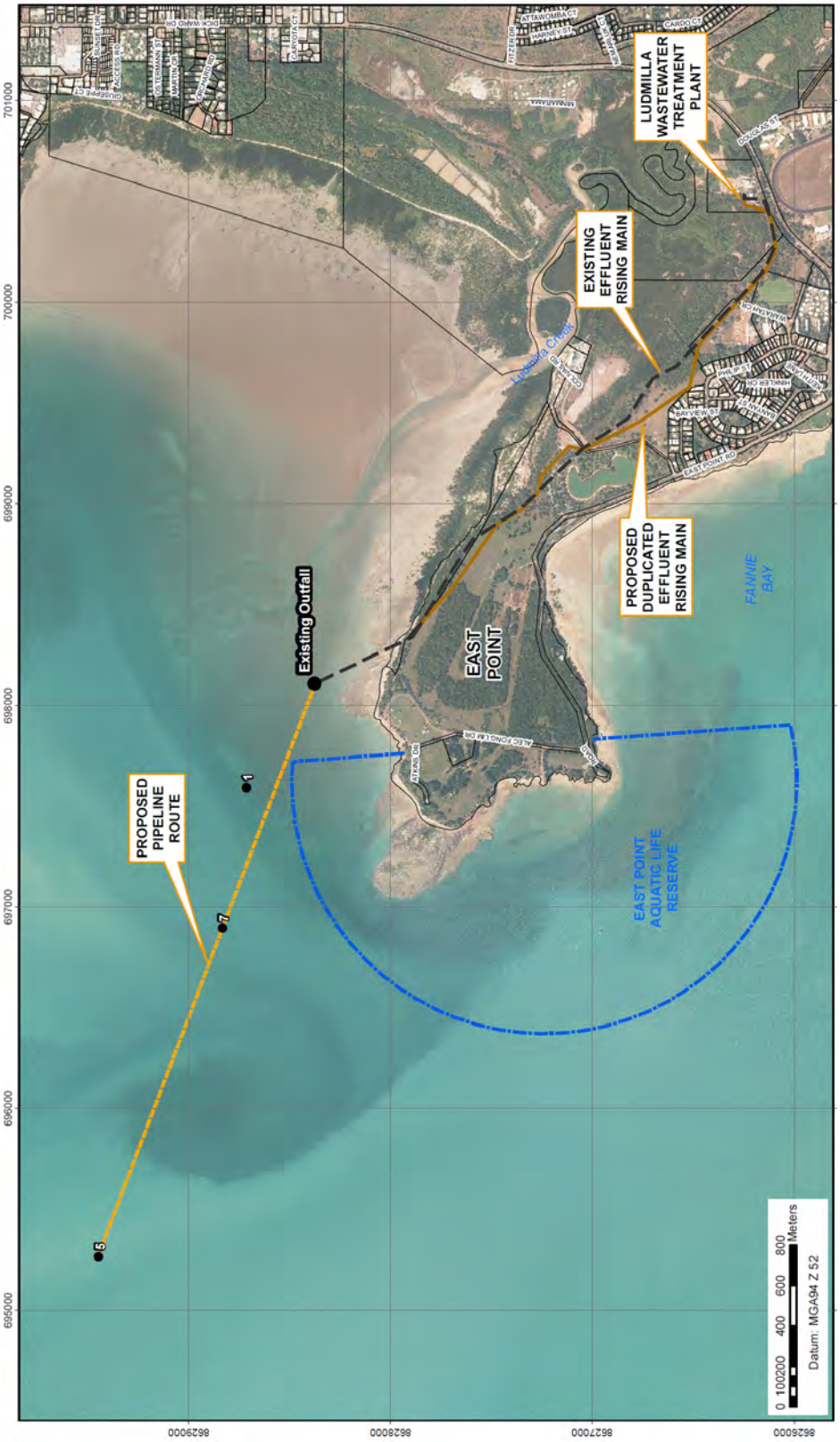
The water quality monitoring parameters adopted in this monitoring program are drawn from the current PWC monitoring program. It is considered that these are appropriate to the acquisition of baseline data for construction and operation of the new outfall. In the long term, while all of the parameters may continue to be monitored at the plant outlet monitoring site (SLu080), ongoing monitoring in the marine environment for some parameters may not be warranted if they are shown to be consistently below guideline values at the point of discharge. Such decisions will be guided by the data from the plant outlet. That is, potential contaminants which have been shown not to occur at above guideline concentrations can be deleted from the harbour monitoring program where there is a time and cost benefit of doing so, although monitoring of these and potentially other minor contaminants at SLu080 should continue as a precautionary measure, given that inputs to the plant and treatment processes may change over time.

Three sites are presently under consideration for the future location of the EPO. The locations and characteristics of these are shown in Figure 1-1 and site coordinates are provided in Table 1-1.

A visual representation of the bathymetry is presented in Figure 1-2. Colours range from yellow (intertidal) through green to dark blue, representing the deepest water found.

1 Introduction

Figure 1-1 Potential outlet locations (Sites 1, 7 and 5)

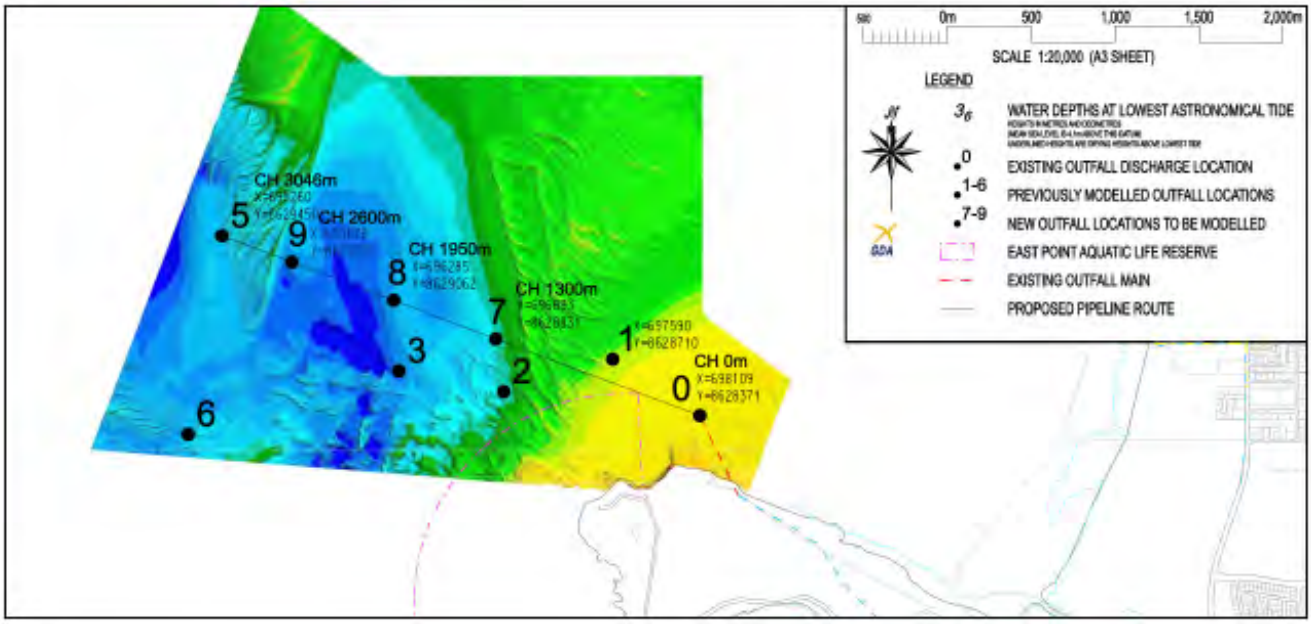


1 Introduction

Table 1-1 Site coordinates and characteristics of the three outfall sites

Site Characteristics	Site 1	Site 7	Site 5
Site coordinates (northing; easting)	697590; 8628710	696893; 8628831	695260; 8629450
Average depth (m)	4.26	10.27	11.96
Depth of discharge (m)	3.26	9.27	10.96

Figure 1-2 Bathymetry at proposed outlet locations



2

Waste Discharge Licence

2.1 Background

The Ludmilla WWTP and EPO currently operate under Waste Discharge Licence Number 150 issued by NRETAS pursuant to Section 74 of the *Water Act*. The current licence was issued on 13 October 2006 and is due to expire on 31 October 2011.

Under the licence, PWC is authorised to discharge wastewater from the EPO under qualitative and quantitative discharge limits which are described below.

2.1.1 Qualitative discharge limits

Wastewater discharged at authorised discharge point LUDMILLA OUTFALL 01 must not cause:

- odours which would adversely affect the use of the surrounding waters
- any objectionable discolouration, or visible oil, grease, foam, scum or litter
- mortality of fish; or
- fish, stock or other aquatic organisms to be unacceptable for human consumption as determined by Territory health standards, and any standard in force from time to time, applying to the sale for human consumption of such fish, stock or other aquatic organisms in the Territory, interstate or overseas.

2.1.2 Quantitative discharge limits

PWC must ensure that wastewater discharged at authorised discharge point LUDMILLA OUTFALL 01 does not exceed the quality limits and / or ranges identified in Table 2-1, below.

Table 2-1 Quantitative discharge limits

Parameter	Unit	Median	90%ile limit
Dry weather flow	kL/day	8 000	11 000
Wet weather flow	kL/day	15 000	30 000
Temperature	°C	-	±5°C ambient
pH	units	-	>6
Biochemical Oxygen Demand (BOD)	mg/L	100	180
Suspended Solids	mg/L	110	170
E. coli	cfu/100 mL	10^6	10^7
Total Nitrogen	mg/L	37	47
Free Ammonia	mg/L	28	33
Total Phosphorus	mg/L	10	15

2.1.3 Discharge regime

There are no specified conditions regarding the discharge regime, e.g. limiting discharge to a maximum flow rate, tide state, etc.

2.2 Monitoring required under existing Waste Discharge Licence

2.2.1 Monitoring sites

Under its existing Waste Discharge Licence, PWC is required to undertake environmental monitoring at the sites and for the purposes identified in Table 2-2.

Table 2-2 Environmental monitoring sites

Site	Purpose	Description	Location
SLu080 (outlet)	Effluent quality	Monitors quality parameters of effluent prior to release to the outfall	Ludmilla final treatment cell MGA 94 S12.422093° E130.84517°
SLu001 (inlet)	Influent quality	Monitors quality parameters of influent prior to treatment at the facility	Inlet works Ludmilla WWTP Ponds MGA 94 S12.42111° E130.84540°

All sites, with the exception of ambient or open water sampling sites are required to be clearly signed with the location, purpose and name of the site. The location of environmental monitoring sites must not be altered without the prior written approval of the Controller.

2.2.2 Monitoring parameters and sampling frequency

Samples collected at the environmental monitoring sites are required to be analysed for the parameters at the frequency and using the methods specified in Table 2-3.

Table 2-3 Water monitoring parameters

Parameter	Units	Sampling Method	Sampling Frequency for Sampling Site	
			SLu080 (Plant Outlet)	SLu001 (Plant Inlet)
Flow	kL/day	Site test	Monthly	Annually
pH	pH units	Site test	Monthly	Annually
Temperature	°C	Site test	Monthly	Annually
Conductivity	µS/cm @ 25°C	Site test	Monthly	Annually
Dissolved Oxygen	% saturation	Site test	Monthly	Annually
Alkalinity[1] $CaCO_3$	mg/L	Site test	Monthly	Annually
Hardness[1]	mg/L	Site test	Monthly	Annually
Turbidity[2]	NTU	Site test	Monthly	Annually
Biochemical Oxygen Demand	mg/L	Grab sample	Monthly	Annually
Chemical Oxygen Demand	mg/L	Grab sample	Monthly	Annually
Total Nitrogen	µg/L	Grab sample	Monthly	Annually

2 Waste Discharge Licence

Parameter	Units	Sampling Method	Sampling Frequency for Sampling Site	
			SLu080 (Plant Outlet)	SLu001 (Plant Inlet)
Ammonia	µg/L	Grab sample	Monthly	Annually
Nitrogen Oxides	µg/L	Grab sample	Monthly	Annually
Total Phosphorus	µg/L	Grab sample	Monthly	Annually
Total Suspended Solids	µg/L	Grab sample	Monthly	Annually
Volatile Suspended Solids	µg/L	Grab sample	Monthly	Annually
Filterable Reactive Phosphorus	µg/L	Grab sample	N/A	Annually
E. coli	cfu/100 mL	Grab sample	Monthly	Annually
Enterococci	cfu/100 mL	Grab sample	Monthly	Annually
Thermotolerant coliforms[3]	cfu/100 mL	Grab sample	Monthly	Annually
Chlorophyll *a*	µg/L	Grab sample	N/A	N/A
Multi element ICPMS	µg/L	Grab sample[4]	Annually	Annually

N/A Not applicable

1 Change from site (field) testing to laboratory testing approved 26/3/2007

2 Approval to delete site (field) testing of turbidity approved 25/3/2007

3 Test no longer conducted (2007-08 WDL report V1.1 submitted March 2010)

4 Change from composite sampling to grab sampling approved 8/6/2007

2.2.3 Testing methods

PWC is required to ensure that all samples not delineated as “site test” for the purposes of sampling method, are:

- Analysed at a laboratory with NATA accreditation for the selected analyses or at a laboratory approved by the Controller.
- Collected and analysed in accordance with the relevant Australian Standards unless otherwise specified by the Controller.

PWC must provide to the Controller all raw data in an electronic format approved by the Controller and at the times specified by the Controller.

All records of sampling and analysis required under this licence must be retained by PWC for a period not less than two years after the date of sampling. Records retained under this clause must be made available to the Controller upon request.

2.2.4 Sample information required

For all sampling PWC is required to record the following information:

- the date on which the sample was taken
- the time at which the sample was taken
- the monitoring point at which the sample was taken
- the measured or estimated daily flow of effluent at the time of sampling
- the results of all monitoring.

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3

Historical and Current Water Quality Monitoring

3.1 Power and Water Corporation monitoring

3.1.1 Historical monitoring

PWC has undertaken a regular programme of monitoring in accordance with the requirements of the Waste Discharge Licence. A summary of water quality monitoring data for the period 1995 to 2009 is presented in Table 3-1. Of note are the significantly higher *E. coli* numbers (up to 16 x 10^6 cfu/100 mL) that occurred prior to upgrading the chlorine injection program for disinfection purposes in 2010.

Table 3-1 Summary of effluent quality discharged from the Ludmilla WWTP January 2005 - October 2009

Assessable Parameter	No. of Samples	Average (mg/L)	Median (mg/L)	90%ile (mg/L)	Min (mg/L)	Max (mg/L)
pH	52	7.7	7.6	8.6	6.7	9.0
Biochemical Oxygen Demand (BOD)	45	124	117	201	3	281
Total Suspended Solids (TSS)	52	103	93	138	18	444
E. coli	15	2 x 10^6 (cfu/100 mL)	5 x 10^4 (cfu/100 mL)	5 x 10^6 (cfu/100 mL)	65 (cfu/100 mL)	16 x 10^6 (cfu/100 mL)
Total Nitrogen	32	37	41	46	12	50
Free Ammonia	47	27	30	36	4	39
Total Phosphorus	47	5.4	5.8	7.5	1.1	10.9

Source: Hunter Water Australia Pty Ltd 2011

3.1.2 2010 - 2011 monitoring

Subsequent to adopting the use of chlorine for odour control purposes, bacteria levels in the discharged wastewater have markedly reduced, with the *E. coli* 12 month rolling median for the period from June 2010 to June 2011 falling to a mpn (most probable number) of 41 per 100 mL (i.e. below the guideline for recreational waters).

Commencing in 2010, PWC initiated a more intensive water quality monitoring program designed to obtain data on the effect of the discharge on the marine environment, and in particular the East Point Aquatic Life Reserve which lies to the south of the outlet (Figure 3-1). Locations for the sites shown in Figure 3-1 are given in Table 3-2.

The reported data for the period February to June 2011 typically show low counts (<1000 to <10 cfu/100 mL) for bacteria at the outlet (SLUEP01) and a relatively small number of toxicants (metals) exceeding the 95% species protection level trigger value, the level consistent with the designation of Darwin Harbour as a slightly to moderately disturbed system. These include copper, mercury, nickel and zinc, with exceedances of the latter three being uncommon. Nutrient values for total nitrogen and phosphorus, ammonium and filterable reactive phosphorus commonly exceed the ANZECC & ARMCANZ (2000) default trigger values for tropical Australia but, as for the other parameters, would be expected to fall below the trigger value within a relatively short distance of the outfall. In addition, nutrient values also show a pattern of reducing concentrations moving into the dry season.

3 Historical and Current Water Quality Monitoring

Figure 3-1 PWC monitoring sites (2011)

Table 3-2 Key to monitoring site locations

Sample Site		Location
PWC	SLUEP01	698109, 8628372
PWC	SLUEP02	697875, 8628477
PWC	SLUEP03	697643, 8628473
PWC	SLUEP04	697250, 8628419
PWC	SLUEP05	697006, 8628291
PWC	SLUEP06	696878, 8628546
PWC	SLUEP07	696771, 8628731
PWC	SLUEP08	697026, 8628914
PWC	SLUEP09	696630, 8629285
PWC	SLUEP10	696413, 8629458
PWC	SLUEP11	698413, 8630380
PWC	SLULC01	701036, 8626487
PWC	SLULC02	700789, 8626369
PWC	SLULC03	700518, 8626537
PWC	SLULC04	699725, 8627164

3.2 Department of Health and Families Monitoring for Recreational Purposes

In addition to the monitoring undertaken by PWC, the NRETAS undertakes regular monitoring of the microbial water quality of beaches in the Darwin region in accordance with the *Northern Territory Recreational Microbiological Water Quality Guidelines*, as part of the planned integrated Darwin Harbour monitoring program.

Contamination of recreational waters from faecal material from animal and human sources can pose significant health problems to beach users due to the presence of disease causing microorganisms.

Beach water samples are collected at shallow locations where swimming may occur. Samples are collected from knee deep water which is the depth most frequented by small children, considered likely to be the most vulnerable group with respect to water quality as they are more at risk of swallowing water, and tend to spend longer in the water, therefore increasing their likelihood of exposure.

It is noted that sampling normally does not occur during the wet season due to the presence of stingers (box jellyfish). This period is nominally 1 October to 1 May each year, however seasonal conditions vary annually and may impact on the period of recreational usage.

Samples are tested for the presence of *E. coli* and intestinal enterococci. The National Health and Medical Research Council (NHMRC) advocates the use of enterococci bacteria as the indicator organism for assessing risks due to microbial contamination in recreational water (NHMRC 2008). Epidemiological studies have shown a clear relationship between concentrations of these bacteria and the level of illness in swimmers in marine waters. Historically, *E. coli* was used as the indicator species and NT authorities are monitoring both *E. coli* and enterococci until a sufficient database is developed (DHCS 2007).

There are nine sites in the Darwin urban area and two at Mandorah which have been identified as being representative of typical local conditions. Eight of the Darwin urban area sites might potentially be considered as coming under the influence of the EPO (and future potential locations for the EPO; (Figure 3-2), although recent modelling (Plate 3-1) has indicated that only locations to the south of the outfall location are potentially at risk under some flow conditions. These are, at increasing distances to the south:

- Site 5 East Point Reserve
- Site 6 Vesteys Beach
- Site 7 Mindil Beach
- Site 8 Mindil Beach (Little Mindil)
- Site 9 Cullen Bay Beach.

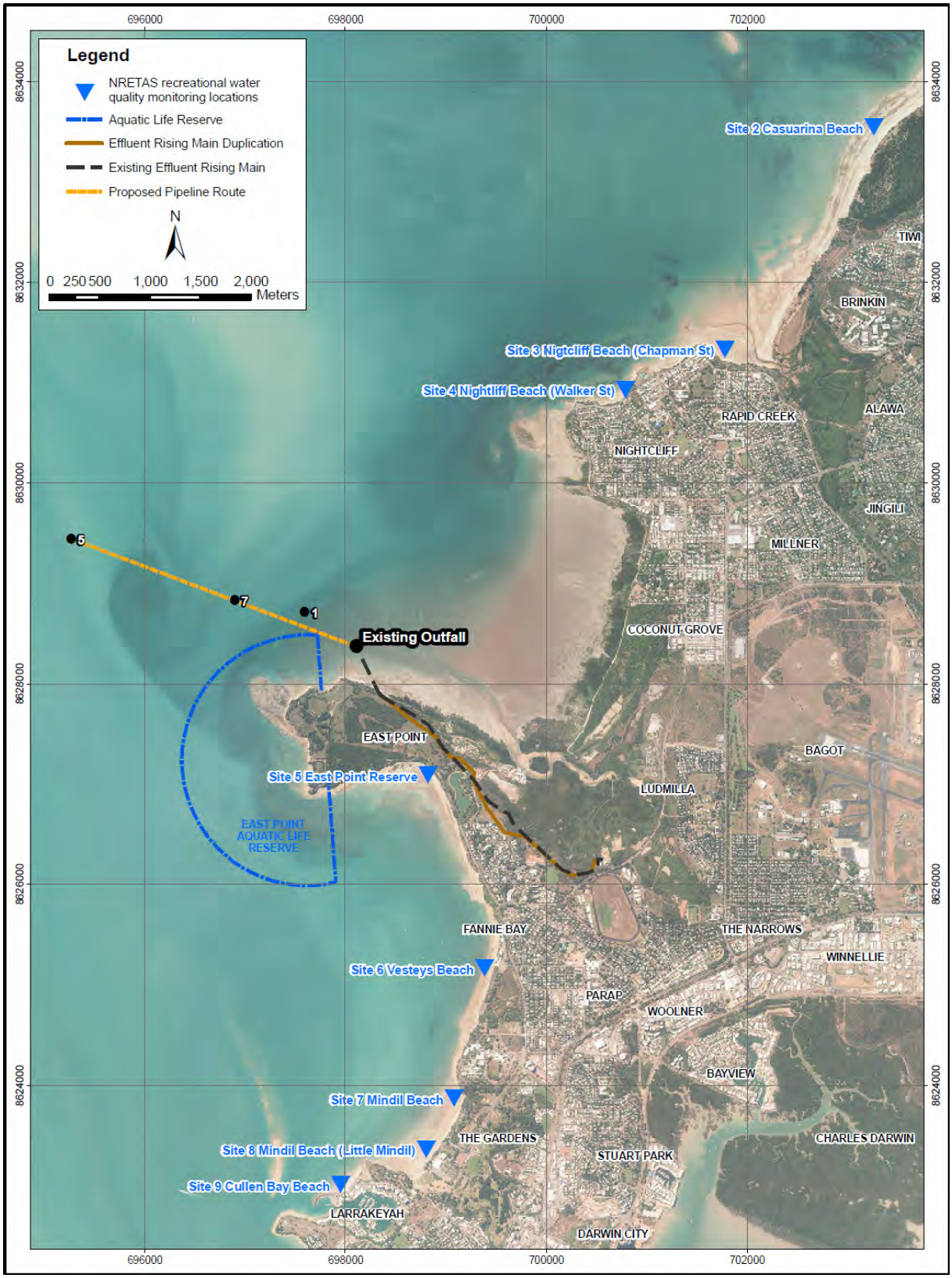
The sites at increasing distances to the north of the EPO are:

- Site 4 Nightcliff Beach (Walker Street)
- Site 3 Nightcliff Beach (Chapman Street)
- Site 2 Casuarina Beach.

Under normal discharge conditions, with chlorine disinfection operational, none of these sites would be subject to bacteria levels from the EPO exceeding the Beneficial Use guideline values for cultural purposes [consumption of aquatic life (median faecal coliform concentration not exceeding 14 MPN/100 mL) or direct contact recreation (no enterococci sample >50 cfu/100 mL)] (NRETAS 2010).

3 Historical and Current Water Quality Monitoring

Figure 3-2 NRETAS monitoring sites (Recreational Water Quality)



3 Historical and Current Water Quality Monitoring

Plate 3-1 Typical dispersion model output for discharge from the existing EPO

Source: Charles Darwin University & Power and Water Corporation 2011a

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Ludmilla WWTP and EPO Upgrade and Future Requirements for Monitoring

4.1 NRETAS Guidelines

In presenting the Guidelines for preparation of a Public Environmental Report for the duplication of the East Point Effluent Rising Main and extension of the East Point Outfall, NRETAS identified three areas of concern in respect of the EPO wastewater outfall. These were:

- impacts on the marine environment due to poor dispersion of the effluent
- impacts on species and ecosystems
- impacts on recreational areas.

In addition, future discharges from the EPO will also be required to meet, beyond the boundary of any agreed mixing zone, water quality criteria necessary to support the designated Beneficial Uses of the receiving waters (Darwin Harbour) which are:

- Cultural Uses (aesthetic, recreational and cultural needs)
- Environment (water to maintain the health of aquatic ecosystems)
- Aquaculture (water for commercial production of aquatic animals).

Priority physico-chemical indicators identified in the Water Quality Objectives for the Darwin Harbour Region – Background Document (NRETAS 2010) are:

- conductivity
- temperature
- pH
- DO
- NO_X, FRP
- turbidity
- chlorophyll-*a*
- TN, TP.

Guideline values for toxicant indicators in water and sediments will continue to be derived from ANZECC & ARMCANZ (2000).

4.2 Water quality impacts arising from the construction and operation of the relocated East Point Outfall

Environmental impacts caused by the proposal to treat additional effluent from the Larrakeyah sewerage catchment will arise through the construction of the upgraded and extended pipeline, and subsequently with the increased volume of wastewater discharged during operations. In respect of operations, it is expected that there will be an improvement in water quality due to improvements to the Ludmilla Wastewater Treatment Plant and extending and upgrading the capacity of the EPO, notwithstanding the additional volume of wastewater that will be discharged.

Monitoring in conjunction with modelling will be used to assist in defining the expected area of potential impact on sensitive marine habitats and species from wastewater discharged through the EPO.

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5

Water Quality Monitoring Program

A summary of all sampling sites, sampling frequencies and parameters which comprise part of this monitoring program is presented in Appendix A, Tables A1 to A5. Further detail is provided in the following sections.

5.1 Aquatic Ecosystem Monitoring Program – physico-chemical parameters and toxicants

5.1.1 Objectives

The objectives of the aquatic ecosystem water quality monitoring program are as follows:

- to obtain baseline data on the condition of the marine environment in the vicinity of the existing and proposed locations of the EPO
- to monitor impacts on water quality, in particular turbidity and suspended solids, during construction of the upgraded EPO
- to confirm, by monitoring, the predictions made in the PER as to the distribution and concentration of toxicants and other substances discharged from the outlet, both within the vicinity of the new outlet and at potential impact locations
- to assess improvement in water quality at the current EPO location following upgrading of the Ludmilla WWTP and relocation of the EPO
- to assess compliance with the conditions of the Waste Discharge Licence and the designated Beneficial Uses of Darwin Harbour.

5.1.2 Background

Since February 2011, PWC has undertaken an expanded program of monitoring of the marine environment in the vicinity of the EPO to improve the understanding of the dispersion and concentration of substances found in the wastewater discharge, to provide input into the site selection process for the relocated outfall and pre-construction information for use in assessing the improvement in water quality that is predicted following relocation and upgrading of the outfall.

The physico-chemical and toxicant monitoring program set out in this document is an expansion of the present program, designed to obtain information on the outfall locations currently under consideration (Sites 1, 7 and 5), together with physical data (turbidity and TSS) to be obtained at a number of potential construction impact and reference sites.

Ongoing review of sampling sites should be undertaken as decisions are made as to the location of the outfall and method of construction, proposed treatment of the wastewater (e.g. long-term disinfection) and, as additional information becomes available, on potential habitats and resources at risk (through further ecological survey).

It is noted that the relatively low initial concentrations of pollutants in the discharge, coupled with the relatively high rates of dispersion predicted for the new outfall locations, will mean that testing at the plant outlet (Site SLu080) will continue to provide the most reliable indicator of the presence/quantity of pollutants, particularly those present at low concentrations which may not be detected in the field.

The use of verified dispersion modelling in combination with the outlet data can then be used to predict concentrations of low level contaminants in the field.

5 Water Quality Monitoring Program

5.1.3 Monitoring sites

The locations currently selected for monitoring by PWC for monitoring in the vicinity of the EPO (Figure 3-1) have been chosen on the basis of proximity to the outfall, sites under initial consideration for the new outfall location, and for assessing the quality of water entering the East Point Aquatic Life Reserve (boundary shown as a blue semi-circle on Figure 1-1). One distant reference site (SLUEP11), to the north of the existing and proposed outfall locations is also monitored.

In this document, seven additional water quality monitoring sites are identified for inclusion in the monitoring program. These are: the three sites identified for further evaluation as potential outfall locations (Sites 1, 7 and 5) and three sites identified during the course of the habitat survey (GHD 2009) as having coral outcrops (EPR1, EPR2) or seagrasses present (B3) and which may represent significant habitats in the local context (Table 5-1 and Figure 5-1).

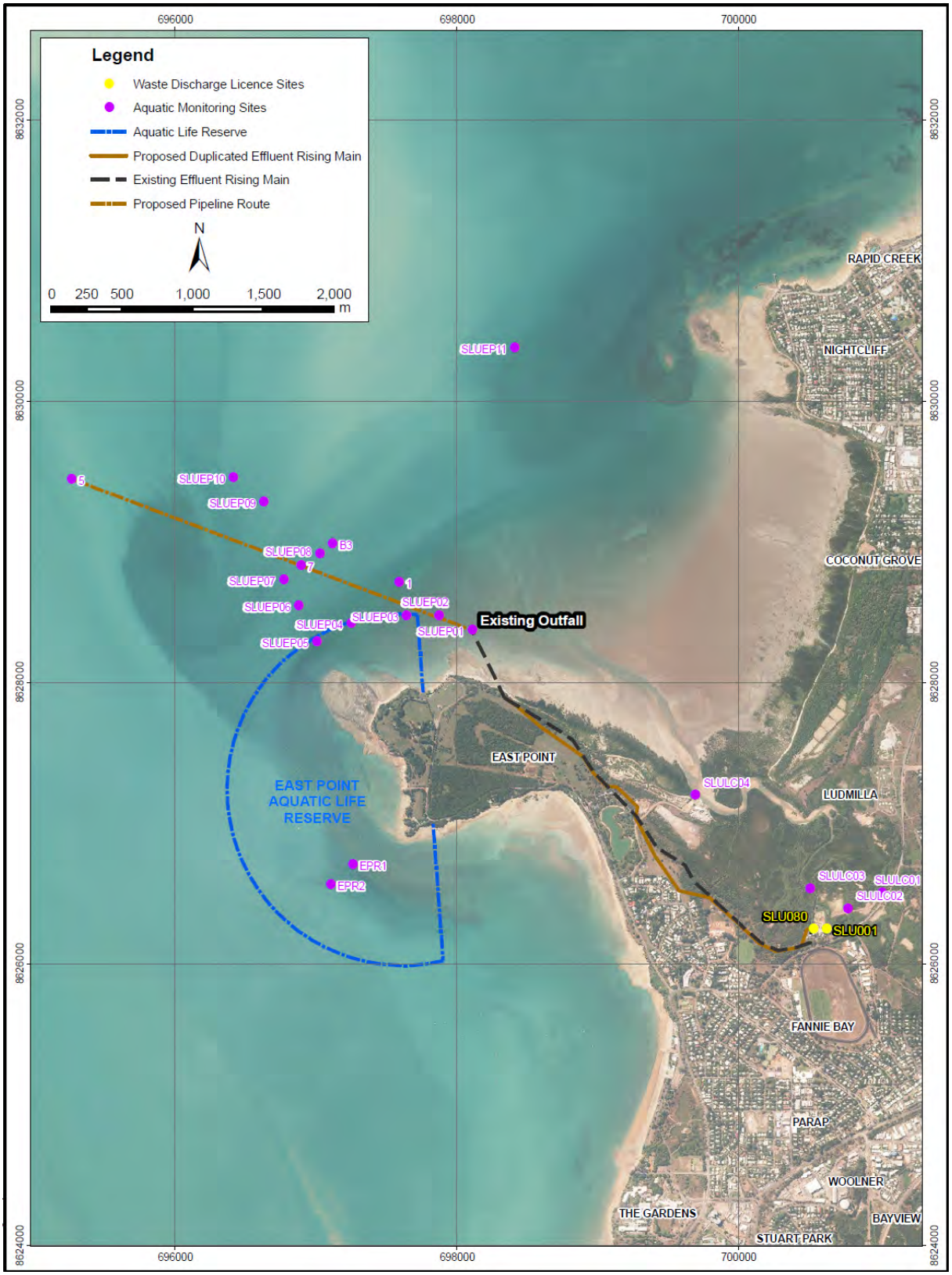
Table 5-1 Water quality sampling sites

Sample Site		Location	Reference
PWC	SLUEP01	698109, 8628372	Figure 3-1
PWC	SLUEP02	697875, 8628477	Figure 3-1
PWC	SLUEP03	697643, 8628473	Figure 3-1
PWC	SLUEP04	697250, 8628419	Figure 3-1
PWC	SLUEP05	697006, 8628291	Figure 3-1
PWC	SLUEP06	696878, 8628546	Figure 3-1
PWC	SLUEP07	696771, 8628731	Figure 3-1
PWC	SLUEP08	697026, 8628914	Figure 3-1
PWC	SLUEP09	696630, 8629285	Figure 3-1
PWC	SLUEP10	696413, 8629458	Figure 3-1
PWC	SLUEP11	698413, 8630380	Figure 3-1
PWC	SLULC01	701036, 8626487	Figure 3-1
PWC	SLULC02	700789, 8626369	Figure 3-1
PWC	SLULC03	700518, 8626537	Figure 3-1
PWC	SLULC04	699725, 8627164	Figure 3-1
Outfall	Site 1	697590, 8628710	Figure 1-1
Outfall	Site 7	696893; 8628831	Figure 1-1
Outfall	Site 5	695260; 8629450	Figure 1-1
GHD	Site EPR1	TBC	Figure 5-1
GHD	Site EPR2	TBC	Figure 5-1
GHD	Site B3	TBC	Figure 5-1
Seagrass	TBC	TBC	

The additional sites will be established so as to avoid direct impact on sensitive habitat. The coordinates will be determined during the initial setup survey. The seventh additional water quality monitoring site will be located at a seagrass habitat site further from the pipeline route. This site will be selected either from a suitable site located during additional habitat survey or from supplementary habitat mapping undertaken by INPEX Browse, Ltd. (2011).

5 Water Quality Monitoring Program

Figure 5-1 Water quality sampling sites



5 Water Quality Monitoring Program

5.1.4 Monitoring parameters

Water samples at all currently monitored sites will be analysed for the suite of physico-chemical biotic parameters, nutrients and toxicants monitored by PWC as part of the EPO monitoring program. These are:

- Physico-chemical parameters
  - Temperature (^{o}C)
  - Conductivity (mS/cm)
  - Total Dissolved Solids (by EC) (mg/L)
  - D.O. (mg/L)
  - pH
  - Salinity (PPS)
  - D.O. (%sat)
  - ORP (mv)
  - Turbidity (NTU)
  - Alkalinity as Calcium Carbonate (mg/L)
  - Total Hardness as $CaCO_3$ (mg/L).
- Biotic parameters
  - Biochemical Oxygen Demand mg/L
  - Chlorophyll-a µg/L
  - Phaeophytin-a µg/L
  - Total Suspended Solids mg/L
  - Blue Green Algal Counts cell/mL
  - Phytoplankton identification.
- Nutrients (in mg/L)
  - Total Nitrogen (TN) as N
  - Organic Nitrogen as N
  - Nitrate (NO_3)
  - Nitrite (NO_2)
  - NH_3-N mg/L
  - Ammonium (NH_4^+)
  - NH_3-N (un-ionised)
  - Total Phosphorus (TP)
  - Filterable Reactive Phosphorus (FRP).
- Total metals and metalloids (in mg/L)
  - Aluminium
  - Arsenic
  - Chromium
  - Copper
  - Iron
  - Lead
  - Magnesium
  - Manganese
  - Mercury
  - Nickel
  - Silver
  - Tin
  - Uranium
  - Zinc.
- Non-metallic inorganics (in mg/L)
  - Chlorine (total residual)

5 Water Quality Monitoring Program

In addition, the following observations should be recorded on each monitoring occasion:

- cloud cover
- wind direction and strength
- tide state, direction of flow (to be confirmed by tide gauge data)
- odours which would adversely affect the use of the surrounding waters
- any objectionable discolouration, or visible oil, grease, foam, scum or litter at the surface
- death of fish or other marine organisms in the vicinity of the outfall.

At sites 1, 7 and 5, EPR1, EPR2, B3 and an additional seagrass habitat site, water samples will be collected from surface, middle and bottom waters and analysed for TSS, and profiled through the water column for turbidity using a direct reading sensor. These data will be used as additional baseline for construction impact assessment purposes, and will be monitored through the construction and post-construction phases.

Table 5-2 Water sample depth and parameters to be analysed

Sample Site		Sampling Depth	Sample Parameters to be tested
PWC	SLUEP01	Surface	All
PWC	SLUEP02	Surface	All
PWC	SLUEP03	Surface	All
PWC	SLUEP04	Surface	All
PWC	SLUEP05	Surface	All
PWC	SLUEP06	Surface	All
PWC	SLUEP07	Surface	All
PWC	SLUEP08	Surface	All
PWC	SLUEP09	Surface	All
PWC	SLUEP10	Surface	All
PWC	SLUEP11	Surface	All
PWC	SLULC01	Surface	All
PWC	SLULC02	Surface	All
PWC	SLULC03	Surface	All
PWC	SLULC04	Surface	All
Outfall	Site 1	Surface, mid and bottom water Profile	TSS Physical parameters
Outfall	Site 7	Surface, mid and bottom water Profile	TSS Physical parameters
Outfall	Site 5	Surface, mid and bottom water Profile	TSS Physical parameters
GHD	Site EPR1	Surface, mid and bottom water Profile	TSS Physical parameters
GHD	Site EPR2	Surface, mid and bottom water Profile	TSS Physical parameters
GHD	Site B3	Surface, mid and bottom water Profile	TSS Physical parameters
Seagrass	TBC	Surface, mid and bottom water Profile	TSS Physical parameters

Note that the inclusion of additional construction impact (TSS and turbidity) monitoring sites or reduction in construction impact monitoring sites may be warranted, depending on the proposed method of installation of the pipeline (depending on which site is selected and whether horizontal drilling or trenching is proposed). For example, trenching to Site 5 may require additional monitoring sites due to the extent of sediment disturbance, while horizontal drilling to Site 1 would allow the deletion of Sites 5 and 7.

It is anticipated that monitoring of construction impact water quality, i.e. the physical impacts on water quality caused by disturbance of the seabed during the pipeline installation process, will not be required for more than 12 months following completion of construction. This is expected to be the case whichever method of construction is adopted, providing that pre-construction seabed levels are reinstated along the pipeline route shortly following construction.

5.1.5 Sampling methodology

Water samples from sites SLUEP01 to SLUEP11 and SLULC01 to SCULC04 will be collected from surface water.

Water samples from the additional sites identified above will be collected from surface, middle and bottom waters using a surface deployed water sampler (e.g. Nisken bottle or pump).

Separate laboratory prepared sample containers will be required for metal, nutrient and bacterial samples.

Samples will be collected and analysed in accordance with the relevant Australian Standards unless otherwise agreed in consultation with NRETAS.

Samples will be analysed at a laboratory(s) with NATA accreditation for the selected analyses or at a laboratory approved by NRETAS.

5.1.6 Sampling frequency

During the pre-construction period all sites will be sampled monthly.

Logging of turbidity over a neap and spring tidal cycle in both wet and dry seasons will be undertaken at each of the four coral or seagrass sites. Deployment of loggers may be undertaken concurrently at all sites, or sequentially, depending on the availability of suitable instruments.

Prior to the commencement of construction the number, location and frequency of monitoring for construction impact monitoring will be assessed on the basis of data obtained during the pre-construction period and the proposed location and method of construction of the new outfall. The monitoring program presented in this report is designed to accommodate an outfall location as far seaward as Site 5 and for pipeline installation by trenching. In the event that a more shoreward location is selected and/or installation is undertaken by horizontal directional drilling, a reduced construction and post-construction monitoring program (sites and frequency) may be appropriate.

5.2 Recreational and Cultural Water Quality Monitoring Program

5.2.1 Objective

The objective of the recreational and cultural water quality monitoring program is to monitor, using the indicator organisms *E. coli* and/or intestinal enterococci, for the presence of potentially harmful human pathogens (bacteria and viruses) in the vicinity of the outfall and, where appropriate, at recreational areas (beaches) and adjacent locations offshore that are potentially subject to the influence of the EPO.

The monitoring program presented herein is specific to PWC's EPO upgrade and is not intended to replace the wider, routine beach water quality testing currently undertaken by NRETAS, but will include review of results from relevant sites in assessing East Point water quality.

5.2.2 Background

The shallow waters offshore Darwin's beaches are potentially subject to contamination arising from a range of sources in addition to the discharges from the sewage treatment plants that discharge into the Harbour. These include: freshwater flows from creeks and rivers, terrestrial runoff and stormwater discharges during the wet season, sewage discharge from vessels (typically cruising yachts moored close to beaches), beach users including recreational users and itinerant campers, waterbirds and domestic animals.

This is the principal reason that the Darwin Harbour recreational water quality monitoring program is undertaken by NRETAS (and formally by the DHF) as part of an integrated Darwin Harbour monitoring program, which includes the monitoring of all WWTP outfalls by PWC.

While it is generally recognised that Darwin Harbour water quality may be improved overall when the Larrakeyah outfall is closed, there will be additional effluent treated at the LWWTP and wastewater discharged through the extended outfall, and hence there may be a localised impact around the East Point area through increased discharges. Monitoring of recreational water at beaches for *E. coli* / intestinal enterococci, and potentially for other human pathogens associated with effluent, are a requirement to ensure public health risks can be ascertained and managed.

Because of the number of different pathogens that might potentially be present in wastewater and the time taken to identify and analyse for each, a recognised indicator organism (enterococci), will be monitored in accordance with NHMRC (2008) guidelines, along with *E. coli* for which a more substantial historical database exists and which is required for compliance with the existing discharge licence.

Under its existing Waste Discharge Licence, PWC is authorised to discharge wastewater from the LWWTP with an annual median *E. coli* count of one million colony-forming units per 100 millilitres of water (10^6 cfu/100mL). It should be noted, however, that under the disinfection (effluent chlorination) regime currently practised by PWC, bacterial levels at the LWWTP outlet point (Slu080) generally remain orders of magnitude below this concentration (10^2 - 10^4 cfu/100mL) and are further diluted at the ocean discharge point (SLUEP01), typically to below the guideline value for recreational waters of 100 cfu/100 mL, but exceeding the cultural guideline of 14 cfu/100 mL (for faecal coliforms) typically by a factor of less than one order of magnitude. As a result, the presence of bacteria levels in the marine environment in excess of either guideline as a result of discharge under normal operating conditions from the EPO will be confined to a very small area about the outfall location.

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The presence of *E. coli* and intestinal enterococci at the discharge point, and within and external to the mixing zone of the existing outfall, is monitored in the current PWC EPO monitoring program and reported on the NRETAS website at http://www.nt.gov.au/nreta/water_sampling/testing/eastpoint.html along with the results of testing by NRETAS and DHF.

5.2.3 Monitoring sites

The locations previously selected by PWC for monitoring of recreational water quality in the vicinity of the EPO have been selected on the basis of the proximity of the site to the present outfall, sites under initial consideration for the new outfall location and for assessing the quality of water entering the East Point Aquatic Life Reserve (Figure 5-1).

One distant reference site, SLUEP11 to the north of the existing and proposed outfall locations, is also monitored.

These sites will continue to be monitored as submerged sites on a monthly basis as part of the existing PWC program.

The following additional sites will be monitored to obtain pre-operational baseline data on bacterial levels:

- two shallow water sites on the north side of East Point (East Point 1 and East Point 2)
- two shallow water sites to the north of Ludmilla Creek, one at the northern end of the mangrove-fringed bay and one at the southern end (Ludmilla N and Ludmilla S), coinciding with the sites selected for sediment monitoring at those locations
- site SLUEP01 under low tidal conditions (when water depth is approximately 0.5 – 0.6 m).

These sites will also be monitored as shallow water sites, i.e. potentially accessible by walking, also on a monthly basis.

The full suite of bacteria water quality monitoring sites is shown in Figure 5-2.

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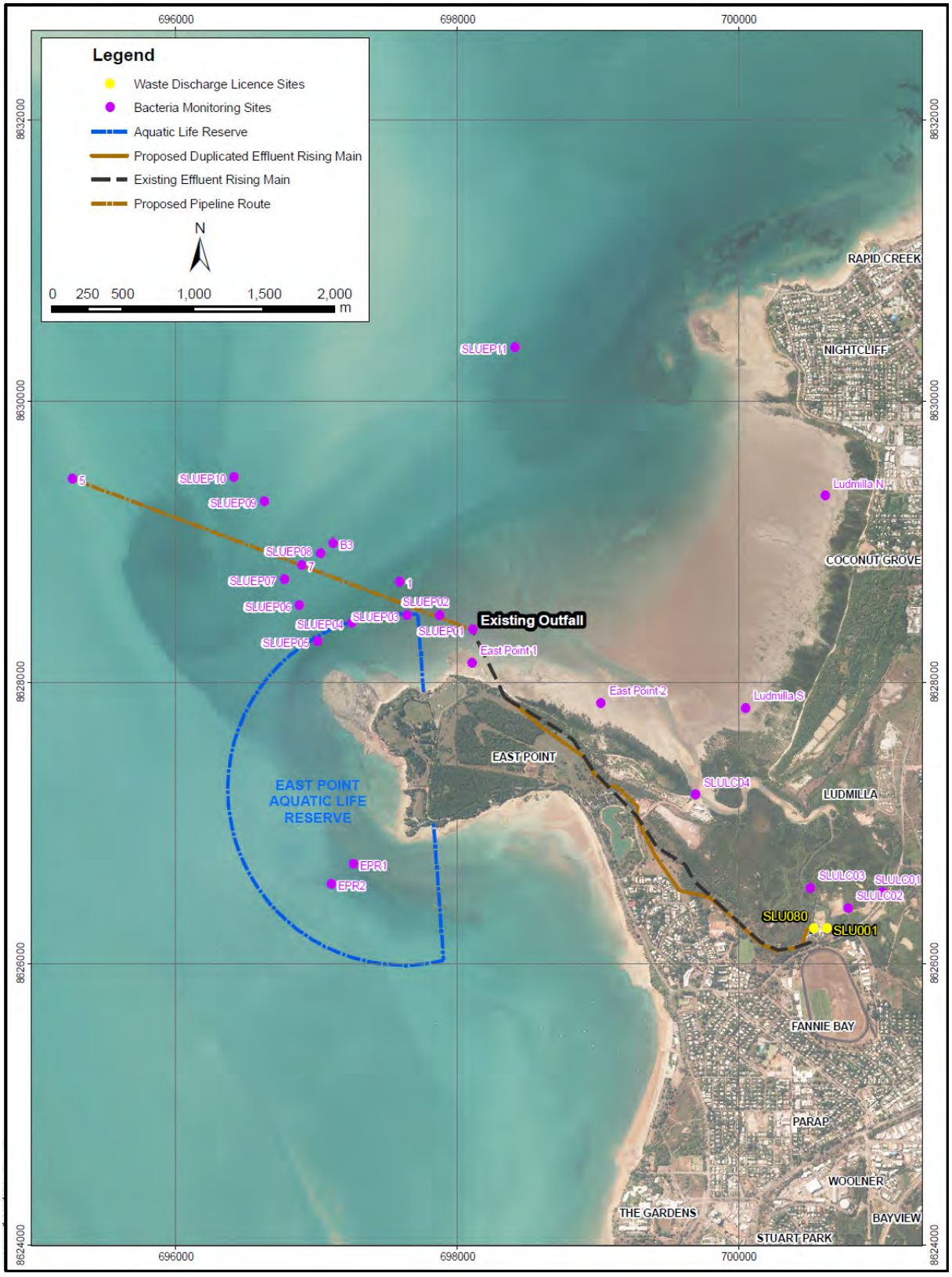
Figure 5-2 Water quality (bacteria) monitoring sites



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5.2.4 Monitoring parameters

The water quality parameters for cultural purposes, including direct contact recreation and harvesting of aquatic life for food are generally addressed under the ANZECC & ARMCANZ (2000) aquatic ecosystems guidelines, as adopted in the Darwin Harbour interim water quality guidelines and objectives (NRETAS 2010).

The following guidelines apply to bacteria:

Water quality for direct contact recreation (e.g. swimming)

- Enterococci no single sample >50 cfu/100 mL

Water quality for harvesting aquatic life for food

- Faecal coliforms median concentration ⩽14 MPN/100 mL
  not more than 10% of samples >43 MPN/100 mL

Water samples at all sites will be collected for enumeration of *E. coli*, intestinal enterococci and faecal coliforms.

5.2.5 Sampling methodology

Bacteria samples from the current outfall location (shallow water conditions) and nearshore sites will be collected from just below the surface in knee deep (0.5 – 0.6 m) water.

Bacteria samples from all other sites (i.e. the current PWC monitoring sites including site SLUEP01 at high tide) will be collected from immediately below the surface into laboratory prepared sample containers.

Samples will be collected and analysed in accordance with the relevant Australian Standards unless otherwise agreed in consultation with NRETAS.

Samples will be analysed at a laboratory(s) with NATA accreditation for the selected analyses or at a laboratory approved by NRETAS.

5.2.6 Sampling frequency

Shallow and deepwater sites will be sampled on a monthly basis during the dry season (June to September).

During the box jellyfish season (October to May inclusive), when stingers are prevalent and beaches are considered unsafe for swimming, bacteria samples will not be routinely collected from shallow water sites but will continue to be collected on a weekly basis at the outlet from the LWWTP (Site SLu080), and on a monthly basis at deepwater sites as part of the overall water quality monitoring program.

6

Sediment and Biota Monitoring Program

6.1 Rationale

6.1.1 Sediment monitoring

The monitoring of sediments at the existing and proposed discharge locations, sensitive potential receptors and reference locations provides input to the existing condition, construction and operational assessment of the proposed EPO upgrade.

As a monitoring tool, sediments are a more conservative indicator of persistent contaminants than water quality measurements which are subject to short-term discharge variability in terms of flow rates and water quality, and also environmental factors, particularly the strong tidal influence which is present in Darwin Harbour.

In proposing to monitor the sediments in the vicinity of the existing intertidal outfall it should be recognised that the present discharge location represents an atypical, and most likely a worst-case scenario, for contaminant accumulation when considering future impacts from a new subtidal outfall location. There are a number of reasons for this. Firstly, discharge at an intertidal location means that wastewater at plant discharge concentration is discharged directly onto the sediments at low tide, which may then be further concentrated by evaporation and effectively drawn into the sediments by the falling tide. At a subtidal location the plume will be buoyant due to its low salinity when compared with the receiving water and will undergo significant dilution before contacting the sediment, potentially some distance down current of the outfall location. It is noted, however, that recent nearfield modelling (URS 2011) indicates that, should the new outfall be located at Site 1, there may be periods when the plume at high concentration comes in contact with the seabed in the vicinity of the outfall.

Monitoring at the existing outfall location is, however, required for construction impact assessment, and post construction for assessment of operational improvements arising from the re-location of the outfall to a subtidal location.

A practical advantage of monitoring the existing intertidal outfall location is the high degree of certainty that can be held as to the sediments having been subjected to the wastewater discharge on a frequent basis. Thus an impact, if it has occurred, should, with a high degree of certainty, be detected.

Monitoring of the sediments at the three alternate outfall locations is included, as are additional sites along the pipeline route and potential impact and reference locations in intertidal and subtidal locations.

6.1.2 Monitoring of marine fauna

Monitoring of selected marine fauna for potential contaminant impacts from a point source poses a number of technical and logistical issues. A species selected for considering potential impacts on human health should be:

- one which is commonly consumed by humans
- is present in the impact and reference locations in sufficient numbers that it can be reliably located and sampled with reasonable efficiency.
- can be sampled in sufficient numbers for analytical purposes without undue stress on the population
- from a population or sub-population which is confined in its distribution to the potential impact (or reference) location, i.e. is relatively sedentary.

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In Darwin Harbour the species most commonly used in such monitoring programs is the intertidal gastropod mollusc *Telescopium telescopium* (mud whelk) where it has been shown to meet all of the above criteria.

Although not found in the immediate vicinity of the existing or proposed outfall, it is expected to be present at the mangrove-lined shoreline at Ludmilla Creek and the adjoining bay to the north and, as such, is potentially exposed to diluted wastewater from the outfall and any discharges to Ludmilla Creek.

The other sedentary animal which has been used in monitoring in Darwin Harbour is the rock oyster which is found on hard substrates, including artificial substrates (pilings, rock walls, etc.).

No subtidal organism which meets the above criteria has yet been identified in the vicinity of the outfall. Studies elsewhere in Australia have used naturally-occurring cockles (south-western Australia) and razor shell (*Pinna* sp.) (Spencers Gulf, SA) as monitoring organisms, while caged oysters and mussels have been deployed as sentinel organisms to monitor for the presence of heavy metals and bacteria.

Fish and crustaceans, despite their importance as food species, are not recommended as monitoring organisms unless their continued presence within the discharge area can be confirmed. This can normally be done only through the use of caged animals.

Due to the configuration of the present outfall (intertidal) and low levels of bacteria in the discharge, the use of caged test animals is not proposed at this time.

The recommended monitoring program is limited to monitoring of *Telescopium* on soft sediments in the intertidal zone adjacent to Ludmilla Creek and in the mangroves to the north of Ludmilla Creek, and rock oysters on the rocky intertidal zone on the north side of East Point.

Results of biota analyses will be compared against pre-construction and historical data (as available) for the same species in Darwin Harbour, the Maximum Levels (MLs) and Generally Expected Levels (GELs) for contaminants in seafood as set out in the current edition of the Food Standards Code by Food Standards Australia New Zealand, and the bacterial limit for fish as set out in the Water Quality Objectives for Darwin Harbour (NRETAS 2010).

6.2 Sediment sampling locations

6.2.1 Existing outfall location

Sediments in the vicinity of the site of the existing outfall (SLUEP01) (refer to Figure 6-1) will be monitored at increasing distance from the outfall to assess the presence and extent of any potential contaminants. Samples will be collected at distances of 5 m, 10 m and 20 m from the outfall at each of the four cardinal points (north, east, south and west), 12 samples in all.

These samples will be collected on low tide to enable sample locations to be accurately plotted.

6.2.2 Proposed outfall locations

Three sites (Sites 1, 7 and 5) (refer to Figure 6-2) are currently under consideration as locations for the proposed outfall. Four samples will be collected at each site to obtain representative values for that site.

Samples will be collected by grab, using the movement (swing) of the vessel or lengthening of the anchor line to spread the sample points by approximately 5 m.

This program will comprise 12 samples (Table 6-1).

6.2.3 Pipeline construction impact locations

In addition to the existing and proposed outfall locations, samples will be collected from pipeline route Sites 8 and 9 (refer to Figure 6-2) and at sites located 500 m to the north-east and south-west of Sites 7 and 5. Six samples in all (Table 6-1).

6.2.4 Potential operational impact locations

Results of the preliminary farfield modelling (Charles Darwin University & PWC 2011a) indicate that the plume will head southward, impinging on East Point and subsequently on beaches to the south (Vestey's Beach, Mindil Beach). Under the present disinfection (chlorination) scheme, the dilution of the wastewater is such that bacteria will not be detectable from background. Similarly, modelling has shown that nutrients, metals and other contaminants will not occur in detectable quantities south of East Point under normal operating conditions.

Intertidal sampling sites

Intertidal monitoring will include two sediment monitoring sites on the north side of East Point, on the intertidal sands seaward of the rock fringe, and two sites on the seaward side of the mangrove-fringed shoreline to the north of Ludmilla Creek, one at the northern end of this bay (Ludmilla N) and one at the southern end (Ludmilla S) (Figure 6-1 and Table 6-1). Pre-construction monitoring of these sites will indicate whether there has been any accumulation of potential pollutants in the sediments from past operations. Post-construction monitoring (if warranted) will provide data on future pollutant accumulation or, as would be expected, decline in concentrations as a result of relocating the wastewater outlet.

Subtidal sampling sites

The limited benthic habitat survey undertaken in 2009 by GHD has shown the presence of small areas where hard corals are present on subtidal rock to the south-east of East Point and seagrass is present on sand to the north of East Point (GHD 2009).

Sediment samples will be collected at two reef sites (GHD Sites EPR1 and EPR2) and two seagrass sites (GHD Site B3 and one additional site [subject to additional survey]) (Figure 6-2 and Table 6-1). In the case of the reef sites, the samples will be taken from the outlet side on sand immediately adjacent to the reef.

Further habitat survey may identify additional/preferred locations for potential impact sites, necessitating some revision to the selected sites.

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Figure 6-1 Intertidal sediment and biota sampling sites

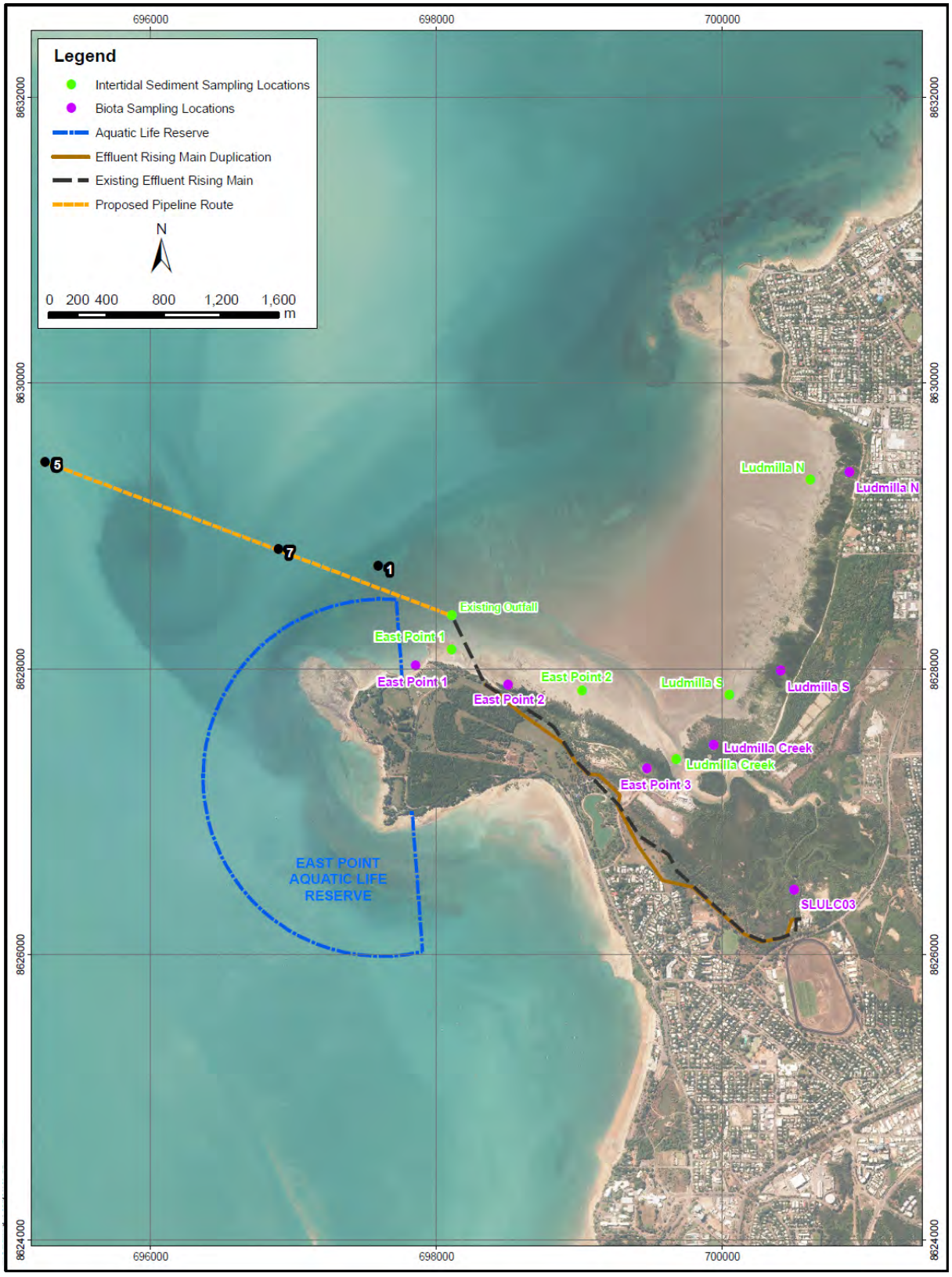

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Figure 6-2 Subtidal sediment sampling sites

6.2.5 Additional reference sites

Due to the additional sites required to assess the three potential outfall locations and alternate means of construction under consideration, it is expected that some of the above sites can also be used as construction and post-construction reference sites. The use of these sites for this purpose will, however, need to be reviewed and confirmed once the outfall site is selected and the method of installation is decided.

Table 6-1 Sediment sampling location, depth and construction phase

Site	Intertidal / Sub-tidal	Baseline (Pre-construction)	Post-construction / Operations
Existing outfall 5 m N	Intertidal	✓	✓
Existing outfall 5 m S	Intertidal	✓	✓
Existing outfall 5 m E	Intertidal	✓	✓
Existing outfall 5 m W	Intertidal	✓	✓
Existing outfall 10 m N	Intertidal	✓	✓
Existing outfall 10 m S	Intertidal	✓	✓
Existing outfall 10 m E	Intertidal	✓	✓
Existing outfall 10 m W	Intertidal	✓	✓
Existing outfall 20 m N	Intertidal	✓	✓
Existing outfall 20 m S	Intertidal	✓	✓

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Site	Intertidal / Sub-tidal	Baseline (Pre-construction)	Post-construction / Operations
Existing outfall 20 m E	Intertidal	✓	✓
Existing outfall 20 m W	Intertidal	✓	✓
Outfall Site 1: 5 m N	Sub-tidal	✓	New outfall site only
Outfall Site 1: 5 m S	Sub-tidal	✓	“
Outfall Site 1: 5 m E	Sub-tidal	✓	“
Outfall Site 1: 5 m W	Sub-tidal	✓	“
Outfall Site 7: 5 m N	Sub-tidal	✓	“
Outfall Site 7: 5 m S	Sub-tidal	✓	“
Outfall Site 7: 5 m E	Sub-tidal	✓	“
Outfall Site 7: 5 m W	Sub-tidal	✓	“
Outfall Site 5: 5 m N	Sub-tidal	✓	“
Outfall Site 5: 5 m S	Sub-tidal	✓	“
Outfall Site 5: 5 m E	Sub-tidal	✓	“
Outfall Site 5: 5 m W	Sub-tidal	✓	“
Pipeline Route Site 8	Sub-tidal	✓	✓
Pipeline Route Site 9	Sub-tidal	✓	✓
Outfall Site 1: 500 m NE	Sub-tidal	✓	Two of six sites (dependant on outfall location)
Outfall Site 1: 500 m SW	Sub-tidal	✓	“
Outfall Site 7: 500 m NE	Sub-tidal	✓	“
Outfall Site 7: 500 m SW	Sub-tidal	✓	“
Outfall Site 5: 500 m NE	Sub-tidal	✓	“
Outfall Site 5: 500 m SW	Sub-tidal	✓	“
Pipeline route Site 8	Intertidal	✓	Subject to outfall site and construction methodology adopted
Pipeline route Site 9	Intertidal	✓	Subject to outfall site and construction methodology adopted
East Point 1	Intertidal	✓	✓
East Point 2	Intertidal	✓	✓
Ludmilla N	Intertidal	✓	✓
Ludmilla S	Intertidal	✓	✓
EPR1 (coral)	Sub-tidal	✓	✓
EPR2 (coral)	Sub-tidal	✓	✓
B3 (seagrass)	Sub-tidal	✓	✓
Seagrass site (TBA)	Sub-tidal	✓	✓

6.3 Biota sampling locations

6.3.1 *Telescopium*

Telescopium will be sampled from the nearest available populations to the sediment sampling sites located on the intertidal sediments adjacent to the mouth of Ludmilla Creek, at Ludmilla N and Ludmilla S, adjacent to SLULC03 and at East Point 3 (refer to Figure 6-1), if sufficiently large populations for sustainable sampling are present in the vicinity of those locations. Sufficient animals will be collected at each site to undertake the analyses described below. It is anticipated that this will require approximately 20 animals per sample.

This program will comprise one composite sample from each of five sites (assuming *Telescopium* is present at each location).

6.3.2 Rock oysters

Rock oysters will be sampled from two sites located on the intertidal rocks adjacent to East Point 1 and East Point 2 (refer to Figure 6-1), if present at those locations. Sufficient oyster flesh will be collected at each site to undertake the analyses described below. It is anticipated that this will require 20-60 animals/sample (dependent on size).

This program will comprise one composite sample from each of two sites.

6.4 Sampling parameters – sediments and biota

The following parameters will be monitored at all sediment sampling sites with the exception of bacteria which will only be monitored at the intertidal monitoring sites. The persistence of faecal bacteria in intertidal sediments has been recognised in international literature as a potential trigger for adverse water quality at recreational beaches in the absence of a water-borne source (e.g. Anderson et al. 2005; Davies et al. 1995). Measurement in samples from the existing outfall and adjacent intertidal sites will be used to test the likelihood for similar conditions in Darwin Harbour.

The parameters for sediment monitoring have been selected to reflect those used in the present water quality program, modified as appropriate for sediments.

6.4.1 Intertidal sampling sites

Physical parameters - sediments

- Particle size
- Total organic carbon.

Physical parameters - fauna

- Shell length – longest axis
- Wet and dry weight.

Metals – sediments and fauna

- Aluminium
- Arsenic

- Chromium
- Copper
- Iron
- Lead
- Magnesium
- Manganese
- Mercury
- Nickel
- Silver
- Tin
- Uranium
- Zinc.

For comparative purposes the above list is taken from the list of metals monitored by PWC in the receiving waters.

Hydrocarbons – sediments and fauna

- Total petroleum hydrocarbons (TPH)
- Total polycyclic aromatic hydrocarbons (Total PAHs).

Nutrients – sediments only

- Total nitrogen
- Total phosphorus.

Bacteria - sediments

- *E. coli*
- Enterococci.

Bacteria – fauna

- *E. coli*

Subtidal sediment sampling sites

As listed above, with the exclusion of bacteria monitoring.

6.5 Sampling methodology

Intertidal samples will be collected on low tide using core tubes to collect surface sediments from the top 20 mm of sediment. Note that the contents of several tubes may need to be pooled to provide sufficient material for all analyses. Separate sample containers will be required for metal, hydrocarbon and bacterial samples.

Subtidal sediments will be collected using a grab (Van Veen or similar) from which sub-sample(s) for analysis will be collected by corer, again collecting the top 20 mm of sediment.

Telescopium shells containing live animals shells will be placed unopened directly into pre-prepared sample containers and packed in ice for transport to the analysing laboratory.

Rock oysters will be opened on site and the flesh transferred to pre-prepared sample containers using pre-cleaned knives and forceps. The sample containers will be sealed and packed in ice for transport to the analysing laboratory

All samples will be collected and analysed in accordance with the relevant Australian Standards unless otherwise agreed in consultation with NRETAS. This will include the collection of replicate and blank samples as specified in the ANZECC & ARMCANZ (2000) guidelines.

Samples will be analysed at a laboratory(s) with NATA accreditation for the selected analyses or at a laboratory approved by NRETAS.

6.6 Sampling frequency

6.6.1 Baseline (pre-construction) survey(s)

Due to the natural conservatism of sediments only two sediment and fauna surveys (sampling events) are proposed as part of the baseline sediment sampling program, a wet season and a dry season survey.

Note however that further pre-construction sampling may be justified if levels of contaminants in excess of ANZECC guideline trigger values, or values for reference sediments elsewhere from Darwin Harbour, are detected at any of the sampling locations. It is noted that the cause of such exceedances could be other than the EPO and this will be taken into consideration when assessing the need for, and design of, additional baseline monitoring.

6.6.2 Construction period sediment survey(s)

The construction phase of the sediment survey program will focus on the impacts arising from construction activities which, based on previous investigations (East Arm Port, Darwin Waterfront), is anticipated to be largely physical in nature, i.e. sediment redistribution potentially leading to smothering of benthic biota or erosion of benthic habitat adjacent to the construction zone.

Release of metals or hydrocarbons at concentrations in excess of water quality guideline concentrations have not been detected even where elevated levels have previously been detected in the sediments (e.g. Darwin Waterfront). Given that the proposed pipeline route and outfall site are, with the possible exception of the immediate location of the existing outfall, located in previously undisturbed sediments, release of contaminants is not anticipated as a result of sediment excavation. (In the event that contaminants are found in significant concentrations during baseline surveys, additional construction water quality sampling may be required as part of the construction period surveys).

An exception may arise if horizontal directional drilling (HDD) is used for all or part of the EPO installation. HDD usually requires the use of drilling fluids (typically water based but containing various additives used to stabilise the bore), all or part of which may be discharged into the marine environment during or close to the end of drilling. Depending on the composition of the drilling fluid, additional monitoring may be required to determine the concentration and distribution of these additives in the sediments.

The construction phase component of the sediment monitoring program will be further developed once the location of the new outlet and method of construction have been identified. In combination with the

findings of the baseline survey and the final output from the modelling program, this will allow the location and parameters for construction monitoring of the sediments to be defined. The main focus of construction surveys is expected to be on water quality (i.e. turbidity and suspended solids).

6.6.3 Operational phase surveys

The purpose of the operational phase of the sediment and fauna monitoring program is threefold:

- to monitor post-construction impacts on the sediments within the construction envelope (Note that part of such investigations may take the form of bathymetric and habitat surveys undertaken as part of other work scopes)
- to confirm the predictions made in the PER as to the distribution and concentration in the sediments and intertidal fauna of contaminants discharged from the outlet within the vicinity of the new outlet and at potential impact locations
- to assess improvement in sediment quality at the current EPO location, should contamination of the sediments be identified during baseline surveys.

The pattern of sampling sites (location and distribution) at the new outfall location and selection of potential impact sites will be guided by the data from the baseline study and final results of discharge modelling.

The scope and frequency of sediment monitoring at all sites is likely to be bi-annually (seasonally) to annually over the first three years (to be confirmed) and be subject to review at the end of this period.

7

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Limitations

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Power and Water Corporation and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the CTR dated 14 January 2011.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between April 2011 and October 2011, and is based on the information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

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Appendix A Sampling site data

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Table A.1 Water quality sampling program - Visual observations and physico-chemical parameters

								Visual Observations						Physico-Chemical Parameters											
							Analyte	Cloud cover	Wind direction and strength	Tide state and direction	Odour	Discolouration/ oil/grease slick, foam, scum or litter at surface	Presence of dead marine organisms at surface	Temperature (field)	Conductivity (field)	Total Dissolved Solids (by EC) (field)	Dissolved Oxygen (field)	Dissolved Oxygen (field)	pH (field)	Salinity (Laboratory)	Oxygen Reduction Potential	Turbidity (field)	Total Solids in Suspension	Alkalinity as Calcium Carbonate	Total Hardness as Calcium Carbonate
							Abbreviation							T	EC	TDS	DO	DO	pH		ORP		TSS		
Water Quality Monitoring Site	Coordinates Easting/ Northing	Note	Sample Depth	Pre-construction (Baseline)	Construction	Post-Construction (Operations)	Unit	%	m/s		Report dominant odour	Report observations	Identify and report	°C	mS/cm	mg/L	mg/L	%Sat	ppm	ppm	mV	NTU	mg/L	mg/L	mg/L
SLUEP01	698109, 8628377	1	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLUEP02	697875, 8628477	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLUEP03	697643, 8628473	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLUEP04	697250, 8628419	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLUEP05	697006, 8628291	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLUEP06	696878, 8628546	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLUEP07	696771, 8628731	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLUEP08	697026, 8628914	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLUEP09	696630, 8629285	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLUEP10	696413, 8629458	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLUEP11	698413, 8630380	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLULC01	701036, 8626487	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLULC04	699725, 8627164	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Outfall Site 1	697590, 8628715	2	Surface, mid-water and bottom samples for TSS. Other physical parameters profiled using a surface deployed multi-parameter water quality meter	Monthly				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓		
Outfall Site 7	696893, 8628836	"	"	Monthly				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓		
Outfall Site 5	695260, 8629455	"	"	Monthly				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓		
EPR1	TBC	3	"	Monthly				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓		
EPR2	TBC	"	"	Monthly				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓		
B3	TBC	4	"	Monthly				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓		
Seagrass site (TBC)	TBC	5	"	Monthly				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓		

Note 1 Requirement for, and frequency of, post-construction monitoring to be determined by findings of baseline survey.
Note 2 Monitoring during and post construction will only be undertaken at the selected outfall location.
Note 3 Sites identified in GHD survey as having coral community present.
Note 4 Site identified in GHD survey as having seagrass present.
Note 5 Seagrass site to be selected following further survey.
Note 6 Outfall sites 1, 7 and 5 and sites EPR1, EPR2, B3 and additional seagrass site: increased frequency of monitoring of suspended solids and turbidity, e.g. deployment of loggers, may be required for periods (e.g. to address seasonaal and tidal cycle variations) if excavation to Site 7 or 5 is selected as the construction option.
Note 7 Sites EPR 1 and 2, B3 and additional seagrass site: construction and post-construction monitoring frequency will depend on outlet location and method of construction selected.

Table A.2 Water quality monitoring program - Nutrients, metals and hydrocarbons

								Nutrients									Metals																Non-metal Inorganics
							Analyte	Total Nitrogen	Organic Nitrogen	Nitrate	Nitrite	Ammonia	Ammonium	Ammonia	Total Phosphorus	Filterable Reactive Phosphorus	Aluminium	Arsenic	Chromium	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Silver	Tin	Uranium	Zinc	Total Redidual Chlorine
							Abbreviation	TN		NO_3	NO_2	NH_3-N	NH4+	NH_3-N (un-ionised)	TP	FRP	Al	As	Cr	Cu	Fe	Pb	Mg	Mn	Hg	Ni	Ag	Sn	U	Zn	Cl
Water Quality Monitoring Site	Coordinates Easting/ Northing	Note	Sample Depth	Pre-construction (Baseline)	Construction	Post-Construction (Operations)	Unit	µg/L																									
SLUEP01	698109, 8628377	1	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLUEP02	697875, 8628477	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLUEP03	697643, 8628473	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLUEP04	697250, 8628419	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLUEP05	697006, 8628291	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLUEP06	696878, 8628546	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLUEP07	696771, 8628731	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLUEP08	697026, 8628914	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLUEP09	696630, 8629285	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLUEP10	696413, 8629458	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLUEP11	698413, 8630380	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLULC01	701036, 8626487	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLULC04	699725, 8627164	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Outfall Site 1	697590, 8628715	2	Mid-water	Monthly	Monthly																												
Outfall Site 7	696893, 8628836	"	Mid-water	Monthly	Monthly																												
Outfall Site 5	695260, 8629455	"	Mid-water	Monthly	Monthly																												
EPR1	TBC	3																															
EPR2	TBC	"																															
B3	TBC	4																															
Seagrass site (TBC)	TBC	5																															

Note 1 Requirement for, and frequency of, post-construction monitoring at selected sites to be determined by findings of commissioning stage studies
Note 2 Construction and post construction monitoring will continue at the selected outfall location only
Note 3 Sites identified in GHD survey as having coral community present, site locations to be confirmed in the field
Note 4 Site identified in GHD survey as having seagrass present, site location to be confirmed in the field
Note 5 Site to be selected following further survey

Table A.3 Water quality sampling program - Biotic parameters and bacteria

								Biotic Parameters					Bacteria	
							Analyte	Biochemical Oxygen Demand	Chlorophyll-a	Phaeophytin-a	Blue-Green Algal Counts	Phytoplankton Identification	*Escherichia coli*	Intestinal enterococci
Water Quality Monitoring Site	Coordinates Easting/ Northing	Note	Sample Depth	Pre-construction (Baseline)	Construction	Post-Construction (Operations)	Abbreviation	BOD	Ch-a	Ph-a			E. coli	Enterococci
							Unit	mg/L	µg/L		cells/mL		cfu/100 mL	
SLUEP01	698109, 8628377	1	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓
SLUEP02	697875, 8628477	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓
SLUEP03	697643, 8628473	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓
SLUEP04	697250, 8628419	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓
SLUEP05	697006, 8628291	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓
SLUEP06	696878, 8628546	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓
SLUEP07	696771, 8628731	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓
SLUEP08	697026, 8628914	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓
SLUEP09	696630, 8629285	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓
SLUEP10	696413, 8629458	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓
SLUEP11	698413, 8630380	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓
SLULC01	701036, 8626487	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓
SLULC04	699725, 8627164	"	Surface	Monthly	Monthly	Monthly		✓	✓	✓	✓	✓	✓	✓
Outfall Site 1	697590, 8628715	2	Surface Mid-water Bottom	Monthly	Monthly	Monthly								
Outfall Site 7	696893, 8628836	"	Surface Mid-water Bottom	Monthly	Monthly	Monthly								
Outfall Site 5	695260, 8629455	"	Surface Mid-water Bottom	Monthly	Monthly	Monthly								
EPR1	TBC	3												
EPR2	TBC	"												
B3	TBC	"												
Seagrass site (TBC)	TBC	4												

Note 1 These sites are a sub-set of the current PWC monthly monitoring program and should be sampled and reported as part of that program
Note 2 Monitoring of only the selected outfall site will continue during and post-construction
Note 3 Sites identified in GHD survey as having seagrass or coral community present, site coordinates to be confirmed in the field
Note 4 Site to be selected following proposed habitat survey

Table A.4 Intertidal and subtidal sediment sampling program

Sediment Site	Coordinates Easting/ Northing	Note	Intertidal/ Subtidal	Pre-construction/ Baseline	Post-Construction/ Operations	Analyte	Particle size	Total Organic Carbon	Aluminium	Arsenic	Chromium	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Silver	Tin	Uranium	Zinc	Total Petroleum Hydrocarbons	Total Polycyclic Aromatic Hydrocarbons	Total Nitrogen	Total Phosphorus	*Escherichia coli*	Intestinal enterococci
						Abbreviation	PSD	TOC	Al	As	Cr	Cu	Fe	Pb	Mg	Mn	Hg	Ni	Ag	Sn	U	Zn	TPH	PAH	TN	TP	E. coli	Enterococci
						Unit	microns (µ)	mg/kg (dry weight)																			cfu/100 g (wet weight)	
SLUEP01 - 5 mN	698109, 8628377	1	Intertidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLUEP01 - 5 mS	698109, 8628367	"	Intertidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLUEP01 - 5 mE	698114, 8628372	"	Intertidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLUEP01 - 5 mW	698104, 8628372	"	Intertidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLUEP01 - 10 mN	698109, 8628382	"	Intertidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLUEP01 - 10 mS	698109, 8628362	"	Intertidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLUEP01 - 10 mE	698119, 8628372	"	Intertidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLUEP01 - 10 mW	698099, 8628372	"	Intertidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLUEP01 - 20 mN	698109, 8628392	"	Intertidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLUEP01 - 20 mS	698109, 8628352	"	Intertidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLUEP01 - 20 mE	698129, 8628372	"	Intertidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLUEP01 - 20 mW	698089, 8628372	"	Intertidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
East Point 1	TBC	2	Intertidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
East Point 2	TBC	"	Intertidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ludmilla Creek Mouth	TBC	3	Intertidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ludmilla S	TBC	4	Intertidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ludmilla N	TBC	"	Intertidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Outfall Site 1 - 5 mN	697590, 8628715	5	Subtidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Outfall Site 1 - 5 mS	697590, 8628705	"	Subtidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Outfall Site 1 - 5 mE	697595, 8628710	"	Subtidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Outfall Site 1 - 5 mW	697585, 8628710	"	Subtidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Outfall Site 7 - 5 mN	696893, 8628836	"	Subtidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Outfall Site 7 - 5 mS	696893, 8628826	"	Subtidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Outfall Site 7 - 5 mE	696902, 8628831	"	Subtidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Outfall Site 7 - 5 mW	696888, 8628831	"	Subtidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Outfall Site 5 - 5 mN	695260, 8629455	"	Subtidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Outfall Site 5 - 5 mS	695260, 8629445	"	Subtidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Outfall Site 5 - 5 mE	695265, 8629450	"	Subtidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Outfall Site 5 - 5 mW	695255, 8629450	"	Subtidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Pipeline Route Site 8	696285, 8629062	6	Subtidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Pipeline Route Site 9	TBC	7	Subtidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Outfall Site 1 - 500 mNE	TBC	8	Subtidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Outfall Site 1 - 500 mSW	TBC	"	Subtidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Outfall Site 7 - 500 mNE	TBC	"	Subtidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Outfall Site 7 - 500 mSW	TBC	"	Subtidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Outfall Site 5 - 500m NE	TBC	"	Subtidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Outfall Site 5 - 500m SW	TBC	"	Subtidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Pipeline route Site 8	696285, 8629062	9		1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Pipeline route Site 9	695637, 8629216	"		1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
EPR1	TBC	10	Subtidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
EPR2	TBC	"	Subtidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
B3	TBC	11	Subtidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Seagrass site (TBC)	TBC	12	Subtidal	1 x Wet season 1 x Dry season	Annual		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		

Note 1	Requirement for, and frequency of, post-construction monitoring to be determined by findings of baseline survey
Note 2	Samples to be collected from the intertidal sands close to the base of the rock cliff
Note 3	Sample to be collected from the creek bank in the mouth of the creek at low tide
Note 4	Samples to be collected from the intertidal sands in front of the seaward mangroves
Note 5	Requirement for, and frequency of, post-construction monitoring to be determined by findings of baseline survey
Note 6	To be monitored while Sites 5 and 7 remain as a possible outfall locations
Note 7	To be monitored only while Site 5 remains as a possible outfall location
Note 8	Six sites to be monitored until outfall location is selected, subsequently only the two adjacent sites to be monitored
Note 9	Pipeline route Sites 8 and 9 to be monitored if Site 5 is selected as the preferred outfall location
Note 10	Sites identified in GHD survey as having coral community present
Note 11	Site identified in GHD survey as having seagrass present
Note 12	Site to be selected following further survey
Note 13	Site locations identified as TBC be confirmed in the field based on the locations shown in Figures 6-1 and 6-2

Table A.5 Intertidal fauna sampling program

Fauna Monitoring Site	Coordinates Easting/ Northing	Note	Intertidal / Subtidal	Pre-construction (Baseline)	Post-Construction (Operations)	Analyte	Test Species	Length of shell along longest axis	Wet weight of soft tissue	Dry weight of soft tissue	Aluminium	Arsenic	Chromium	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Silver	Tin	Uranium	Zinc	Total Petroleum Hydrocarbons	Total Polycyclic Aromatic Hydrocarbons	*Escherichia coli*
						Abbreviation		Shell length	Wet weight	Dry weight	Al	As	Cr	Cu	Fe	Pb	Mg	Mn	Hg	Ni	Ag	Sn	U	Zn	TPH	PAH	E. coli
						Unit		mm	g	g	mg/kg (dry weight)																MPN *E. coli* (wet weight) and SPC
East Point 1	TBC	1	Intertidal	1 x Wet season 1 x Dry season	Seasonal / Annual		Rock oyster	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
East Point 2	TBC	"	Intertidal	1 x Wet season 1 x Dry season	Seasonal / Annual		Rock oyster	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
East Point 3	TBC	2	Intertidal	1 x Wet season 1 x Dry season	Seasonal / Annual		Telescopium	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ludmilla Creek	TBC	"	Intertidal	1 x Wet season 1 x Dry season	Seasonal / Annual		Telescopium	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SLULC03	TBC	3	Intertidal	1 x Wet season 1 x Dry season	Seasonal / Annual		Telescopium	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ludmilla S	TBC	4	Intertidal	1 x Wet season 1 x Dry season	Seasonal / Annual		Telescopium	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ludmilla N	TBC	"	Intertidal	1 x Wet season 1 x Dry season	Seasonal / Annual		Telescopium	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Note 1	Oyster samples to be collected from the intertidal rocks at the foot of East Point, adjacent to the sediment sampling sites
Note 2	Telescopium samples to be collected from mangroves adjacent to the mouth of Ludmilla Creek (west and east sides respectively) if present
Note 3	Telescopium samples to be collected from the mangrove zone adjacent to the Ludmilla WWTP emergency overflow to Ludmilla Creek
Note 4	Telescopium samples to be collected from the mangrove zone, as close as possible to the adjacent intertidal sediment sampling sites
Note 5	Site locations to be based on the locations shown in Figure 6-1 but determined in the field by the presence of populations of target organisms sufficiently large to support the proposed sampling effort.
Note 6	Post construction sampling frequency and duration for all sites to be reviewed following the initial post-construction survey, and annually thereafter
MPN	Most Probable Number
SPC	Standard Plate Count

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