

East Point Outfall – Water Quality Monitoring and Management Plan

June 2016

Executive Summary

Power and Water Corporation (PWC) operate the Ludmilla Wastewater Treatment Plant (LWwTP) which is located six kilometres north of the Darwin central business district, adjacent to Ludmilla Creek, at 21 Dick Ward Drive Ludmilla. Primary treated effluent from the treatment plant is transferred via the East Point rising main (EPRM) for discharge to Darwin Harbour via the East Point outfall (EPO). The treated effluent is discharged to the intertidal zone approximately 350 metres off the northern shoreline of East Point. The LWwTP construction was commenced prior to Cyclone Tracy in 1974, with construction completed in 1977. The treatment plant has been discharging treated effluent to Darwin Harbour continuously via the intertidal outfall since 1977.

The closure of the Larrakeyah macerator and outfall in late May 2012 resulted in an increase in sewage flowing to the LWwTP with the addition of wastewater from the Larrakeyah and Darwin central business district sewage catchments. To manage the increased inflow the treatment and hydraulic capacities of the LWwTP were upgraded in 2012. Augmentation (duplication) of the East Point rising main from the treatment plant to the intertidal outfall at East Point was approved in 2013 with works completed in late 2014. The increased capacity of the EPRM has been undertaken to increase the LWwTP's capacity to discharge via the East Point Outfall and minimise diversion of the wet season overflows of treated effluent to Ludmilla Creek.

The Commonwealth Department of the Environment's approval EPBC 2009/5113 and the Northern Territory Environment Protection Authority's assessment for the construction and operation of the augmented rising main both included the requirement for a Water Quality Monitoring and Management Plan (WQMMP). The aim of the WQMMP is to verify the extent of the impact of the increased discharge on water quality and environmental indicator in the vicinity of the outfall, and by managing the discharge impacts, protect the foraging habitats of sensitive receptor species including inshore dolphins, turtles and dugongs.

Commissioning of the duplicated portion of the East Point rising main cannot commence until the WQMMP is approved by the Commonwealth Minister.

The WQMMP presents the background and design of a monitoring program which includes water quality, sediment condition and biological uptake of contaminants. The program is designed to provide data to inform the assessment of triggers that will ensure the protection of the identified sensitive receptor organisms.

The WQMMP sits alongside the compliance (Waste Discharge Licence) monitoring for WDL150-04 (LWwTP) to provide a suite of water quality indicators to inform the assessment, alert and action triggers and to guide a management response plan designed to identify and mitigate impacts resulting from the increased discharge from the East Point Outfall.

The monitoring program is based on the outcome of the hazard assessment undertaken for the discharge (Appendix 1) which used data from the PWC Darwin Harbour receiving waters monitoring program which commenced in 2011. The Darwin Harbour monitoring data has provided a comprehensive understanding of effluent dispersion and environmental exposure processes in the vicinity of the outfall and has informed the development and validation of a hydrodynamic model that informs decision making in relation to the outfall.

The Darwin Harbour water quality monitoring program has been operating as a monthly program since 2011 and since 2013 it has been supplemented by seasonal sediment and biota monitoring programs which include bioaccumulation, ecotoxicology, stable isotope analysis of effluent, biota and sediments and benthic in-fauna assessments.

The proposed WQMMP includes monthly water quality monitoring and assessment of water quality augmented by seasonal surveys of sediment and biota condition. The sampling sites, sampling methods, data analysis and reporting requirements are described for the water quality, sediment and biota monitoring components of the WQMMP.

This WQMMP and the compliance monitoring data will both inform and be informed by the benthic in-fauna monitoring and management plan (BIMMP) (CEE 2015) which will monitor benthic in-fauna and seagrass up to 1 km from the existing outfall.

Marine ecosystem triggers are specified for three tiers of management response, which are described from lowest to highest response as:

Level 1: Identify, assess and monitor

Level 2: Alert and prepare

Level 3: Act and manage

The monitoring program includes a reporting framework to ensure timely reporting of identified exceedances and non-compliances and annual reporting of the monitoring program to the relevant authorities until the closure of the existing intertidal outfall.

The WQMMP monitoring and assessment program will commence within 20 business days of notification of approval of the WQMMP by the Minister.

In accordance with Condition 13(b) of the Environmental Approval PWC has made a strong commitment to implementing the WQMMP until the existing outfall becomes non-operational.

An Annual Monitoring Report including an assessment of all monitoring data collected as part of the WQMMP; a summary of all Level 1 (Assessment Triggers); Level 2 (Alert Triggers); or Level 3 (Act and Manage Triggers) exceedances and a summary of management actions implemented to mitigate any effect. The Annual Monitoring Report will be provided to the regulatory authority within 10 Business Days of receiving the Independent Reviewer's approval for the Report and in any case within 60 Business Days of the Anniversary of the approval of the WQMMP.

The WQMMP includes reporting and assessment criteria across three levels of response:

Level 1: 'Assessment trigger' - for which exceedance events will not be reported to the regulator unless it is considered likely that the impact zone will expand. If the assessment of the exceedance predicts that the effect is likely to increase the Department of the Environment, as the Regulator will be advised of the outcome within 10 business days of the assessment being completed.

Level 2: 'Alert trigger' - for which exceedance events will be reported to the regulator where the assessment of the exceedance indicates that an expansion of the impact is likely a report will be provided to the regulator within 5 business days.

Level 3: 'Action trigger' - for which exceedances will be reported to the Regulator within 48 hours of becoming aware of the exceedance of the trigger.

In addition to the initial exceedance report all Level 3 exceedance events will result in the preparation of an investigation report which will assess the most probable source of the effect and any management actions required to be implemented to mitigate the effect.

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Introduction

Power and Water Corporation of the Northern Territory (PWC) is responsible for collection, treatment, reuse and disposal of municipal wastewaters in Darwin and elsewhere in the Northern Territory.

Ludmilla Wastewater Treatment Plant (WwTP) is located close to Ludmilla Creek at 21 Dick Ward Drive between Fannie Bay and Coconut Grove, north of the Darwin CBD. The wastewater treatment plant has been in operation since 1977. Advanced primary treated wastewater from the plant is discharged to Darwin Harbour via an intertidal outfall located approximately 350 metres off shore to the north of East Point in the bay between East Point and Nightcliff (Figure 1-1).

On 31 May 2012 the Larrakeyah macerator and outfall were closed and sewage/wastewater from the Larrakeyah and Darwin central business district catchments was redirected to the LWwTP, this represented the completion of Stage 1 of the Larrakeyah closure plan. The Larrakeyah closure plan is a key component of PWC's commitment to improve the performance of the Darwin Region's wastewater treatment and disposal facilities and reduce the potential impacts on the environment from sewerage operations. The closure of the Larrakeyah outfall resulted in an increase in the average dry weather inflow (ADWF) to Ludmilla WwTP from 9.5ML/day before to 12.5 ML/day immediately after the closure. Inflow has subsequently increased to ADWF approximately 13.7 ML/day in 2014/15.

Stage 2 of the Larrakeyah outfall closure plan involved the upgrading of the LWwTP to cater for the diverted load from the Larrakeyah and Darwin CBD areas following the closure of the Larrakeyah outfall. The upgrade provided additional capacity to provide for the immediate increased load and for future population growth. The treatment plant upgrade was completed in April 2013.

The LWwTP upgrade has improved the hydraulic and treatment capacity of the plant and as a result the discharge water quality has improved. In 2011-12, prior to the Larrakeyah outfall closure, the East Point Outfall (EPO) discharged 23 tonnes of total phosphorus (TP) and 180 tonnes of total nitrogen (TN); in 2013-14 despite the increased volume of wastewater discharged via the EPO the discharge loads were 13 tonnes TP and 186 tonnes of TN respectively. This represents an overall decrease in contaminants to Darwin Harbour but a slight increase in TN discharged via the EPO.

The East Point rising main (EPRM) carries treated wastewater from the LWwTP to the EPO. The EPRM is currently restricted to 300 L/second. The increased inflow to the LWwTP has resulted in an increase in the volume of treated wastewater discharged to Ludmilla Creek, particularly in the wet season. In 2014/15 the rate of discharge from the LWwTP averaged 13.7 ML/day in the dry season and 40 ML/day in the wet season. The transfer of treated wastewater from LWwTP to the EPO is now limited by the capacity of the EPRM.

Stage 3 of the Larrakeyah Closure plan, the augmentation (duplication) of the EPRM to increase the capacity from 300 L/second to 1000 L/second was the subject of a Public Environmental Report (PER). The NT EPA recommendations in relation to the augmented EPRM were made in NT EPA Assessment Report 72, December 2012 and the Commonwealth Government's Environmental Approval EPBC 2009/51113 was issued in March 2013. The construction works for the augmented EPRM were completed in late 2014 and it yet to be fully commissioned.

During the period 1 November 2012 to 31 October 2014 (the previous waste discharge licence) approximately 81% of the total LWwTP discharge was via the EPO intertidal outfall with 19% discharged via the Ludmilla Creek overflow weir. The dry season discharge to Ludmilla Creek represented approximately 0.4% of the total discharge, the remaining 18.6% of the discharge to Ludmilla Creek occurring during high inflow events in the wet season. The capacity limitation of the EPRM has resulted in an increase in discharges to Ludmilla Creek, especially during high inflow periods in the wet season.

Plate 1-1 East Point Outfall on Low Spring Tide



Source: East Point Outfall (Low Tide) – Trevor Durling (PWC 2014)

1 Background to WQMMP

Augmentation of the East Point rising main (EPRM) was considered as a Public Environmental Report (PER) by the Northern Territory Environment Protection Authority (NT EPA) and the Commonwealth Department of the Environment. The Northern Territory Environment Protection Authority assessment recommendation (NT EPA 2012) and the Commonwealth Department of the Environment Approval (Ward 2013) for the construction and operation of the augmented East Point rising main both included the requirement for a Water Quality Monitoring and Management Plan (WQMMP). The WQMMP is to document the extent of the existing discharge's impact on ecosystem values and in the Commonwealth Environmental Approval to demonstrate protection of inshore dolphin, marine turtle and dugong (*Dugong dugon*).

Commissioning of the duplicate main cannot commence until the WQMMP is approved by the Commonwealth Minister. PWC contracted URS Consultants to develop a suitable Water Quality Monitoring and Management Plan to satisfy the requirements of the NT EPA recommendation and Commonwealth Approval. This report reviews recent information on water quality, sediment condition and marine biota monitoring programs in the vicinity of the outfall, presents a rationale for the design of a monitoring program and describes the recommended monitoring program for review and recommendation by the Independent Technical Advisor and Commonwealth Ministerial Approval.

1.1 Regulatory Requirements

Northern Territory environmental assessment recommendations and Commonwealth regulatory approval for the East Point rising main augmentation project included requirements for a water quality monitoring and management program.

1.1.1 NT EPA Assessment Recommendations

Northern Territory EPA assessment recommends ecotoxicological assessment and stable isotope assessment to identify the extent of impact of the current outfall and monthly water quality monitoring to inform amendments to the discharge licence applicable for the Ludmilla Wastewater Treatment Plant.

The NT EPA Assessment Report 72 (NT EPA 2012) in relation to the EPRM augmentation works included the following four recommendations.

Recommendation 4: ecotoxicological investigation

The Proponent is required to demonstrate the extent impact on marine species through ecotoxicological investigation and assessment within the mixing zone at the current outfall.

The ecotoxicological investigation and assessment should be clearly scoped to provide clear guidance to selecting a site for the proposed outfall extension.

The ecotoxicological investigation and assessment report is to be provided to the NT EPA within 12 months to inform conditions on the Waste Discharge Licence.

Recommendation 5: Stable Isotope Analysis

The Proponent is to undertake stable isotope analysis to determine the extent of zone impacted by sewage and to distinguish between contaminants originating from Ludmilla WWTP effluent and contaminants from background and other sources such as stormwater. The analysis report is to be provided to the NT EPA within 12 months of this report.

Recommendation 7: Water Quality Monitoring Program

The Proponent is to design and implement a Water Quality Monitoring Program to the satisfaction of the NT EPA, consistent with WDL150-02. Monitoring should be conducted on a monthly basis and results reported to the NT EPA annually until the extension of the outfall is completed.

Recommendation 9: Reporting Monitoring Results

If monitoring results indicate a departure from expected impacts, the Proponent must implement contingency measures in consultation with the NT EPA to deliver improved environmental outcomes equivalent to those expected from the East Point Outfall extension.

The NT EPA required that the reports on these programs be provided to the NT EPA for consideration in the issuing of a new discharge licence. The reports were provided to NT EPA for consideration in the most recent licence application and a new discharge licence (WDL150-04) was issued on 1 November 2014. WDL150-04 includes monitoring conditions relating to water, sediment and biota quality in the East Point Outfall zone of influence. The WDL 150-04 also includes requirements for water, sediment and biota monitoring in Ludmilla Creek to assess the impact of overflows to the creek. The monitoring requirements of the licence are included as Appendix A of this report.

1.1.2 NT EPA (2014) Guidelines for East Point Outfall Project

In the October 2014 (draft) Terms of Reference for an Environmental Impact Statement (EIS) for the East Point Outfall, the NT EPA highlighted a number of potential construction impacts, including erosion and long-term integrity of sand waves; suspended matter reducing light availability for aquatic fauna; transport of sediment to the intertidal waters impacting on wader bird feeding areas; loss of biodiversity; under water noise impacting cetaceans and dugong; and the introduction of marine pests during construction in addition to matters associated with the ongoing discharge from the outfall.

The specific matters identified by the NT EPA association with the ongoing discharge from the outfall included discharge identified were impacts within the identified mixing zone and an increase in the nutrient load discharged from the outfall. The NT EPA also identified the build-up of sediment at the outfall due to particulate matter in the effluent and the accretion of nutrients in the sediments due to the increased nutrient load in the effluent as potential matters of concern.

An Environmental Impact Statement (EIS) will be prepared to support decisions relating to the relocation of the outfall and the EIS will include as much monitoring data as can be captured prior to construction and operation of the new outfall.

1.1.3 NT EPA (2014) Waste Discharge Licence WDL150-04

Discharges from the Ludmilla Wastewater Treatment Plant are authorised under provisions of a Waste Discharge Licence (WDL) 150-04 granted under Section 74 of the *Water Act 1992* (NT). The licence includes the requirement to monitor water quality, sediment and biota within and at the boundary of the identified zone of impact (mixing zone) associated with the discharge at East Point outfall and the point where the discharge from the overflow weir enters Ludmilla Creek. Discharge licences are generally granted for not more than 2 year and include specific monitoring and reporting requirements. Conditions in the current licence were informed by the reports generated in response to requirements of the NT EPA Assessment Report 72 recommendations (NT EPA 2012) and the Commonwealth Approval EPBC 2009/5113 (Ward 2013).

1.1.4 Commonwealth Requirements

Approval from the Commonwealth Department of Environment (DoE) was required under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwth.) due to concern that the increased discharge may impact on 'Matters of National Environmental Significance' including threatened and migratory marine species. DoE was particularly concerned that the 'foraging habitat for marine turtles, inshore dolphins and dugong (*Dugong dugong*)' should remain protected. DoE reiterated the requirements of the NT EPA, adding that the monitoring plan must be reviewed by the Independent Technical Advisor prior to being submitted to the Commonwealth Minister for approval.

The Commonwealth approval of the East Point Rising Main augmentation works EPBC 2009/5113 (Ward 2013) includes specific requirement for a Water Quality Monitoring and Management Plan.

EPBC 2009/5113 Condition 13: Water Quality Monitoring and Management Plan (WQMMP)

*The person taking the action must submit a WQMMP for the Minister's approval to protect marine turtles, inshore dolphins and dugong (*Dugong dugong*). The duplicated rising main cannot be commissioned until the Minister has approved the WQMMP. The WQMMP must:*

- a) *consider the application of stable isotope analysis to determine the extent of zone impacted by effluent and to distinguish between contaminants originating from Ludmilla WWTP effluent and contaminants from background and other sources.*
- b) *include ongoing monitoring of water quality in the vicinity of the existing outfall (as shown in Appendix B) until the existing outfall becomes non-operational.*
- c) *include management triggers, contingency measures, corrective actions and responsible persons to manage impacts from potential contaminants.*
- d) *monitoring results must be reported to the **department** annually until the existing outfall (as shown in Appendix B shown as figure 1.1) becomes non-operational.*

The Commonwealth Approval (EPBC 2009/5113) makes it clear that the water quality monitoring and management plan is to follow the principles of adaptive management and states:

EPBC 2009/5113 Condition 15 states:

"Management plans must be reviewed annually, from the date of approval, by the independent technical reviewer to enable continuous improvement and adaptive management of water quality and benthic in-fauna. The person taking the action must provide to the Minister a copy of all advice and recommendations made by the independent technical reviewer and an explanation of how the advice and recommendations will be implemented within the management plan(s) or an explanation of why the person taking the action does not propose to implement certain recommendations. This information must be provided to the Minister when the management plan(s) are submitted for approval."

EPBC 2009/5113 Condition 16 states:

Exceedances of any threshold trigger levels from a management plan must be reported to the department within 48 hours of becoming aware of the breach.

Appendix B of the Environmental Approval EPBC 2009/5113 is presented below as Figure 1-1. The map indicates the location of the Ludmilla Wastewater Treatment Plant; the East Point rising main and the augmented rising main; the existing intertidal East Point Outfall; alternative locations considered for the relocation of the outfall into sub tidal waters; and water quality monitoring sites in Darwin Harbour and Ludmilla Creek. The PWC receiving water monitoring program sites are used to characterise the zone of influence of the existing outfall and to provide background environmental data against which to assess the impact of any future relocation of the outfall.

1.2 Independent Reviewer

As required by Condition 11 of the Environmental Approval EPBC 2009/5113, PWC has contracted an Independent Technical Advisor to provide advice and review the WQMMP prior to submission of the WQMMP for approval by the Commonwealth Minister.

As required by the NT EPA recommendations and Commonwealth Government approval for the augmentation of the East Point Rising Main the outcomes of the 2013-14 studies have been used to inform the design of the ongoing WQMMP. The recommended design has been reviewed and endorsed by the independent reviewer prior to being submitted to the regulators for approval.

1.3 Review of the WQMMP

As required by Condition 15 of the Environmental Approval EPBC 2009/5113 the WQMMP will be reviewed annually and the report and recommendations provided to the Independent Technical Advisor with the objective of enabling continuous improvement and adaptive management of water and sediment quality as well as managing impacts on the condition of biota and benthic in-fauna.

Power and Water will provide the Annual Monitoring Report and the advice of the Independent Technical Advisor to the Commonwealth Minister for the Environment and the NT EPA along with an explanation by PWC of how the advice/recommendations of the independent technical reviewer will be or have been incorporated in the management plans or why such advice/recommendations are proposed not to be adopted.

The Independent Technical review and PWC response will be submitted to the Commonwealth Minister for the Environment when the management plans are submitted for approval.

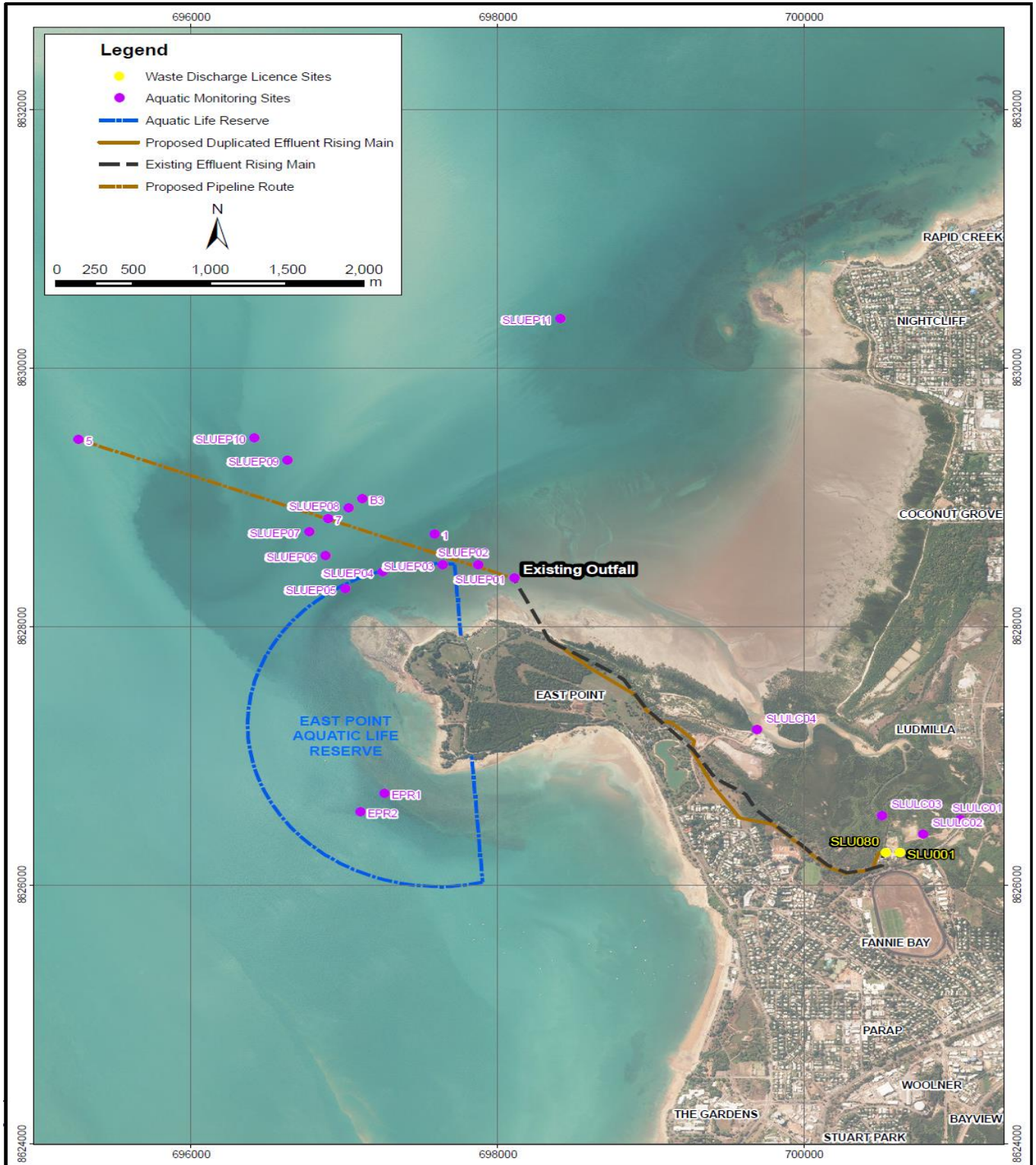


Figure 1-1 Environmental Approval EPBC 2009/5113 Appendix B (Existing Outfall Location and Monitoring Site Map)

1.4 Responsibilities for the WQMMP

In accordance with the requirements of Condition 13(c) of the Environmental Approval EPBC 2009/5113 a table of authorities (based on position rather than the individual) is required to identify responsibilities for all actions.

Table 1-1 Program Responsibilities

Task	Responsibility	Organisation
Preparation of the monitoring plan(s) (and any amendments)	Water Quality Officer	PWC
Endorsing the monitoring plan(s) (and any amendments)	Independent Technical Reviewer	External
Approval of the monitoring plan (and any amendments)	Responsible Minister	Commonwealth
Implementation/Conduct of the monitoring program	Senior Water Quality and Treatment Officer	PWC
Preparation of management and compliance reports for submission to regulatory authorities	Water Quality Officer	PWC
Review of monitoring and management reports	Independent Technical Advisor	External
Submission of reports to Department of the Environment and/or NT EPA.	General Manager Water Services	PWC
Notification of exceedances of management triggers	Water Quality Officer	PWC
Implementation of contingency measures	Senior Water Quality and Treatment Officer	PWC
Review and implementation of management measures (corrective actions)	Senior Water Quality and Treatment Officer	PWC
Independent review of implementation and management measures	Independent Technical Advisor	GHD
Review and revision of WQMMP	Water Quality Officer	PWC

2 Background to the Monitoring and Management Program

2.1 Background to the EPO Monitoring Program

In 2011 the East Point Outfall (EPO) Water, Sediment and Biota Monitoring Program (URS 2011) was developed in support of plans by Power and Water Corporation (PWC) to upgrade the Ludmilla Wastewater Treatment Plant (LWwTP) including the augmentation of the East Point Effluent Rising Main (EPRM) and extension/relocation of the intertidal EPO to a new sub tidal location.

The Monitoring Program, was included as part of the rising main augmentation PER, and was designed to monitor the effects of the increased LWwTP plant upgrade on Darwin Harbour water and sediment quality and effects on biota arising from changes in effluent quality and quantity discharged at the existing outfall location. The program also provided baseline data for the planned outfall extension.

In 2012 PWC expanded its water quality monitoring program to include potential environmental impact sites and three proposed sites for the outfall relocation. Between 2012 and 2015 PWC has undertaken additional studies to assess the impact of the existing outfall and provide baseline data for the selection, construction and operation of the new EPO location. These studies include:

- A survey of the sediments in the vicinity of the existing wastewater discharge points to determine the current condition of the sediments and to assess any potential for adverse impact including potential for accumulation of toxicants in the sediments.
- An ecotoxicological assessment of the treated wastewater discharge from the plant to determine the dilution required to minimise toxic impacts (ESA 2014).
- An investigation of stable isotopes in seagrass and mangrove leaves and in the gastropod mollusc *Telescopium telescopium* as an input to determining the extent of influence of the existing waste water discharge (PWC 2014).
- An investigation into the presence of toxins in intertidal fauna (*Telescopium telescopium* and the rock oyster *Saccostrea cucullata* (SKM 2014 a)
- A survey of invertebrate fauna in the vicinity of the wastewater outlets (EPO and Ludmilla Creek) (Jacobs 2014).
- An investigation into the presence of toxins in the sediments in the vicinity of the existing outfall and at increasing distances from the outfall, and at reference sites and potential sites for the relocated outfall (SKM 2014b).

A monthly water quality monitoring program assessing physical, chemical and biological parameters at the EPO outlet location and in the surrounding waters was implemented by PWC in February 2011 at sites shown in Figure 1-1. This program considerably exceeded the monitoring requirements as set out in the LWwTP discharge licences WDL150-01 to 04. Prior to 2011, monitoring of Darwin Harbour sites was not required under the licence conditions and was largely undertaken on an ad-hoc basis. The principal issue addressed was identification of bacterial contamination following occasional unsatisfactory bacteria levels on beaches within Darwin Harbour which had resulted in beaches being closed. In most cases contamination was attributed to multiple potential sources. Subsequently, the use of chlorine for odour control, which had the additional benefit of disinfection of the wastewater discharged from the LWwTP, had seen outfall bacteria levels in wastewater discharged from the plant reduced to extremely low levels, in many cases meeting recreational water quality guidelines at the point of discharge (NHMRC 2008).

The PWC bacterial survey data complement the harbour-wide recreational (bacteriological) monitoring program which monitors bacterial levels at recreational beaches around the harbour. The nearest recognised swimming beaches are at Nightcliff and to the south of East Point.

Monitoring of other water quality parameters is undertaken on a harbour-wide basis and in addition to the current and historic routine program there have been a number of short-term and project specific water, sediment and marine and estuarine flora and fauna studies undertaken within the harbour which provide background and reference data.

Data collected in the PWC Darwin Harbour Water Monitoring Program (2011 onward); the 2012 EPRM augmentation monitoring of water, sediment quality and biota contamination; compliance monitoring for WDL 150-03; and studies conducted in response to the NT EPA Assessment Report 72 recommendations and the Commonwealth Environmental Approval EPBC 2009/5113 have all been used to inform an environmental risk assessment and to develop site specific trigger values for the LWwTP discharge. The monitoring data and the risk assessment have been used to inform the monitoring requirements of the most recently licence WDL150-04 which commenced on 1 November 2014.

It is expected that data collected in the ongoing WDL150-04 licence monitoring and the WQMMP (receiving water monitoring) will be used to provide licence compliance assessment and to identify variations from the impacts predicted in the EPRM PER.

If environmental impacts are identified that exceed those predicted in the EPRM PER, the monitoring data will be used to inform development of a responsive management plan/s. The plans will be tailored to meet the individual circumstances of any exceedance however the plan may include actions such as increased monitoring of treatment processes; increased monitoring of the receiving environment; optimisation of treatment performance through modification of chemical dosing to reduce pathogen loads or to increase sedimentation rates to improve removal of contaminants; or in exceptional circumstances may include diversion of treated effluent to Ludmilla Creek via the overflow weir rather than to the East Point Outfall.

The hazard assessment developed from the monitoring data is shown in Table B1 in Appendix B.

2.2 Water Quality Monitoring

The hazard assessment and risk characterisation is included in Appendix B as table B1. A summary of the water quality monitoring data indicated:

At the East Point Outfall:

- pathogen indicators *E.coli* and enterococci were above the levels considered suitable for the protection of the beneficial uses of aquaculture and the cultural use of food collection;
- nutrients exceed the Darwin Harbour Water Quality Objectives for slightly to moderately impacted ecosystem protection, eutrophic conditions indicators were not exceeded; and
- copper and ammonia as toxicants were above the moderate hazard level.

Zone of Impact for the East Point Outfall:

- Pathogen indicators indicate level B recreational water quality
- Ammonia and total nitrogen are above the DHWQO, however no impacts were evident
- No toxicants were above the 95% species protection level (slightly to moderately impacted)

Ludmilla Creek

- Displayed significant seasonal variations in water quality;
- Pathogen indicators were above levels considered acceptable for aquaculture or cultural uses (swimming and food collection);
- Nutrient levels were above the moderate hazard level for ammonia, total nitrogen and total phosphorus and occasionally experienced high chlorophyll-a and low dissolved oxygen upstream of the overflow discharge
- Ammonia at the discharge drain entry exceeded the trigger level for toxicants.

2.3 Sediment Monitoring

To provide a contaminant status baseline for discharge impacts prior to the augmentation of the East Point rising main PWC conducted sediment monitoring at 42 locations around the existing East Point Outfall, in Ludmilla Creek and at sites that may be impacted by construction works associated with the relocation of the outfall. The monitoring locations are shown in Figure 2-1, the initial survey confirmed that a number of parameters were not present at levels that could be detected and the program was restructured to focus on providing data that was relevant to the discharge and that would inform discussions relating to impacts on benthic in-fauna in the vicinity of the East Point Outfall. Figure 2-1 identifies sample sites for wet season only, dry season only and sites sampled in the wet and dry seasons.

The sediments were assessed for physico-chemical properties, nutrient status, metals and metalloids, total petroleum hydrocarbons, polycyclic aromatic hydrocarbons and microbiological characteristics.

The results of the wet and dry season monitoring conducted during April and September 2013 were consistent with previous investigations of sediment contamination in Darwin Harbour.

Conclusion

The discharge of treated wastewater to Darwin Harbour via the East Point Outfall and the treatment plant overflow drain to Ludmilla Creek is having an impact on the sediments in the vicinity of the outfall at East Point and in Ludmilla Creek.

Nutrient accumulation is apparent in the sediments in the vicinity of the outfall, with the results towards the upper end for sediments in Darwin Harbour.

The sediments showed no evidence of toxicant impacts associated with the discharge of treated effluent from the LWwTP. Metals and other toxicants detected in the sediments within the impact zone of the outfall and within the zone of influence of the outfall were all below the ANZECC ISQG-Low values (ANZECC 2000) and are assessed as being low risk. Nutrient levels in the sediments were identified as being in the upper range of sediment levels typically found in Darwin Harbour and the pore water nutrient levels exceed the Darwin Harbour Water Quality Guidelines (NRETAS 2010), however no evidence of sediment anoxia has been detected in the sediments within the zone of influence of the East Point Outfall discharge.

While no guidelines exist for pathogen indicators in sediments the results were all below levels considered to indicate contamination with sewage.

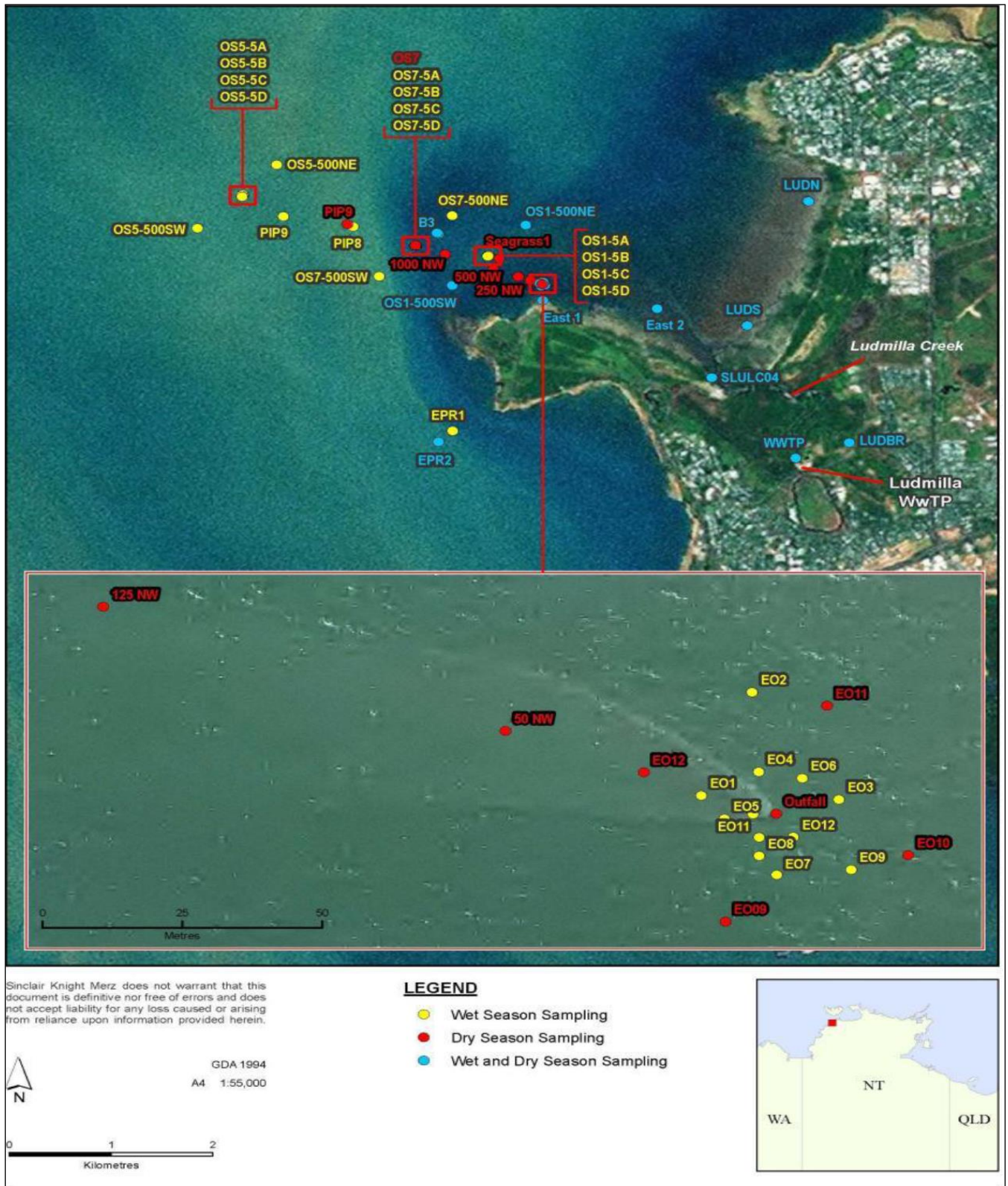


Figure 2-1 Sediment Monitoring Sites East Point Rising Main Augmentation Program

2.4 Biota Monitoring

As a requirement of the NT EPA recommendations and the Commonwealth Environmental Approval for the East Point rising main PER PWC commissioned wet and dry season surveys of contaminants in biota in the vicinity of the East Point Outfall and in Ludmilla Creek in the vicinity of the overflow bypass drain (SKM 2014b). Sample collection sites are shown in Figure 2.2.

The sampling and analysis was conducted in April (wet season) and September (dry season) 2013. Tissue samples were collected for the assessment of microbes, metals, metalloids and organics using National Assessment of Testing Authorities (NATA) accredited laboratories, the National Measurements Institute (NMI) and Path West. The specialist nature of the analysis limited the available laboratories accredited for the analysis and duplicate samples were analysed at laboratories that were not NATA accredited for the particular tests however protocols were used that provided validated and therefore comparable results.

Results for all parameters were analysed and interpreted to distinguish any patterns or trends across the various sites which may be attributable to the discharge effluent.

The Australian and New Zealand Food Authority (ANZFA) guidelines for Maximum Residue Levels (MRLs) and Generally Expected Levels (GELs) were used as the basis for assessing the risks contaminant levels in biota posed to public health and safety. MRLs identify potential health risks arising from consumption of biota, where there is no public health or safety reason to declare a MRL, a GEL provides information based on tissue levels of analytes found in commercially sold food products. Contaminant levels in the biota were compared to both the MRLs and GELs, in addition a 2013 study of contaminants in food species collected in Darwin Harbour (Padovan et. al. 2013) provided baseline data against which biota samples from the potential impact zone were able to be compared to both impacted and reference site data.

The results indicate that the risk associated with consumption of mud whelks collected from Ludmilla Creek at the overflow drain and mud whelks and oysters from the rocks closest to East Point Outfall is slightly higher in the wet season than in the dry season.



Figure 2-2 Biota Collection Sites East Point Rising Main Augmentation Program

2.5 Background to the Revised PER Water Quality Monitoring Plan

In presenting the guidelines for preparation of a PER for the augmentation of the EPRM and extension of the EPO, NRETAS (now NT EPA) identified three areas of concern in respect of the water quality discharged from the EPO. 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, it was noted that future discharges from the EPO would 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 specified (NTG 27, 10 July 2010) as:

- Aquaculture
- Environment (Aquatic Ecosystem Protection)
- Cultural (including recreational water quality, collection of food organisms and aesthetics).

In making the determination in response to the PER the Commonwealth Environmental Approval EPBC 2009/5113 identified the potential impacts on listed and threatened species as being the issue of concern for the EPO discharge. Key species of concern were identified as marine turtles, inshore dolphins and dugongs (*Dugong dugon*). None of these species have been identified as being directly reliant on habitat, flora or fauna commonly located within the vicinity of East Point Outfall or Ludmilla Creek; however turtles and dolphins are occasionally sighted in the area.

Turtles and dugong in the Darwin coastal region feed on seagrasses and some other marine plants. Extensive areas of priority habitats for turtles or dugongs have not been identified in the vicinity of the East Point Outfall. Previous studies have listed seagrass as ephemeral and sparse in the vicinity of the Outfall and not present in Ludmilla Creek.

Inshore dolphins range along the coast and feed on fish and cephalopods (squid and octopus). Seagrasses may provide some useful habitat for fish and cephalopods and hence benefit inshore dolphins. Fish and cephalopods may also forage over the intertidal mudflats at high tide, thereby indirectly interacting with the discharge and associated biota. The benthic in-fauna survey (CEE 2015) includes a further assessment of seagrass status in the East Point area and will provide useful data for characterising risks to the priority sensitive receptor species arising from the increased EPO discharge.

Treated effluent from the LWwTP is discharged to the waters of Darwin Harbour through the EPO (Plate 1-1 and Figure 2-3). The present outfall pipe extends approximately 350 m offshore in a north-westerly direction below an intertidal mudflat and discharges in the intertidal zone. The outlet at the end of the pipeline is a vertical discharge, visible at tide heights below neap tide low water level (Plate 1-1) and up to 2.2 m below the surface at mean sea level. In 2014 the rate of discharge averaged 13.7 ML/day in the dry season and up to 40 ML/day in the wet season. During periods of high inflow in the wet season and, as a result of fault and maintenance shutdowns, treated wastewater may be diverted to Ludmilla Creek from where it discharges to the harbour. In accordance with WDL 150-4, discharge to Ludmilla Creek can take place only when the inflows to the LWwTP exceed 300 L/s (25.9 ML/d) prior to augmentation/duplication of the East Point rising main and 1000 L/s (86.4 ML/d) after commissioning of the augmented EPRM.

During the WDL150-03 licence period (1 November 2012 to 31 October 2014) approximately 81% of the total discharge was via the EPO intertidal location with 19% discharged via the Ludmilla Creek diversion. Only 0.4% of the total discharge was to Ludmilla Creek during the dry season, the remaining 18.6% occurs during high inflow events in the wet season.

Operation of the augmented EPRM will result in fewer overflows of treated wastewater via the overflow weir to Ludmilla Creek and while the total discharge from LWwTP will remain unchanged, the discharge to Darwin Harbour via the EPO will increase in the wet season.

The purpose of the WQMMP is to provide the data to enable assessment of potential issues of concern due to the increased discharge from the LWwTP via the existing EPO location. The monitoring program will also provide data to assess the background water quality and any impacts associated with the proposed relocation of the East Point Outfall to a sub-tidal location. These were identified by Natural Resources, Environment, The Arts and Sport (NRETAS) in 2010 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 Public Environmental Report (PER) provided a modelled impact zone and the WQMMP will identify impacts beyond those predicted in the PER.

The LWwTP discharge, Ludmilla Creek sites and the 'impact or mixing zone' adjacent to the East Point Outfall are monitored as a condition of WDL150-04, this program is subject to a review in granting the next licence. The focus of the WQMMP is on monitoring in Darwin Harbour outside the 'mixing zone' to determine whether impacts are different to those predicted in the PER. Licence water quality monitoring and data assessment are conducted monthly and non-compliances reported to the NT EPA. An annual water quality monitoring report is prepared as a condition of the licence.

The WQMMP is designed to specifically address the recommendations and conditions of the environmental approval for the augmentation of the Effluent Rising Main (NT EPA Assessment Report 72 and EPBC 2009/5113) however it will also inform the environmental approval for the EPO relocation. The monitoring requirements of the EPRM approval and the EPO extension include water, sediment and biological monitoring. Sediment and biota integrate contaminant impacts over time and the sediment and biota have a key role as environmental triggers of relevance to the sensitive listed species. The title of the plan remains as the Water Quality Monitoring and Management Plan (WQMMP) to retain terminology consistent with the EPBC Approval.

The WQMMP stands alongside the existing WDL150-04 compliance monitoring program and is inclusive of all the Darwin Harbour and discharge monitoring sites included in the compliance monitoring. The WQMMP also includes a more comprehensive range of parameters and a number of sites outside the zone monitored under the more targeted compliance monitoring program. The subsequent assessment of triggers included in the WQMMP will be informed by the licence compliance monitoring as well as the process monitoring conducted within the LWwTP. The post-upgrade Ludmilla WwTP influent and effluent water quality monitoring data and the results of additional baseline studies including stable isotopes, biota and sediment contamination and invertebrate fauna; have been reviewed as a guide to determining monitoring parameters.

The relocation of the East Point outfall is currently under EIS consideration. Figure 2-3 shows the nine sites assessed for the potential outfall relocation, the sites identified for further assessment are Site 1, Site 5 and Site 7. PWC's preferred relocation site is Site 1 (SLUEP12) with Sites 5 (SLUEP13) and Site 7 (SLUEP14) providing the most suitable alternative locations. These three

sites are currently being assessed for effectiveness of dispersion and potential environmental, social and economic impacts via an Environmental Impact Statement (EIS).

A visual representation of the bathymetry of the harbour in the vicinity of the outfall and at the potential outfall relocation sites is presented in Figure 2-3. Colours grade from yellow (intertidal) through green to dark blue, which represents the deepest water found. The coordinates of the three sites under assessment for the outfall relocation are included in Table 2-1.

Until the EIS is released, assessed and an environmental approval granted, the PWC will continue monitoring at all sites as identified in the EPRM PER water quality monitoring program (URS 2011b). These sites include the preferred relocation site, Site 1 (SLUEP12) and the alternate sites Site 5 (SLUEP13) and Site 7 (SLUEP14) and three sites identified as environmentally sensitive for potential ecological impacts, these sites are identified as EPR1 (SLUEP15 – coral reef); EPR2 (SLUEP16 – coral reef) and B3 (SLUEP17 – a possible seagrass site).

Table 2-1 Site Coordinates and Characteristics of the Alternative Outfall Locations

Site characteristics (from monitoring data neap low tide)	Site 1 (SLuEP12)
Site coordinates (easting; northing; MGA)	697590; 8628710
Average depth (m)	7.3 (4.26 lowest astronomical tide)
Depth of discharge (m)	6.3 (3.26 lowest astronomical tide)
Alternative Sites characteristics	Site 5 (SLuEP13)
Site coordinates (easting; northing; MGA)	695260; 8629450
Average depth (m)	7.3 (12.1 lowest astronomical tide)
Depth of discharge (m)	6.3 (11.1 lowest astronomical tide)
Alternative Sites characteristics	Site 7 (SLuEP14)
Site coordinates (easting; northing; MGA)	696893; 8628831
Average depth (m)	12.8 (9.8 lowest astronomical tide)
Depth of discharge (m)	11.8 (8.8 lowest astronomical tide)

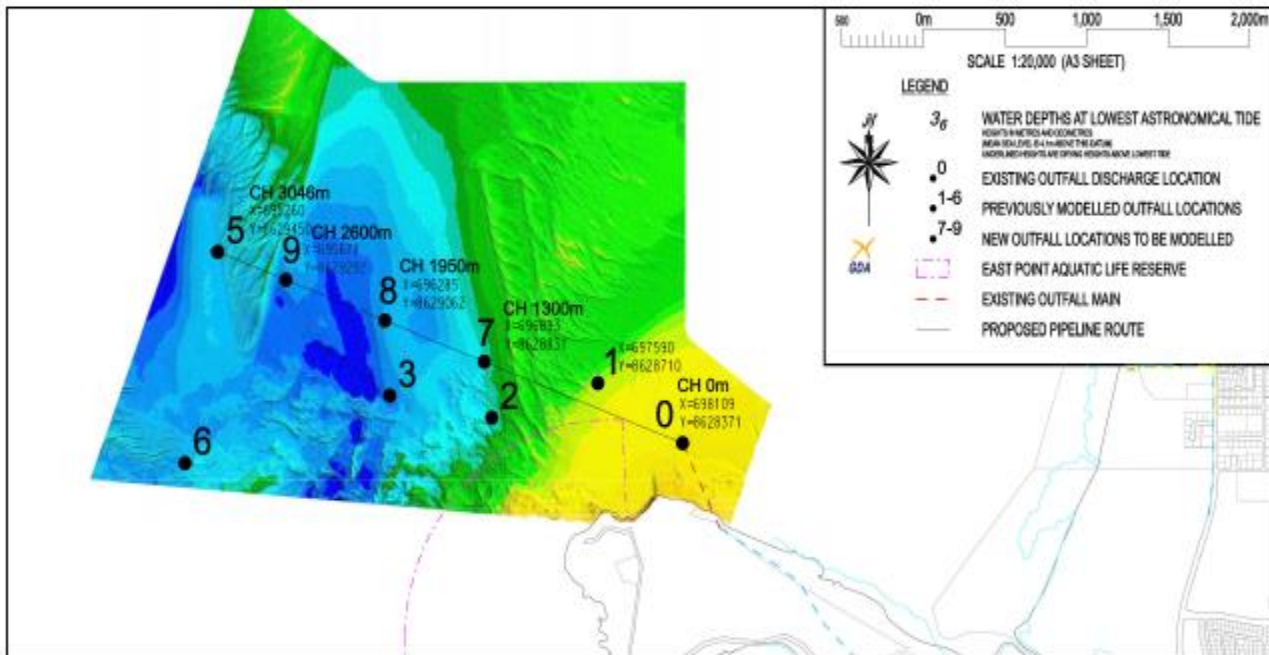


Figure 2-3 Bathymetry at the Existing Outfall (Site 0) and Alternate Outfall Locations

The water quality monitoring parameters adopted in this monitoring program are drawn from PWC's current (2014-15) Darwin Harbour water quality monitoring program. The Waste Discharge Licence monitoring is a more limited suite of sites and parameters which includes three Darwin Harbour Sites (SLUEP01, SLUEP02 and SLUEP03) and three Ludmilla Creek sites (SLULC01, SLULC03 and SLULC04) and effectively forms a sub-set of the PWC Darwin Harbour monitoring program. The Waste Discharge Licence monitoring is conducted at sites identified as potentially impacted by the discharge or within the potential zone of influence of the discharge. These sites are appropriate for impact assessment for the current operation of the LWwTP. The Waste Discharge Licence monitoring sites, coupled with the additional sites included in the PWC Darwin Harbour water quality monitoring program provide the baseline data for identifying impacts associated with the operation of the augmented main and the new outfall.

Where contaminants are not present in the treatment plant effluent monitoring site (SLU080/SLULCDP), ongoing monitoring in the marine environment may not be warranted. It is possible that, over time, potential contaminants which have been shown to not occur at above guideline concentrations in the treatment plant discharge may be removed from the receiving waters program. As a precaution these contaminants would be continued in the treatment plant discharge monitoring to ensure that changes in inputs to the plant are identified.

WDL 150-04, granted on 1 November 2014, considered the data presented in the Appendix of this report to inform a monitoring program which is a statutory requirement of the licence. The licence monitoring requirements are focused on the East Point Outfall mixing zone and Ludmilla Creek, the program includes water quality, sediment and biota monitoring. Details of the WDL monitoring program are included in Appendix A.

In this report each section includes a description of the WDL150-04 compliance monitoring requirements and the proposed Water Quality Monitoring and Management Plan (WQMMP) which is designed to supplement the compliance monitoring and integrate water quality, sediment quality and biota assessments to guide decisions relating to variation from the expected impacts on sensitive receptor organisms identified in the PER.

- Section 3 describes the water quality component of the WDL compliance monitoring and the Water Quality Monitoring and Management Program (WQMMP);
- Section 4 describes the sediment quality component of the WDL compliance and the WQMMP; and
- Section 5 describes the biota monitoring component of the WDL and the WQMMP.

The compliance monitoring program is associated with the WDL, as granted by the Northern Territory Environment Protection Authority and the WQMMP, as approved by the Commonwealth Minister are described separately as they require separate commitments to implementation.

The commitment to implementation of the compliance monitoring, as described in the WDL, is a condition of the licence. Licenses and the associated monitoring program are granted for a period of no more than 2 years and the commitment to implement the monitoring is bound up in accepting the licence conditions and failure to conduct the monitoring is an offence.

To ensure compliance with the Environmental Approval EPBC 2009/5113, a separate commitment to implement the monitoring associated with the WQMMP.

Until such time as the existing outfall becomes non-operational PWC is committed to implementing the monitoring programs described in the WQMMP and approved by the Commonwealth Government Minister.

3 Water Quality Monitoring Program

Darwin Harbour is a macro-tidal estuary with a tidal range of greater than 7 metres. Macro-tidal estuaries are typically quite turbid due to strong tidal currents resuspending the fine sediment. The turbidity acts as a control on phytoplankton production and biomass reducing the likelihood of algal blooms but also increasing the potential for nutrients to build up in the system (Geoscience Australia http://www.ozcoasts.gov.au/conceptual_mods/geomorphic/tde/tde.jsp).

As an estuary in the wet/dry tropics water quality exhibits distinct differences between the wet and dry seasons. High rainfall in the wet season results in large freshwater inflows with associated nutrients, sediments and pathogens runoff resulting in low water clarity and poorer water quality.

Like the majority of waterways entering Darwin Harbour Ludmilla Creek is ephemeral, with freshwater inflow only occurring in association with catchment runoff which typically occurs during the wet season (October to April). Ludmilla Creek displays the water quality properties of an estuary in the wet season and in the dry season it is more similar to a tidal inlet. Water quality has distinctly different seasonal characteristics and as such, where sufficient data is available it is most appropriate to assess data from similar seasons to isolate differences arising from seasonal factors such as freshwater runoff.

The LWwTP discharges to Darwin Harbour under conditions specified in Waste Discharge Licence Number 150-4 (WDL150-4) issued by the Northern Territory Environment Protection Authority (NT EPA) pursuant to Section 74 of the *Water Act*. The licence authorises discharges to occur via the existing intertidal East Point outfall and, in high inflow conditions via an overflow weir into Ludmilla Creek.

The water quality monitoring associated with the LWwTP discharge includes two distinct components, the compliance monitoring required by WDL150-04 as granted by the NT EPA on 1 November 2014 and monitoring associated with the Environmental Approval and as proposed for the WQMMP.

The WDL150-04 monitoring is a compliance requirement focused on the discharge from the treatment plant, impacts in Ludmilla Creek and water quality within the identified impact zone (mixing zone) of the existing outfall. The licence compliance monitoring program is not a component of the WQMMP however data collected in compliance monitoring will be used to inform decisions in relation to the cause of any exceedances identified by the WQMMP. The licence identifies an impact zone and it is the boundary of this zone which forms the basis for decisions in relation to the management triggers and management actions. The compliance monitoring is described in section 3.2 and Appendix 1.

The second component of PWC's water quality monitoring is monitoring within Darwin Harbour, this is defined as monitoring which occurs from the boundary of the identified impact zone to a distance of approximately two kilometres which represents the area within which no impacts from the current outfall and discharge are expected and therefore the focus of the WQMMP which is further described in Section 3.3.

As required by Condition 13 (d) of the Environmental Approval EPBC 2009/5113, the monitoring program, as described in the WQMMP, will continue until the current outfall is no longer operational. An annual review of the program will be included in the Annual Monitoring Report and recommendations for changes to the approved WQMMP will be assessed by the Independent Technical Reviewer and approved by the DoH as the Regulatory Authority prior to implementation.

3.1 Indicators, Receptors and Triggers

The Department of the Environment (DoE) Environmental Approval EPBC 2009/5113 requires that the person taking the action (PWC) must submit a WQMMP for the Minister's approval. The WQMMP is to demonstrate that impacts are as predicted in the PER and the water quality is to protect sensitive receptor organisms including marine turtles, inshore dolphins and dugong (*Dugong dugong*). The duplicated rising main cannot be commissioned until the Minister has approved the WQMMP. The WQMMP must:

- consider the application of stable isotope analysis to determine the extent of zone impacted by effluent and to distinguish between contaminants originating from Ludmilla WWTP effluent and contaminants from background and other sources.
- include ongoing monitoring of water quality in the vicinity of the existing outfall (as shown in Appendix B of the approval) until the existing outfall becomes non-operational.
- include management triggers, contingency measures, corrective actions and responsible persons to manage impacts from potential contaminants.
- monitoring results must be reported to the department annually until the existing outfall (as shown in Appendix B shown here as Figure 1.1) becomes non-operational.

This section discusses the information specific to the existing, intertidal East Point Outfall and presents a framework to address the DoE Environmental Approval Requirements.

Sensitive species are not commonly observed in the vicinity of the outfall, this may be due to the shallow intertidal location or because of the lack of reliable seagrass which limits the available food sources. Visual observations of dolphins, turtles and dugong will be made to assess the likelihood of elevated risks resulting from the discharge. In addition visual observations in relation to algal blooms and the impact of the discharge on the behaviour of marine animals will be collected and assessed.

The compliance monitoring program for the WDL150-04 program includes water quality, sediment quality and biota programs investigating the extent of sewage derived nitrogen uptake into biota and the uptake of chemical contaminants and bacteria into food source biota.

WDL150-04 includes annual seasonal monitoring of sediment in the vicinity of the discharge points. Sediments are considered to be conservative indicators that accumulate contaminants over time and provide a long-term record of contaminant accumulation. The WDL150-04 sediment monitoring program is focused in the vicinity of the East Point Outfall and in Ludmilla Creek. The programs has identified the localised sediments as being of low risk of impacting on the ecological health of the sediments as toxicant levels and are below the Australian and New Zealand Environment and Conservation Committee (ANZECC 2000). Interim sediment quality guidelines levels for low risk (ISQG-Low) and the nutrient levels in the vicinity of the outfall are within the upper range of the levels typically found in Darwin Harbour sediments.

The WDL sediment monitoring results were confirmed by the sediment monitoring program conducted for the East Point rising main PER which assessed sediment quality both within and beyond the immediate impact zone of the discharge. The zone of influence of the effluent discharge has been confirmed through a study of stable isotopes of nitrogen in the sediment. During 2013 and 2014 sediment samples were collected in the 250 metre zone around the existing outfall (SLUEP01), while the total nitrogen in the sediments was elevated the $\delta^{15}\text{N}$: $\delta^{14}\text{N}$ ratios were similar to those obtained from the sediments of Darwin Harbour creeks with little exposure to wastewater discharges. These results suggest the stable isotopes of nitrogen are

useful as a tracer for sewage derived nitrogen and carbon in the sediments radiating out from the outfall.

The 2013 biota monitoring program identified elevated levels of pathogen indicators (*E.coli*), copper and zinc in oysters and *Telescopium* collected near the East Point Outfall, this monitoring is a WDL150-04 compliance requirement however all data from that program will be added to the WQMMP reports.

It is proposed that as with the WDL150-04 monitoring program the site specific trigger values (SSTV) are applied to the WQMMP sites. The SSTVs include a combination of primary and secondary indicators which will be applied for stressor indicators such as nutrients in the impact (250 metres) and the zone of influence to 500 metres, the light blue zone in Figure 3-1. Secondary indicators are only assessed if the primary indicator (chlorophyll and dissolved oxygen) triggers further assessment. It is recommended that the WQMMP includes monitoring and assessment of water quality beyond the identified impact zone (mixing zone) for the licence to identify possible impacts arising from the increased discharge volume arising from augmentation of the East Point rising main. The impact zone is identified as the bright blue zone in Figure 3-1 and extends to approximately 250 metres from the existing outfall with site SLUEP02 located just beyond the boundary of the impact zone.

The focus of the WQMMP is water quality outside the impact (mixing) zone identified in the WDL 150-04 where compliance monitoring is specified. Compliance monitoring is required by WDL150-04 and will inform decisions in relation to the most probable source of any exceedance of triggers at the WQMMP monitoring sites.

The sites proposed for the WQMMP program include licence compliance sites (impact and influence zone) and Darwin Harbour 'receiving water' sites beyond the zone recognised as potentially impacted by the current discharge. The receiving water sites provide additional spatial coverage to ensure that any exceedances of the Darwin Harbour Water Quality Objectives and the ANZECC 95th percent species protection toxicant triggers are identified; managed; and reported. The level of spatial coverage is designed to ensure a high level of confidence that the sensitive receptor species and food and habitat important to the sensitive receptor species are not subjected to an increased level of impact beyond that predicted in the PER due to the increased wet season discharges arising from the augmented East Point rising main and that level of protection of beneficial uses currently experienced in Darwin Harbour is maintained.

It is proposed that beyond the identified impact zone a tiered system of assessment will be used to trigger management responses (described in greater detail in Section 3-10).

- Level 1 Identify, Assess and Monitor – exceedance 250 to 500 metres from discharge;
- Level 2 Alert and Prepare – exceedance 500 to 1000 metres from discharge;
- Level 3 Act and Manage – exceedance beyond 1000 metres from discharge.

3.2 Waste Discharge Licence Compliance Monitoring

The LWwTP currently discharges to Darwin Harbour and Ludmilla Creek under conditions included in WDL150-4 issued by the NTEPA, under powers delegated of the Controller of Water Resources, pursuant to Section 74 of the *Water Act (NT) 1992*. The current licence was issued on 31 October 2014 and is valid for the period 1 November 2014 to 31 October 2016.

WDL150-04 identifies an impact zone from the outfall to 250 metres and a zone of influence from 250 to 500 metres from the East Point Outfall (Figure 3.1). The discharge licence WDL150-04 requires PWC to conduct water, sediment and biota monitoring at locations specified in the

licence (see Appendix A). Appendix A tables A1 to 4 reproduces the water quality monitoring, assessment and reporting criteria as listed in Appendix 1 of the licence. The WDL150-04 monitoring program is focused on the impact of the discharge within the impact zone (mixing zone) and the potential zone of influence as identified in the licence. Monitoring occurs in the discharge and at the two authorised discharge points; the East Point Outfall and the overflow drain discharging to Ludmilla Creek.

Discharge licence WDL150-4, authorises PWC to discharge wastewater via two 'Authorised Discharge Points'. The Authorised discharge points are SLUEP01 (East Point Outfall) and SLULCDP (the overflow weir discharge to Ludmilla Creek). Discharges via the overflow weir are only authorised in high inflow periods. The licence defines the high inflow periods as any inflow greater than 300 litres per second prior to the commissioning of the augmented EPRM and any inflow greater than 1000 litres per second after the commissioning of the augmented EPRM.

WDL150-04 identifies the monitoring locations as the overflow weir (SLULCDP=SLU080); this site reflects the effluent quality at the end of the treatment process, before it enters the East Point Rising main or the overflow drain to Ludmilla Creek.

Monitoring is also required at the East Point Outfall (SLUEP01) and two sites seaward of the outfall (SLUEP02 and SLUEP03) and three sites in Ludmilla Creek, SLULC01 upstream of the overflow drain, SLULC03 which is at the point where the overflow drain enters Ludmilla Creek and SLULC04 which is downstream of the discharge near the Ludmilla Creek mouth (see Table 3-1 below).

3.2.1 Water Quality Monitoring Sites

The monitoring points for the WDL150-04 and the WQMMP are described in Table 3-1.

Table 3-1 WDL150-4 and WQMMP Monitoring Site Details

Site	Location (Easting; Northing; MGA)	Description	Purpose
WDL150-04 Monitoring Program Sites			
SLU080 = SLULCDP	700500, 8624283	Re-carbonation chamber discharge point to East Point Rising main and overflow weir to Ludmilla Creek. Within the treatment plant	WDL 150-04 discharge site Monitors quality parameters of effluent discharged to the East Point Rising Main and effluent released to Ludmilla Creek
SLULC03	700518, 8626537	Ludmilla Creek at overflow drain entry point	Impact Zone of discharge to Ludmilla Creek
SLULC01	701036, 8626487	Ludmilla Creek upstream at Dick Ward Drive bridge	Monitors quality of water in Ludmilla Creek subject to impact from the discharge to Ludmilla Creek
SLULC04	699725, 8627164	Ludmilla Creek downstream Close to creek mouth	
SLUEP01	698109, 8628372	Existing East Point Outfall intertidal discharge point	Monitors quality parameters of effluent at the point of discharge to the marine environment

Table 3-1 WDL150-4 and WQMMP Monitoring Site Details (continued)

WDL and Darwin Harbour Receiving Waters (WQMMP) Monitoring Program Sites			
Level 1 Trigger Zone: Identify, Assess and Monitor			
SLUEP02	697875, 8628477	300 m WNW (seaward) of SLUEP01 (impact zone boundary)	WDL and WQMMP monitoring of harbour water quality down gradient from the point of discharge. Darwin Harbour Sites within the zone of influence.
SLUEP03	697643, 8628473	~500 m WNW (seaward) of SLUEP01 (zone of influence boundary)	
Level 2 Trigger Zone: Alert and Prepare			
SLUEP12 (Outfall Relocation Site 1)*	697590, 8628710	~650 metres NW of outfall (preferred outfall relocation site)	WQMMP East Point Marine Environment and baseline
SLUEP04	697250, 8628419	~900 m WNW (seaward) of outfall	WDL 150-04 and WQMMP monitoring.
Level 3 Triggers Zone: Act and Manage			
SLUEP05	697006, 8628291	~1100 metres W of outfall	WQMMP East Point marine environment: dispersion monitoring, reference at increasing distance from existing East Point Outfall WQMMP parameters at increasing distances from the outfall location (includes reference site SLUEP10). Site SLUEP11 is an unsuitable reference site due to catchment impacts
SLUEP06	696878, 8628546	~1250 metres WNW of outfall	
SLUEP07	696771, 8628731	~1350 metres WNW of outfall	
SLUEP08	697026, 8628914	~1250 metres WNW of outfall	
SLUEP09	696630, 8629285	~1750 metres WNW of outfall	
SLUEP10	696413, 8629458	~2000 metres NW of outfall	
SLUEP11	698413, 8630380	~2000 metres NNE of outfall	
Outfall Relocation Impact Study			
Site 1 (SLUEP12)*	697590, 8628710	~650 metres NW of outfall (preferred outfall relocation site)	Baseline impact assessment (profile) assessment
Site 5 (SLUEP13)	695260, 8629450	~3000 metres WNW of outfall (alternative relocations site)	
Site 7 (SLUEP14)	696893, 8628831	~1250 metres WNW of outfall (alternative relocations site)	
EPR1 (SLUEP15)	697258, 8626670	1800 and 2100 meters SSW of outfall. Darwin Harbour, East Point Reserve potential impacts on coral impacts	
EPR2 (SLUEP16)	697098, 8626525		
Site B3 (SLUEP17)	697102, 8628976	1200 metres NW of outfall Potential seagrass impacts	

* Directions indicated as a combination of N (North - 90°) W (West- 180°) S (South 270°) E (east – 0/360°) with intermediate directions indicated based on 360° position from East Point Outfall.

Note in Table 3.1:

- ❖ Grey highlighting indicates discharge site within the treatment plant
- ❖ Bright blue highlighting indicates impact zone sites (discharge to the environment).
- ❖ Light pink highlighting indicates Ludmilla Creek WDL150-04 sites
- ❖ Light blue highlighting indicates potential zone of influence sites (Level 1 Trigger).
- ❖ Light Green highlighting sites provide an alert of potential abnormal impacts (Level 2 Triggers)
- ❖ No highlighting indicate outer sites beyond the predicted zone of influence (Level 3 Triggers)
- ❖ Light yellow are relocation impact background sites, * Site SLUEP12 is also a WQMMP site.

The map in Figure 3-1 indicates the WDL150-04 identified impact zone (highlighted in bright blue) and a secondary potential zone of influence (highlighted light blue) where water quality has previously experienced low level impacts due to atypical discharge quality.

The WDL150-04 discharge (site SLU080/SLULCDP) and the East Point Outfall (SLUEP01) require daily monitoring of flow, fortnightly monitoring for pathogen indicators and monthly monitoring for water chemistry indicators. With the exception of dissolved oxygen, where results below 30% saturation require immediate reporting all other reporting is annual and based on discharge loads.

Within the zone of impact Table 3.1 (bright blue) and at the entry point of discharge drain into Ludmilla Creek (site SLULC03) analysis of risks to water quality are based on monthly interpretation of the data at the 90% species protection level, acknowledging that beneficial uses may not always be protected to the slightly to moderately impacted level (95% species protection).

The waste discharge licence requires that water quality in the outer (light blue) zone of influence meets the slightly to moderately impacted marine /estuarine water quality objectives of the Water Quality Objectives for the Darwin Harbour Region (NRETAS 2010) as specified in the licence.

Consistent methodology will apply across the compliance (WDL150-04) monitoring and the WQMMP monitoring the protocols for field safety, sample collection, sample analysis and data interpretation are included in Section 3.4 of this report. The potential zone of influence corresponds to the WQMMP Level 1 Trigger Zone (Identify, Assess and Monitor).

The WDL150-04 specifies site specific trigger values to demonstrate the protection of the declared beneficial uses. The licence recognises three distinct zones, the discharge, an impacted zone to approximately 250 metres from the outfall and a zone of influence to approximately 500 metres from the outfall (see figure 3.1). Sites outside the identified zones are required to meet all the 'slightly to moderately impacted' water quality objectives specified in the declaration of Beneficial Uses and Water Quality Objectives Northern Territory for the saline waters of Darwin Harbour (NTG 2010) and documented in the Darwin Harbour Water Quality Objectives Background Report (NRETAS 2010). The environmental objectives and guideline values are based on:

- 20th and 80th percentiles of reference data from good quality reference sites;
- toxicants in water ANZECC (2000) 95% species protection levels;
- toxicants in sediments ANZECC (2000) >90% individual species protected;
- biological median lies within 20th to 80th percentile of reference range.

3.2.2 Discharge Regime

Other than with respect to the volume of discharge from SLULCDP there are no specified conditions regarding the discharge regime, e.g. limiting discharge to a maximum flow rate, tide state, etc. however flows from SLUEP01 and SLULCDP are required to be recorded daily and reported annually.

In addition, discharges from Authorised Discharge point SLULCDP are only permitted when inflows to the Ludmilla WWTP exceed:

- 300 L/s until such time that the East Point rising main duplication is commissioned; and
- 1000 L/s at any time after commissioning of the East Point rising main duplication.

3.2.3 Qualitative Discharge Conditions

In accordance with Condition 14 of WDL150-04, wastewater discharged from the authorised discharge points SLUEPO1 (East Point Outfall, Darwin Harbour) and SLULCDP (overflow weir discharge to Ludmilla Creek) must not:

- contain any visible matter;
- cause or generate odours which would adversely affect the use of the surrounding waters;
- cause algal blooms;
- cause visible change in the behaviour of fish or other aquatic organisms;
- cause mortality of fish or other aquatic organisms; or
- cause adverse impacts on plants.

The field record sheet includes reporting provisions to record observations in relation to the qualitative discharge criteria (see Figure 3.5).

3.2.4 Site Specific Trigger Values

The site specific trigger values included in WDL150-04 are based on a comparison of the declared Water Quality Objectives for Darwin Harbour and, where no objective is declared, application of the toxicant triggers as listed in ANZECC 2000. The Darwin Harbour objectives have been developed based on water quality monitoring programs in Darwin Harbour over a number of years. In developing site specific trigger values to apply to the discharge the immediate zone of influence which was defined based on a water quality monitoring data set from January 2012 and October 2014. The data assessment indicated that in Darwin Harbour the zone of impact or mixing zone is identified as extending from the outfall (SLUEP01) to approximately 250 metres, before Site SLUEP02, the zone was confirmed based on an assessment of impact on biotic assemblages present in the benthic in-fauna.

A possible secondary zone of influence extending from 250 metres to approximately 500 metres from the outfall (Sites SLUEP02 and SLUEP03), this zone demonstrated some change from reference conditions however it was unclear whether this difference was caused by the discharge from the EPO or due to differences between inter and sub tidal sites. Table 3.2 outlines the site specific trigger values that apply to the WDL compliance monitoring program at the discharge, within the zone of influence and beyond the boundary of the zone of influence. Outside the zone of influence water quality is required to meet the Darwin Harbour Water Quality Objectives (NRETAS 2010, NTG 2010) and the ANZECC (2000) trigger values at the 95 percent species protection level or the water quality criteria for a 'slightly to moderately disturbed' ecosystem.

Table 3-2 (below) contains the site specific trigger values applying for water quality within the discharge impact zone and in the 'slightly to moderately disturbed' aquatic ecosystem zone as required for compliance with the monitoring program as specified in Appendix 1 of WDL150-04.

Table 3-2 WDL150-04 Water Monitoring Parameters and Trigger Values

Parameter	Unit	LWWTP Discharge and Zone of Impact sites (ZOI) – Highly disturbed	Slightly to Moderately Disturbed Aquatic Ecosystem Sites
		SLU080 (= SLULCDP), SLUEP01, SLULC03	SLULC01, SLULC04, SLUEP02*(L1 trigger), SLUEP03*(L2 trigger),
Daily flow	kL/day	SLU080 / SLULCDP / SLUEP01 only	not relevant
pH	units	<7.0 or >8.5	<7.0 or >8.5
Electrical Conductivity (EC)	µS/cm	No trigger	No trigger
Dissolved Oxygen (DO) ¹	% sat	<50 or >110	<80 or >110
Temperature	°C	No trigger	No trigger
Total Suspended Solids (TSS)	mg/L	>10	>6 (SLUEP02 and 3) >10 (SLULC01 and 04)
Biochemical Oxygen Demand (BOD ₅)	mg/L	>5	>5
Chlorophyll-a ¹ (Chl-a)	µg/L	>2 >4	>2 (SLUEP02 and 3) >4 (SLULC01 and 04)
Ammonia ² (NH ₃ -N) toxicant trigger (pH corrected)	µg/L	pH adjusted toxicant trigger based on 80 th ile	>20 stressor > pH adjusted toxicant trigger based on 95 th ile
Total nitrogen ² (TN)	µg/L	>300 annual load	>300
Oxides of nitrogen ¹ (NOX)	µg/L	>20 annual load	>20
Total phosphorus ² (TP)	µg/L	>20 annual load	>20 (Harbour - SLUEP02 and 03) >30 (SLULC01 to SLULC04)
Filterable reactive phosphorus ² (FRP)	µg/L	>5 (Harbour - SLUEP02 and 03) >10 (Creek - SLULC01 and 04)	>5 (Harbour - SLUEP02 and 03) >10 (Creek - SLULC01 and 04)
³ Copper (total and dissolved)	µg/L	1.3	1.3
³ Zinc (total and dissolved)	µg/L	15	15
³ Mercury (total and dissolved)	µg/L	≤0.4	≤0.4
<i>E. coli</i>	cfu/100 mL	>50	>14 (median) >43 (90 th percentile)
Enterococci	cfu/100 mL	>200	>50
Endocrine disrupting chemicals	ng/L	No trigger	No trigger

* Assessed as both compliance and WQMMP site

¹ Primary indicator

² Non-compliance only if both the primary indicator objective¹ and site specific trigger are exceeded.

³ Trigger is for dissolved metals however assessment is made for both the total and dissolved metal.



Figure 3-1 WDL150-04 Compliance Monitoring Sites

3.3 Objectives of the Water Quality Monitoring and Management Plan

Two separate, but linked programs will be implemented to monitoring the impact of the discharge from the Ludmilla WwTP. The first is the discharge licence compliance monitoring program which focuses on the discharge, the immediate zone of impact (250 metres from the outfall) and influence (500 metres from the outfall). This program covers both Darwin Harbour at East Point and Ludmilla Creek. The second program is focused on the Darwin Harbour receiving waters beyond the compliance zone identified in the waste discharge licence. It is the Darwin Harbour receiving water monitoring program that forms the basis of the proposed Water Quality Monitoring and Management Plan (WQMMP). The WQMMP objectives are to:

- Provide data on the condition of the marine environment in the vicinity of the existing EPO beyond the identified impact (mixing) zone;
- Provide baseline data for the proposed EPO relocations sites;
- Confirm, by monitoring, the predictions made in the EPRM PER as to the distribution and concentration of toxicants and other substances discharged from the East Point Outfall;
- Confirm the predictions made in the PER in relation to the risks posed to sensitive species;
- Inform management decisions in the event that predicted impacts are exceeded; and
- Enable ongoing assessment of water quality at the current EPO location following the augmentation of the rising main and prior to the relocation of the EPO.

3.4 PWC Darwin Harbour Water Quality Monitoring Program

3.4.1 Background

PWC is committed to the ongoing implementation of the Darwin Harbour monitoring as described in the WQMMP until such time as the existing outfall becomes non-operational.

The WQMMP is an extension of PWC's existing comprehensive Darwin Harbour monitoring program that has been ongoing since February 2011. The program aims to improve PWC's understanding of the concentration of substances found in the wastewater discharge and the dispersion of those substances in the receiving waters.

The data has been used in the validation of the hydrodynamic model for the receiving waters and to provide input into the site selection process for the outfall relocation and pre-construction information for use in assessing the improvement in water quality that is predicted following relocation of the outfall.

The Darwin Harbour receiving water monitoring that forms the basis of the WQMMP is conducted concurrently with the compliance monitoring program specified in WDL150-04. The receiving waters monitoring is not a licence requirement however this monitoring of water quality beyond the impact zone provides context as to both the impacts of the discharge and the harbour's background water quality beyond the influence of the LWwTP discharge.

The physico-chemical, nutrient and toxicant monitoring program set out in this document are base the basis of the WQMMP. The WQMMP contains an assessment of water quality data at sites all sites from SLUEP01 to SLUEP12 (the preferred outfall location).

The low concentrations of many pollutants in the effluent stream (SLu080) and at the outfall (SLUEP01), coupled with the relatively high rates of dispersion in Darwin Harbour, results in the

LWwTP effluent (Site SLU080) providing the most reliable indication of the presence of pollutants of concern in the discharge. Data from the compliance monitoring program will be used to inform decisions in relation to the WQMMP and the two programs will be conducted concurrently.

The water quality data for the discharge will also inform the sediment and biota components to identify hazardous chemicals that may accumulate in sediments or in sensitive species.

The use of dispersion modelling in combination with the outlet data can then be used to predict concentrations of low level contaminants in the Darwin Harbour receiving environment and to identify potential target sites for accumulation of contaminants.

3.4.2 PWC Darwin Harbour Monitoring Sites

In addition to the sites described in the WDL 150-04 compliance monitoring program PWC also undertakes monthly monitoring of water quality at 12 sites in Darwin Harbour in the East Point area; all sites are listed in Table 3-1, a further 5 sites are assessed as a vertical profile to investigate potential impacts associated with relocation of the East Point Outfall. The WQMMP will ensure a more thorough focus on assessing water quality beyond the compliance zone listed in WDL150-04.

The receiving environment monitoring program commenced in 2011 and was designed to obtain data on the effect of the wastewater discharge on the marine environment in the vicinity of the East Point Outfall, including the sensitive environments within the East Point Aquatic Life Reserve which lies to the south and west of the outlet. The ten locations selected by PWC for monitoring are in the vicinity of the EPO (Figures 2-1 and 3-1) and were chosen on the basis of proximity to the existing outfall, knowledge of the plume dynamics and dilution and to provide information on water quality at sites under consideration for the outfall relocation. The sites are used to assess the impact of the discharge on the East Point Aquatic Life Reserve (boundary shown as a blue semi-circle on Figure 3-1). One distant site (SLUEP11), to the north of the EPO has been used as a potential reference water quality site.

In 2012 a further six water quality (impact) monitoring sites were added to the 2011 program. These were, the three sites identified as potential outfall relocation sites (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 ephemeral seagrasses communities (B3) and which may represent locally significant habitats (Table 3-1 and Figure 3-2). These additional sites were established so as to provide early warning of impacts on sensitive habitat and the coordinates were determined during the initial PER assessment survey.

The WQMMP receiving water monitoring sites SLUEP01 to SLUEP12 will be monitored monthly for water quality parameters listed in Table 3-2. Water quality will be assessed using a multi-parameter probe to record: temperature, conductivity, dissolved oxygen, pH, salinity and turbidity. Water samples will be collected for laboratory analysis for total suspended solids (TSS); biological oxygen demand (BOD5); Chlorophyll-a; nutrients (total ammonia-N, total nitrogen, oxides of nitrogen, total phosphorus, filterable reactive phosphorus); total and dissolved metals and metalloids (copper, zinc, nickel, lead, cadmium, chromium, mercury and arsenic); and pathogen indicators *E. coli* and enterococci.

Of these parameters only the pathogen, nutrients (TN, NH3-N and TP) and the metals copper and zinc have been identified as posing a risk beyond the immediate discharge point. It should be noted that the outfall (SLUEP01) and the Darwin Harbour receiving water sites SLUEP02 and SLUEP03 are also WDL150-04 compliance monitoring sites and they will be reported within both programs.

Receiving water (impact) monitoring sites SLuEP12 to SLuEP17 are to be sampled monthly at three depths (surface, middle and bottom) using a multi-parameter probe to record temperature, conductivity, dissolved oxygen percent saturation, pH, salinity and turbidity and water samples are collected for the measurement of TSS. The baseline data collected over the different depths will inform impact assessments on subsurface water quality for the relocated outfall.

3.4.3 WQMMP Water Quality Monitoring Sites

PWC has identified Site 1 (SLUEP12) as the preferred site for the proposed outfall relocation. Until the environmental approval is granted in response to the Environmental Impact Statement for the outfall relocation (in preparation) the full suite of receiving water and impact monitoring sites will be maintained.

The WQMMP sites will be assessed monthly for exceedance of the relevant Site Specific Trigger Values (WDL150-04) (detailed in Appendix B), the Darwin Harbour Water Quality Objectives (NRETAS 2010) and Guidelines for Fresh and Marine Water Quality Guideline trigger values (ANZECC 2000).

Where Darwin Harbour Water Quality Objectives (NRETAS 2010) or ANZECC toxicant trigger values (ANZECC 2000) are exceeded an assessment of causal factors responsible for the exceedance will be undertaken; and depending on the outcome of the assessment, appropriate contingency measures and corrective actions will be implemented.

The most appropriate corrective actions may vary with the nature of the exceedance, however potential corrective actions may include:

- optimising chlorine dosing to reduce pathogen levels in the discharge;
- increasing contact time within the sedimentation tanks to increase pathogen kill levels;
- or
- optimising the pH, ferric or polymer dosing to improve sedimentation to reduce suspended solids or particulate associated contaminants such as metals in the discharge.

In the event of serious impacts becoming apparent within the Darwin Harbour in the monitoring area, the need to discharge to Ludmilla Creek via the overflow weir will be considered. This management option would only be considered in exceptional circumstances and would only occur following and assessment of the relative risks of the two discharge options conducted in consultation with both the Commonwealth Department of the Environment, the NT EPA and other relevant stakeholders.

Reporting of exceedances to the will be undertaken in accordance with the reporting protocol in Section 3.4.11. The level of response triggered is described in greater detail in section 3.4.10. The monitoring sites and specific program linkages are described in Table 3-1 which covers sampling sites for the compliance (WDL150-04) and the WQMMP monitoring programs.

Monitoring sites will be reviewed annually and recommendations for variations to the program included in the Annual Monitoring Report.

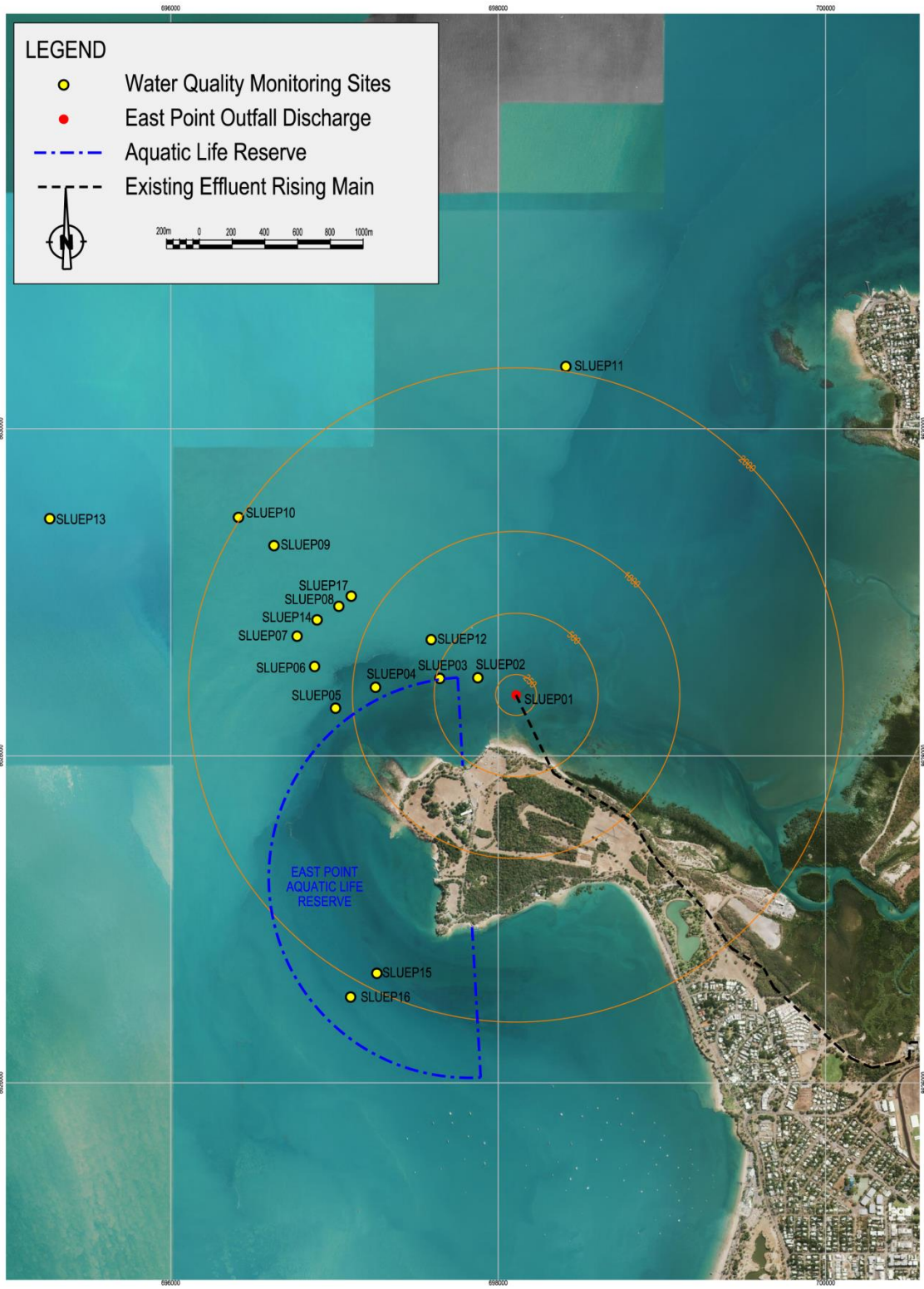


Figure 3-2 PWC Receiving Water Environmental Monitoring Sites

3.4.4 Environmental Monitoring Parameters and Sampling Frequency

The WQMMP uses the Darwin Harbour receiving waters environmental monitoring sites listed in Table 3-4. Two of the WQMMP sites SLUEP02 and SLUEP 03 are also included in the WDL150-04 water quality compliance monitoring programs. All WQMMP sites (Table 3-1) are to be analysed for the parameters listed, at the frequency specified and using the sample collection methods specified in Table 3-3. Sites SLUEP12 to SLUEP17 are designed to provide a baseline against which to identify early signs of environmental impacts resulting from the relocation of the East Point Outfall, the collection of field test data for these sites will provide for a more responsive identification of potential impacts and the collection of samples at different depths will assist with identifying any sub-surface impacts.

The compliance monitoring program for WDL150-04 (SLULCDP/SLU080; SLUEP01 and Ludmilla Creek sites SLULC01; SLULC03 and SLULC04) will be conducted concurrent with the WQMMP program to allow for direct comparison in the event of exceedance of trigger values.

In addition to the water quality samples the following observations will be recorded for 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;
- the presence of algal blooms in the area;
- any objectionable discolouration, or visible oil, grease, foam, scum or litter at the surface;
- the presence of dead fish or other marine organisms in the vicinity of the outfall;
- the presence of sensitive species (turtles, dugong or dolphins) in the area.
- any evidence of behavioural changes in aquatic animal species; and
- any evidence of a decline in important plant species (e.g. seagrass, mangroves).

The WDL150-04 compliance monitoring program is subject to change with each new licence (2 years) and will therefore vary on a different frequency to the WQMMP. The compliance monitoring included in the WDL150-04 is focused on the effluent discharged; the immediate impact zone (250 metre); and the zone of influence (500 metre) from the East Point Outfall. This monitoring is specified for sites SLU080/SLULCDP, SLUEP01, SLUEP02 and SLUEP03, and for three sites in Ludmilla Creek.

The WQMMP Darwin Harbour receiving water monitoring program contains all the monitoring required by the compliance program and includes additional sites and parameters, consequently any change in the WDL150-04 compliance monitoring program will not impact on the delivery of the WQMMP.

Should the WQMMP detect exceedances of trigger levels in the Darwin Harbour receiving waters the WDL compliance monitoring program will provide one important source of evidence to determine the source of the exceedance.

Table 3-2 WQMMP Site Water Quality Monitoring Program

Parameter	Units	Sample Type	Sampling Frequency
Monitoring Sites: SLUEP02 ¹ ; SLUEP03 ¹ ; SLUEP04; SLUEP05; SLUEP06; SLUEP07; SLUEP08; SLUEP09; SLUEP10 ³ ; SLUEP11; SLUEP12 ²			
pH	pH units	Field test (on site)	Monthly
Temperature (T)	°C	Field test (on site)	Monthly
Electrical Conductivity (EC)	µS/cm	Field test (on site)	Monthly
Dissolved Oxygen (DO)	% saturation	Field test (on site)	Monthly
Turbidity	NTU	Field test (on site)	Monthly
Total Suspended Solids (TSS)	mg/L	Surface water sample	Monthly
Biochemical Oxygen Demand (BOD)	mg/L	Surface water sample	Monthly
Total Nitrogen (TN)	µg/L	Surface water sample	Monthly
Ammonia – (total NH ₃ -N)	µg/L	Surface water sample	Monthly
Nitrogen Oxides (NO _x)	µg/L	Surface water sample	Monthly
Total Phosphorus (TP)	µg/L	Surface water sample	Monthly
Filterable Reactive Phosphorus (FRP)	µg/L	Surface water sample	Monthly
<i>E. coli</i>	cfu/100 mL	Surface water sample	Monthly
Enterococci	cfu/100 mL	Surface water sample	Monthly
Chlorophyll-a (<i>Chl-a</i>)	µg/L	Surface water sample	Monthly
Multi element ICPMS (metals and metalloids) Total and dissolved (As, Cd, Cr, Cu, Hg, Ni, Pb, and Zn);	µg/L	Surface water sample	Monthly
*Relocation Impact monitoring sites: SLUEP12 ² ; SLUEP13; SLUEP14; SLUEP15; SLUEP16 ;SLUEP17			
Vertical profile using YSI probe TSS, DO, EC, Turbidity , pH, Temperature	mg/L % saturation µS/cm NTU pH units °C	3 water depth sample Field test (on site) Field test (on site) Field test (on site) Field test (on site) Field test (on site)	Monthly (surface, mid and bottom)

¹ Compliance and WQMMP site;

² WQMMP and relocation impact site, sampled twice per month once for each program;

³ Recommended site specific water quality reference site;

*Sample collection for the relocation impact assessment is on neap tide but not concurrent with WQMMP.

As required by Condition 13 (d) of the Environmental Approval EPBC 2009/5113, the WQMMP program is focused in the Darwin Harbour receiving waters and will continue until the East Point Outfall is relocated or is no longer operational.

Changes to the WQMMP will only occur following consideration of monitoring data collected for a period of no less than two years following any significant operational change to treatment or discharge practices. Any amendments to the WQMMP will be made in consultation with the Independent Technical Reviewer and the amended WQMMP will only be implemented once the amendment has been approved.

3.4.5 Sampling Methodology

Water samples from sites SLUEP01 to SLUEP12 will be collected on the NEAP tide from immediately below the water surface in >0.5 m water column depth with sampling commencing in the intertidal waters at high tide to allow for maximum water depth and safe access. WDL150-04 compliance samples from the treatment plant (SLU080/SLULCDP) and for Ludmilla Creek are to be collected on the same day and as close as practicable to the same time to minimise variables that may confound decisions relating to the source of any exceedance of triggers.

Separate laboratory prepared sample containers will be required for metal, nutrient and bacterial samples. Field measurements are to be conducted using field instrumentation calibrated in accordance with protocols in accordance with the relevant Australian Standard and calibration records must be kept for all instruments used for the collection of field data.

Samples from all other sites (i.e. the current PWC monitoring sites including site SLUEP01) will be collected from immediately below the surface into laboratory prepared sample containers attached to purpose built sampling poles designed to minimise contamination during sample collection and to reduce the need to lean overboard to collect samples.

All samples will be collected in accordance with Australian and New Zealand Standards series AS/NZS 5667 and the Australian Guidelines for Water Quality Monitoring and Reporting (ANZECC 2000).

Samples will be analysed at a laboratory(s) with NATA accreditation and at the relevant limits of detection for marine environmental water samples. Copies of all field and laboratory reports will be retained and stored in PWC's electronic records database (TRIM) and water quality data will be stored in the PWC water quality database. Records of all quality assurance and quality control results must be also provided with the analysis reports for each batch of samples submitted.

3.4.6 Monitoring Frequency

All WQMMP water quality sites will be sampled monthly on the high neap tide and sampling for the WDL (compliance) and WQMMP monitoring will be conducted concurrently. Monitoring of 'Potential Impact' sites (the vertical profile monitoring) will be conducted at a time as close as possible to the WQMMP and in any case by the next available neap tide. The primary consideration in scheduling monitoring events will be to ensure that the compliance and WQMMP monitoring are conducted in accordance with the monthly schedule. Regular monitoring programs in Darwin Harbour require balancing the tidal range and climatic conditions while endeavouring to achieve a regular regime for sample collection and delivery to interstate laboratories.

The WQMMP design and implementation includes consideration of the logistics of sample collection at the appropriate point of the tidal cycle; aligning with air transport services to enable delivery of samples to NATA accredited laboratories (interstate); ensuring samples are received within the timeframes required for sample analysis; and that samples are maintained within the appropriate temperature range.

The climatic and tidal conditions that occur in the tropics and are experienced in Darwin Harbour do, at times make field sampling from a boat in the marine environment unsafe. In these circumstances, while all things reasonable and practicable will be done to ensure delivery of the regular monitoring program, the primary consideration must remain the safety of field personnel. In these circumstances the monitoring will be rescheduled to the next available NEAP tide. The preference will be to conduct the WDL and WQMMP monitoring over the collection of the depth profile impact samples.

3.4.7 Field Safety Considerations

No field monitoring program is entirely without safety risks however marine sampling programs in the wet dry tropical environment of Darwin Harbour water quality sampling from a boat includes a number of safety factors that must be included in the job safety analysis and field sampling and safety protocol that is required for each monitoring program.

As a minimum the safety protocol must include consideration of the tidal regime on safe sampling procedures and on sample integrity.

- The procedure must include consideration of safe working procedures in tropical conditions in addition to maintaining sample integrity while also ensuring staff safety.
- Safe boat handling procedures and training and documentation of training in both field safety and in field sampling procedures.
- Field safety procedures must also include protocols for collection of samples in an environment that includes saltwater crocodiles, sea snakes and a range of venomous creatures.

A full job safety analysis is required for all PWC monitoring programs and must contain specific details relating to each site including information relating to the specific conditions predicted for the day of sampling and a site by site analysis of potential hazards and control measures to minimize the likelihood of risk.

An example of a suitable field sampling checklist, including key safety requirement is attached as Figure 3.3.

Site Notes and Sampling Check lists

PWC_DHSWMP_AA

All Sampling personnel are required to be trained in Standard Operating Procedure for Darwin Harbour Surface Water Monitoring Programme (PWD01802-12) Rev AA prior to commencing work.

Sampling Location and Details:

Staff Performing Sampling (and contact numbers)

Date:	Start Time:	High Tide:	Samples at Toll by (time):	Finish Time:	Con Note No:

Checklist:

Comms? <input type="checkbox"/> Entering <input type="checkbox"/> Leaving PWC site	Completed and signed JSEA? <input type="checkbox"/>	QAQC samples collected/recorded? <input type="checkbox"/>
Completed sampling checklist prior to departure <input type="checkbox"/>	Called PWC project officer? <input type="checkbox"/> Entering water at boat ramp; <input type="checkbox"/> Exiting water at boat ramp	Probe/Meter: _____ Calibrated? <input type="checkbox"/> Date of Calibration: _____

Weather and General Observations:

QA/QC Samples

Sent to AWQC (routine):

Sent to QHFSS (EDCs):

Duplicate #1	Site taken:	Site taken:
Duplicate #2	Site taken:	Site taken:
Duplicate #3	Site taken:	Site taken:
Duplicate #4	Site taken:	Site taken:

Signature:		
All samples taken	Yes <input type="checkbox"/>	No <input type="checkbox"/>
If samples are not taken, list reasons/comments why they have not been taken. Otherwise N/A.		
Any exceedance of qualitative discharge limits.	Yes <input type="checkbox"/>	No <input type="checkbox"/>
If exceedance, list sites here.		

Confirm the following has been loaded prior to departure

Keys to restricted area, labelled sample bottles, eskies with ice bricks, water 3L per person, sample pole, filter kit, camera, TWS mobile, Calibrated quanta with guard cap, 02 black pens and 02 permanent markers, hat, factor 50 sunscreen, repellent spray, turbidity meter, waste bag, container, gloves and antibacterial hand wash, spare batteries, all field paperwork, sample bottles prep. **Yes**

Confirm the following has been completed and or is available post trip

AWQC address labels and large laminated labels, bubblewrap, instrument post calibration, sample submission forms, con notes, chain of custody, sites notes, field sheets copy is given to PWC and TWS to archive. **Yes**

Contact Numbers:

Water Operations (business hours) Vicki Robertson: 89857169
 Additional PWC Contact: Dianne Rose 044797 4010 or 899 55837
 Toll Priority Darwin 8920 0100 Toll priority Jemma Barber – 0412 259 502
 AWQC Office Hours Scott Kraft 08 7424 1250
 AWQC AccMan Outside of hour’s emergency work - 0417863575

PWC Project Officer: Karen Kennedy 0412528521 Or 89857100
 System Control Hudson Creek (24 hrs): [89477015]
 Toll priority John Schier – 0418 819 359
 AWQC Office Hours Vanessa Loveader 08 7424 2093

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Figure 3-3 Example Field Sampling Checklist

3.4.8 Sample Information to be Recorded


For each sample required to be collected, PWC will record and retain 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 name of the person who collected the sample
- the chain of custody form relating to the sample
- the field measurements and/or analytical results for the sample; and
- laboratory QA/QC documentation.

Field Instrument Calibration

Field instrumentation is used to overcome problems associated with the time taken between collection of a sample in the field and analysis in the laboratory. To ensure reliable results it is important that equipment is calibrated and that complete records of the calibration of each instrument are maintained. Figure 3.5 provides an indication of the information required to be collected and maintained for each instrument.

Calibration Sheet



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 Email: admin@tropwater.com.au
 ABN 86 086 853 287

Equipment Type and #	Quanta QT06025		
DATE CALIBRATED	7/09/2015		
DATE POST CAL	11/09/2015		
FIELD SITE	PWC/CDU Aquatic Foods Study		
Battery Voltage	4.4v		
Barometric Pressure (Pre Cal)	1016.4hPa		
Barometric Pressure (Post Cal)	1017.9hPa		

Parameter	Pre-field calibration				Post-field calibration		
	Known Value	Reading Pre-Cal	Reading Post-Cal	Error	Known Value	Reading	Error
Temperature (°C)	31.40	31.38	N/A	0.02	31.5	31.5	0.0
pH 7.0	7.00	7.26	7.00	.26	7.00	7.04	.04
pH 4.0 or 10.0	4.00	4.15	4.00	.15	4.00	4.01	.01
EC Zero - Air (µS/cm ²⁵)	0	0	0	0	0	0	0
EC Standard (µS/cm ²⁵)	58000	57300	58000	700	58000	57000	1000
LDO (%Sat) in Air	100.0	96.0	100.0	4.0	100.0	99.8	.2
Depth (m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Notes/Comments: Pre-calibration indicates all sensors are operating as required.
 Post-calibration records indicate all sensors are functioning within manufacturer’s specifications.
 Calibrations undertaken by Shane Kavanagh TWS.

Figure 3- 4 Examples of Suitable Pre and Post Calibration Checklist for Field Instruments

Field Sampling Record Sheet

In addition to observations in relation to the environmental conditions at the time of conducting the sampling program it is important that a consistent record of factors including the quantitative environmental observations are recorded and maintained. The licence requires that the discharge does not result in a number of environmental impacts. Information in relation to visible matter including litter, debris oil or surface scums, algal blooms, fish kills, visible changes in fish behaviour, visible changes in plants (e.g. seagrass and mangroves) or odours that may indicate and environmental impact associated with the discharge are recorded for each sampling location. An example of a suitable site notes template is included as Figure 3-5.

Site Notes and Sampling Check lists TWS_DHSWMP_AA

All Tropical Water Solutions personnel are required to be trained in Standard Operating Procedure for Darwin Harbour Surface Water Monitoring Programme (PWD01802-12) Rev AA prior to commencing work.

Sampling Location and Details:

TWS Staff Performing Sampling (and contact numbers)

Date: Start Time: High Tide Time: Samples at Toll Con Note No:

Checklist:

Comms? <input type="checkbox"/> Entering <input type="checkbox"/> Leaving PWC site	Completed and signed JSEA? <input type="checkbox"/>	QAQC samples collected/recorded? <input type="checkbox"/>
Completed sampling checklist prior to departure <input type="checkbox"/>	Called PWC project officer? <input type="checkbox"/> Entering water at boat ramp; <input type="checkbox"/> Exiting water at boat ramp	Probe/Meter: Calibrated? <input type="checkbox"/> Date of Calibration:

Weather and General Observations:

QA/QC Samples	Sent to AWQC (routine):	Sent to QHFSS (EDCs):
Duplicate #1	Site taken:	Site taken:
Duplicate #2	Site taken:	Site taken:
Duplicate #3	Site taken:	Site taken:
Duplicate #4	Site taken:	Site taken:

Qualitative Discharge Limits	Site Code Yes/No?	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N
Presence of visible matter, oil & grease or petroleum hydrocarbon sheen or scum or litter or other objectionable matter																					
Odours that affect surrounding use?																					
Algal blooms?																					
Change in behaviour of fish or other aquatic organisms?																					
Mortality of fish or other aquatic organisms?																					
Adverse impacts on plants?																					

Please provide additional details regarding each 'Yes' above (describe for each site and record using digital photos)

Site:	Details:	Photos:

Signature:

Figure 3-6 PWC Field Sampling Event Report

For each site a record of field conditions and field observations data is to be prepared and stored in the PWC electronic documents record system (TRIM) to enable a review of the sampling event to be conducted or the program to be audited and to identify issues that may be reflected in the water quality analysis data.

Chain of Custody Record for Sample Submission

A record of submission of samples from the field to the laboratory must be maintained to track progress and to identify where including submission outside of relevant holding times may occur. The chain of custody record is stored in the PWC electronic file management system and provides a signed record of collection and submission of samples. An example of an appropriate chain of custody record is shown below as Figure 3-6.



CHAIN OF CUSTODY
Water Resources Group

ABN: 94 105 060 320
Page.....of.....

Melbourne Office:
22 Dalmore Drive
Scoresby VIC 3179
Phone: 03 8756 8000
Fax: 03 9763 1862

Canberra Office:
16B Lithgow St
Fyshwick ACT 2609
Phone: 02 6202 5431
Fax: 02 6202 5452

Bendigo Office:
Gate 6 Sharon St
La Trobe University,
Bendigo VIC 3650
Phone: 03 8441 0700
Fax: 03 5444 5208

Geelong Office:
49 Carr St
Geelong VIC 3220
Phone: 03 5226 5249
Fax: 03 5229 0242

Wangaratta Office:
48 Faithful St
Wangaratta VIC 3676
Phone: 03 5722 2688
Fax: 03 5722 4727
Mobile: 0419 007 749

Traralgon Office
4/55 Hazelwood Rd
PO Box 1469
Traralgon VIC 3844
Phone: 03 5176 4170
Fax: 03 5176 4473

Client: Power and Water Corporation: Water Services Ben Hammond						<i>Office use only</i>											
Contact:						Lab Work Order No:											
Address:						LIMS Program Code:											
Phone:						Fax:			TESTS REQUIRED								
Email:																	
P/O No.:			Quote No.:														
T/A Time:			Sampler:														
Job/Proj Ref: Shellfish and marine water survey																	
Special Instructions:																	
Relinquished By:						Received By:			Company:			Date:			Time:		
<small>This form is for recording of sample data after prior consultation with an analyst regarding sampling procedures and does not over-ride pricing agreements, OHS requirements and our terms and conditions.</small>						<small>LAB USE ONLY</small>			<small>Sample conditions:</small>			<small>Samples received undamaged [Yes/No]</small>			<small>Samples adequately preserved [Yes/No]</small>		
<small>As an Occupational Health and Safety consideration, it is a requirement of ALS Water Resources Group that all samples received be undamaged and prior advice given in writing of any potential health risks.</small>									<small>Samples within recommended holding times [Yes/No]</small>			<small>Samples transported at appropriate temperature [Yes/No]</small>					

Figure 3-6 Example of Chain of Custody Sample Submission Form to be used

3.4.9 Data Assessment Methodology

As a minimum all water, sediment and biota quality data for all field and laboratory results, including duplicates and any quality assurance and quality control data will be compiled into a database and presented in data tables and control charts. Statistical assessment will use Hazen methodology for pathogen indicators in recreational waters and excel for other water quality parameters.

Data reports will be prepared following each survey which;

- Describes the methods used
- Provides a metastable containing the dates, sites and notes any changes in the position of the sample sites;
- Presents a table of summary water quality data and statistics for the current survey;
- Assesses outcomes against management triggers and identifies the zone of impact; and
- Where relevant recommends modifications to program design that will improve detection of effects.

3.4.10 Assessment Decision Criteria

The WDL150-04 compliance monitoring program includes assessment against site specific trigger values relevant to the protection of the declared Beneficial Uses. The relevant Beneficial Uses are declared under provisions of the *Water Act (NT) 1992* in Government Gazette G27, 7 July 2010 (NTG 2010).

The Beneficial Uses are the protecting of water quality for cultural, environmental and aquaculture uses. The trigger values specified in WDL 150-4 are included in Table 3-5 and Appendix B.

The WQMMP applies specifically to water quality from the boundary of the identified impact zone (SLUEP02) as identified in the WDL and decision criteria relate to protection of the Beneficial Use of environment. The relevant water quality criteria are those declared water quality objectives gazetted in the NTG 2010 and described in NRETAS 2010.

The treatment plant effluent discharge point (SLULCDP/SLU080); the East Point outfall (SLUEP01) and the Ludmilla Creek samples (SLULC01, SLULC03 and SLULC04) are to be used in assessing the source of any exceedance of trigger values.

Table 3-4 WDL150-4 and WQMMP Water Monitoring Parameters and Trigger Values

Parameter	Unit	Slightly to Moderately Disturbed Aquatic Ecosystem Sites
SLUEP02, SLUEP03; SLUEP04, SLUEP05, SLUEP06, SLUEP07; SLUEP08; SLUEP09; SLUEP10; SLUEP11; SLUEP12		
Daily flow (SLU080 and SLUEP01)	kL/day	relevant only to discharge
Physico-Chemical Indicators		
pH	units	≥ 7.0 or ≤ 8.5
Electrical Conductivity (EC)	$\mu\text{S}/\text{cm}$	Marine/ estuarine system no trigger
Dissolved Oxygen (DO)	% sat	≥ 80 or ≤ 110
Temperature	$^{\circ}\text{C}$	No trigger
Total Suspended Solids (TSS)	mg/L	≤ 6
Biochemical Oxygen Demand (BOD ₅)	mg/L	≤ 5
Nutrient Indicators		
Chlorophyll-a* (primary indicator)	$\mu\text{g}/\text{L}$	≤ 2
Ammonia (total NH ₃ -N) as a toxicant	$\mu\text{g}/\text{L}$	≤ 910 (toxicant 95 th ile)
Ammonia ¹ (total NH ₃ -N) as a nutrient	$\mu\text{g}/\text{L}$	≤ 20
Total nitrogen ¹ (TN)	$\mu\text{g}/\text{L}$	≤ 270
Oxides of nitrogen ¹ (NOX)	$\mu\text{g}/\text{L}$	≤ 20
Total phosphorus ¹ (TP)	$\mu\text{g}/\text{L}$	≤ 20
Filterable reactive phosphorus ¹ (FRP)	$\mu\text{g}/\text{L}$	≤ 5
Metals and Metalloids Indicators²		
Arsenic	$\mu\text{g}/\text{L}$	≤ 2.3 ANZECC 95 th ile (low reliability trigger)
Cadmium	$\mu\text{g}/\text{L}$	≤ 5.5 ANZECC 95 th ile
Copper (total and dissolved)	$\mu\text{g}/\text{L}$	≤ 1.3 ANZECC 95 th ile
Chromium	$\mu\text{g}/\text{L}$	≤ 4.4 ANZECC 95 th ile
Lead	$\mu\text{g}/\text{L}$	≤ 4.4 ANZECC 95 th ile
Mercury (total and dissolved)	$\mu\text{g}/\text{L}$	≤ 0.4 ANZECC 95 th ile
Nickel	$\mu\text{g}/\text{L}$	≤ 70 ANZECC 95 th ile
Zinc (total and dissolved)	$\mu\text{g}/\text{L}$	≤ 15 ANZECC 95 th ile
Pathogen Indicators		
<i>E. coli</i>	cfu/100 mL	≤ 14 (median) ≤ 43 (90 th percentile)
Enterococci	cfu/100 mL	≤ 40 (NHMRC 95 th percentile recreational Category A)

¹ Non-compliance for nutrient stressor only considered as exceedance if primary objective* (chlorophyll-a) is exceeded and site specific trigger (SSTV) based on Darwin Harbour Water Quality Objective is also exceeded.

² Non-compliance with ANZECC low reliability triggers must be assessed against background water quality data relevant to the East Point region of Darwin Harbour as local water quality.

WQMMP decision criteria

Darwin Harbour, as a working harbour adjacent to a city is recognised as being 'slightly to moderately impacted'; in that change from reference conditions are evident however significant ecological values remain intact. The SSTV values specified in WDL 150-04 are for the slightly to moderately impacted zone (SMIZ) are the water quality objectives for Darwin Harbour (NRETAS 2010), where no objective is specified the relevant ANZECC 2000 or the Recreational Water Quality Guideline (NHMRC 2008) criteria apply. If the water quality objectives are exceeded beyond the impact zone of influence (site SLUEP01 to 250 metres from EPO) the following decision and reporting criteria apply for monitoring sites SLUEP02 to SLUEP12.

To account for natural variation in water quality resulting from natural environmental factors and seasonal variability, where site specific trigger values are exceeded, water quality will be assessed against seasonally appropriate data for the same site and assessed against the relevant statistical criteria from the local reference site (SLUEP10) which is beyond the impact zone for the discharge. The receiving water monitoring program conducted monthly since 2011 includes two sites, SLUEP10 and SLUEP11 approximately 2 km from the outfall which are beyond the zone of influence of the discharge and provide background water quality data.

Assessment of the water quality data for these sites from 2011 onwards indicates that water quality at Site SLUEP11 is occasionally influenced by catchment runoff discharges from drains from the Coconut Grove catchment. This site is therefore considered to be unsuitable as a reference site. Water quality at Site SLUEP10 is not subject to the influence of discharges from stormwater and is beyond the zone of influence of the EPO discharge plume and is therefore considered to a more appropriate 'reference' site as it represents the water quality in the mid-estuary zone of Darwin Harbour beyond the immediate influence of catchment contaminant sources. The suitability of Site SLUEP10 as an ongoing reference site will be reviewed following relocation of the East Point Outfall as the discharge will then be closer to the site.

The East Point Outfall is described in the Waste Discharge Licence and the Public Environmental Report as a zone of impact, exceedances of water quality criteria are expected at this site however any exceedance of discharge licence criteria at site SLUEP01 (East Point Outfall) will trigger an assessment of the monitoring data at receiving water sites to determine what, if any impact an elevated result in the designated impact zone has on water quality within the harbour.

The monitoring data from sites within the treatment plant, including at the discharge to the East Point Rising main (SLU080) and the overflow weir (SLULCDP), and Ludmilla Creek are primary data source to be used in assessing whether the discharge is the source of any exceedances at the outfall. In addition influent water quality (pre-treatment) and data within the treatment plant will be assessed to identify potential control points and to optimise treatment performance.

Construction of the LWwTP commenced in 1974, prior to Cyclone Tracy and was completed in 1976 with treated effluent discharged via the intertidal East Point Outfall since 1977. In 2012 LWwTP received a major upgrade in hydraulic and treatment capacity to allow it to ensure it had the capacity to treat the wastewater produced by a population of more than 40 000 people. The treatment process removes contaminants from wastewater by grit screening; pH control; chlorination; chemically assisted sedimentation; and sludge removal by centrifugation.

Wastewater treatment plants serves as a barrier to prevent illness due to contact with and exposure to raw sewage. To continue to protect public health it is not possible to shut the treatment plant; to cease discharges; or to retreat the wastewater as these actions would result in untreated wastewater backing up in the sewers causing uncontrolled raw sewage discharges.

The proposed management and contingency actions focus on optimising treatment within the current treatment systems as the holding capacity is limited both within the treatment plant and in the sewerage network. Redirection of effluent to Ludmilla Creek is not the preferred approach as it prioritises one environment over another however in extreme situations it may be considered based on an assessment of relative risks to the environment and to public health.

The Waste Discharge Licence identifies an impact zone of ≤ 250 metres, if impacts are identified beyond this zone the following assessment and response criteria will be applied.

Level 1 Identify, Assess and Monitor

This zone is within the boundary of the East Point Outfall's zone of influence identified in the Waste Discharge Licence and the Public Environmental Report and the Environmental Approval EPBC 2009/5113 studies; water quality triggers may occasionally be exceeded and minor changes in benthic infauna have been identified.

Identify, Assess and Monitor Triggers for assessment:

Where water quality criteria in samples collected from between >250 metres and ≤ 500 metres from the outfall, as measured at sites SLUEP02 and SLUEP03 (the potential zone of influence) exceed the 'slightly to moderately disturbed zone' (SMZ) and site specific trigger values (SSTV triggers) as documented in WDL150-04. The following decision criteria will apply:

Response

- If assessment triggers are exceeded PWC is to assess water quality data for the discharge and the outfall to determine likely source of the exceedance; and
- PWC to compare water quality data for the effluent and the effect site to historic seasonal data for the same site; and
- Where the East Point Outfall is identified as the probable source of the exceedance:
 - PWC to identify changes in influent characteristics and remedy; and
 - PWC to identify changes in the treatment process that may cause the exceedance and remedy; and
 - PWC to consider implementing additional monitoring of the discharge and impact site.
- PWC will review and assess appropriate management options for consideration should the exceedances persist; and
- If the East Point Outfall discharge is identified as the most probable or likely source of the exceedance and the effect is predicted to increase PWC is to advise the Department of the Environment (DoE), as the responsible Regulatory Authority, of the exceedance within 10 business days of the completion of the assessment; and
- PWC will report the "Level 1- Identify, Assess and Monitor trigger" exceedance and include a summary of the assessment in the Annual Monitoring Report (the Annual Report) as described in the WQMMP.

Contingency or Control measures

- Assess monitoring data to determine if the exceedance is persisting or spreading within the zone;
- Review monitoring data at the inlet and outlet and within the treatment plant to optimise treatment performance through maximising contact time with chlorine to reduce pathogens or through optimising pH, ferric or polymer dosing to improve sedimentation rates to remove particulate matter, organics or metals in the discharge;
- If the exceedance is identified as persisting for more than one sampling period, report the exceedance to the DoE as the responsible Regulatory Authority; and
- Implement control measures related to treatment plant performance optimisation.

Level 2 Alert and Prepare

Exceedance of triggers not predicted to occur as a result of the increased volume of treated wastewater discharge from the East Point Outfall; these sites are beyond the zone of influence identified in the Public Environmental Report and the Waste Discharge Licence.

Alert and Prepare Triggers for assessment:

Water quality at sites between >500 and ≤1000 metres from the outfall as measured at sites SLUEP04 and SLUEP12 exceeds the SMZ SSTV triggers from WDL150-04.

Response

- PWC will compare median data for each site for the relevant seasonal indicator (minimum last 6 samples) to the 20th and 80th percentile of relevant nutrient or stressor data for reference sites SLUEP10.
For toxicant data compare the 95th percentile of the site data to the 95th percentile +/- 1 standard deviation for the relevant parameter/s at the reference site SLUEP10 (minimum 24 months data); and
- If the stressor median or toxicant 95th percentile falls outside the reference site range PWC is to identify whether the East Point Outfall is the probable source of the effect; and
- In determining whether the East Point Outfall is the probable source of the effect PWC is to assess water quality and other relevant data for the treatment plant effluent, discharge, impacted site and surrounding environment; and
- If the East Point Outfall is identified as the probable source of the effect PWC is to:
 - identify major changes in influent characteristics and where possible remedy; and
 - identify changes in treatment process that may have caused the effect and correct; and
 - develop a management plan appropriate to the cause of the effect; and
 - Consider implementing additional monitoring as relevant to the cause of the effect.
- PWC will develop a management plan including relevant contingency measures to remedy the cause of the exceedance.
- In the event of a “Level 2 – Alert and Prepare trigger” exceedance PWC is to advise DoE as the Regulatory Authority within 5 business days of the completion of the assessment if further expansion of effect is predicted; and
- A summary of all “Level 2 – Alert and Prepare triggers” and the assessments will be included in the Annual Report.

Contingency or Control Measures

- Review monitoring data from the outfall and within the treatment train to identify relevant control measures to optimise treatment performance;
- Implement control measures related to treatment plant performance optimisation; and
- Where impacts are not associated with minor modification to optimisation of treatment performance develop a management plan to improve discharge quality;

Level 3 Act and Manage

The East Point Outfall is not predicted to cause exceedance of triggers; all sites are significantly beyond the zone of influence identified in the Waste Discharge Licence and the Public Environmental Report.

Act and Manage Trigger for assessment:

- Water quality at any site in the East Point monitoring zone greater than 1000 metres from the outfall (Sites SLUEP5, SLUEP06; SLUEP07; SLUEP08; SLUEP09; SLUEP10 and SLUEP11) exceeds the SMD triggers; or
- Any observations of death, decline or behavioural changes in sensitive receptor species (coastal dolphins, dugongs or turtles) or in the food or habitat requirements for sensitive receptor species within the EPO monitoring zone.

Response

- For stressor indicator exceedances compare the median of site data for the seasonally relevant indicator to the 20th and 80th percentile of nutrient and stressor data for reference site SLUEP10;
- For toxicant indicator exceedances compare the 95th percentile of the site data to the 95th percentile +/- 1 standard deviation of the monitoring data from site SLUEP10;
- If the stressor median or toxicant 95th%ile falls outside the reference site range PWC is to implement an investigation into probable sources of the effect; and
- If the East Point Outfall is identified as a probable source of the effect PWC is to:
 - Investigate inflow and effluent characteristics to identify potential sources of effect;
 - If changes in influent or effluent quality are identified as the source of effect PWC will implement corrective processes to reduce contaminants in the discharge; and
 - Review appropriateness of management plan prepared in response to Level 2 Triggers, if no management plan has been developed or the cause of the exceedance is not addressed by the existing management plan then develop a management plan to address the exceedance;
 - Implement management plan; and
 - Implement additional monitoring as relevant to the cause of the effect.
- If factors outside PWC's control are responsible for the effect, where appropriate PWC will contribute to identification and implementation of solutions to mitigate the effect;
- A preliminary report of the exceedance event will be made to DoE as the relevant Regulatory Authority within 48 hours of becoming aware of the exceedance; and
- An investigation report will be provided to the regulatory authority within 5 business days of completion of the investigation and summarised in the Annual Report.

Contingency or Control Measures

- Review all treatment performance data to identify key control points; and
- Implement management plan to improve performance at key control points; and
- Undertake an assessment of the relative risks associated with the impact of the Level 3 Trigger in Darwin Harbour compared to a discharge via Ludmilla Creek; and
- Consult with relevant Regulatory Authorities (e.g. DoE and NT EPA) on implementing an operational change prior to making changes to the discharge location, except where specifically permitted under a condition of the Waste Discharge Licence; and
- Implement changes to the discharge location as agreed with the Regulatory Authorities.

3.4.11 Reporting

The WDL150-04 compliance monitoring program has specific reporting requirements that are not included in the WQMMP plan. The WDL 150-04 requires that all monitoring data is reviewed on a monthly basis and exceedances of site specific trigger values are reported to the NT EPA within 5 business days of identifying the exceedance. In addition an annual report examining water quality trends for all indicators required by the licence is required prior to the anniversary of the granting of the licence. Compliance monitoring data will be included in the assessment of WQMMP exceedances.

Water quality data for the WQMMP will be stored in the PWC water quality database and reviewed as soon as practicable and in any case within 5 Business Days of all data having been received for each month of the monitoring program.

All records of sampling and analysis required under this licence will be retained by PWC for a period not less than two years after the date of sampling and made available to the DoE as the Regulatory Authority upon request.

The results of the water quality monitoring program will be reported annually and will comprise the presentation of that year's data with comparison to previous data and guideline values.

Individual exceedances of criteria for specified analytes and exceedances of criteria for specified periods (rolling percentiles – normally based on a minimum of 12 months data) will be reported once the monthly data set is complete, this may take up to one month for all results to be received and assessed. For assessment against the reference sites where 95th percentiles and standard deviations are required a minimum of 24 months of data will be used. Where a parameter is influenced by seasonal water quality characteristics a minimum of 24 months of seasonally relevant data will be used.

In the wet/dry tropics the wet season is nominally defined as beginning in October and ending at the end of April, the dry season is therefore from the beginning of May to the end of September. As water quality is more accurately characterised by the onset of the monsoon and rainfall in the preceding days will be considered in assessing the likely source of the exceedances.

General Reporting

The WQMMP monitoring and assessment program will commence within 20 Business Days of the notification of approval of the WQMMP by the Minister (The Anniversary).

An Annual Monitoring Report (the Annual Report) will be provided to the Independent Reviewer within 20 Business Days of receiving all results and will be provided to DoE as the Regulatory Authority within 10 Business Days of receiving approval from the Independent Reviewer, and in any case within 60 Business Days of the Anniversary of the approval of the WQMMP. The Annual Report will include:

- an assessment of all monitoring data collected as part of the WQMMP;
- a comparison against water quality samples from the same location collected in previous years;
- a summary of all exceedances;
- a summary of the outcomes of the investigation conducted into the exceedance;
- a summary of management actions implemented to mitigate the effect for each exceedance;
- all observations of death, decline or behavioural changes in sensitive receptor organism, food or habitat in the vicinity of the East Point Outfall discharge (the entire

- monitoring zone) will be reported to the relevant authorities and investigated as a potential Level 3 exceedance; and
- a review of the WQMMP and recommendations for improvements to ensure that the WQMMP remains a relevant, responsive and adaptive monitoring and management program.

Reporting of Alert, Assessment and Action Trigger Exceedances and Management Actions

Level 1 Assessment Trigger notifications:

Level 1: 'Assessment trigger exceedance events will not be reported to the regulator unless it is considered likely that the impact zone will expand. If the assessment of the exceedance predicts that the effect is likely to increase, DoE as the Regulatory Authority will be advised within 10 Business Days of the assessment being completed.

Level 2 Alert Trigger notifications:

Level 2, Alert trigger exceedance events will be reported to the regulator where the monitoring data indicates that an expansion of the impact is likely.

Reporting to DoE as the Regulatory Authorities will occur within 5 Business Days of the conclusion of the investigation, if the investigation concludes that the discharge from the outfall is the most probable cause of the effect and an expansion of the effect is likely.

Level 3 Action Trigger notifications:

In accordance with Condition 16 of the Department of the Environment (Cwth.) Environmental Approval EPBC 2009/5113, all Level 3, 'Act and Manage' trigger exceedance events will be reported to DoE as the Regulatory Authority within 48 hours of the Water Quality Officer becoming aware of the event.

The preliminary report to DoE as the Regulatory Authority will include details of the exceedance and the outcome of any preliminary investigation.

All Level 3, Action trigger exceedance events will result in the preparation of an investigation report which will assess:

- whether the discharge from the outfall is the most probable source of the effect;
- if the outfall is the most probable source of the effect what management actions have been implemented to mitigate the effect; and
- If the discharge is found not to be the cause of the effect, then what action has been taken by PWC to influence management actions to mitigate the observed effect.

The exceedance investigation report will be provided to DoE as the responsible Regulatory Authority within 5 business days of the conclusion of the investigation.

4 Sediment Monitoring Program

4.1 Background to Sediment Sampling

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

WDL 150-04 requires that sediment monitoring is conducted at the existing outfall location (SLUEPO1) on an annual frequency. Sampling is conducted during the dry season. It is proposed that the WQMMP monitoring program will be ongoing while the current East Point Outfall. A relevant supplementary monitoring program may be required during construction of the relocated outfall.

A practical advantage of monitoring the existing intertidal outfall location is the high degree of certainty that the sediments have been exposed to the wastewater discharge on a frequent basis as at tides below 0.8 metres the outfall is exposed and the sediment is subjected to 100% treated effluent for a period of hours. Thus an impact, if it has occurred, should be detected with a high degree of certainty as to the source of the impact.

In monitoring the sediments in the vicinity of the existing intertidal outfall it is noted 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 sub tidal outfall location. There are a number of reasons for this. Firstly, discharge at an intertidal location means that at times wastewater is discharged undiluted directly onto the sediments once the outfall is exposed on a falling tide, which may then be further concentrated by evaporation and effectively drawn into the sediments as the tide continues to fall. At a sub tidal location the plume will be buoyant due to its low salinity and will generally undergo significant dilution before contacting the sediment, potentially some distance down current of the outfall location. However, near field modelling (URS 2011) indicates that at the proposed EPO location, Site 1, there may be periods when the plume comes in contact with the seabed in the vicinity of the outfall at elevated concentrations.

The baseline investigation identified nutrients as the only contaminants that were elevated and these were within the range previously identified for Darwin Harbour sediments, with all metals below the ANZECC Interim Sediment Quality Guidelines (Low Risk) (ISQG-L) and petroleum hydrocarbons and polycyclic aromatic hydrocarbons were below ISQG-L levels and most were below the laboratory limits of detection.

4.2 Baseline Investigation - Toxins in Sediments

An intensive baseline investigation of contaminants in sediments was undertaken by SKM in 2013-2014 (SKM 2014b). The findings discussed below are taken from that report.

No metal/metalloid contamination was evident at the outfall or within Ludmilla Creek, with all samples below the ANZECC (2000) Interim Sediment Quality Guideline Low risk (ISQG-Low) guidelines (ANZECC 2000) for both wet and dry season sampling events. This would suggest that despite 40 years of discharging via the East Point Outfall the discharge from the Ludmilla WWTP has not resulted in metal or metalloid contamination of the sediments in the discharge area. SKM (2014b) considered these findings to be consistent with previous studies of the impact of the discharge of treated wastewater to the harbour by Moir (1995), Parry et al. (2002) and Padovan

(2003), which found the discharge to have no effect on metal/metalloid concentrations in sediments adjacent to discharge sites.

Total phosphorus concentration in both the wet and dry seasons was generally higher at the EPO site and considered likely to be associated with the wastewater discharge. However, all concentrations were within ranges previously recorded in other Darwin Harbour studies. Both nitrogen and phosphorous levels were elevated in Ludmilla Creek sediment compared with marine sediments. This may be associated with the treated wastewater discharges, stormwater runoff or be a naturally occurring aspect of the mangrove habitat. Further investigation would need to be conducted to differentiate between natural nutrient levels within upper mangrove sediments and any influence/impact of the WWTP (SKM 2014b).

No TPH/PAH were detected in any sample collected during the wet season survey. Based on these findings no TPH/PAH analysis was conducted on dry season samples.

Bacteria (*Enterococci* and *E.coli*) were assessed in both intertidal and Ludmilla Creek sediments. *E. coli* was recorded at only one site, EO7 which is approximately 10 m south of the EPO, above the limit of detection in the wet season survey. No results above the level of detection were recorded during the dry season.

Enterococci were detected at the majority of sites during the wet season with the highest numbers found at the EPO (15 org/g), SLULC03 (17 org/g) and a site upstream (LUDBR) 28 org/g. Dry season results were lower (≤ 2 org/g) at all sites with the exception of SLULC03 (59 org/g) and LUDBR (12 org/g). Higher concentrations recorded in the wet season were considered to have been possibly caused by increased effluent discharge volumes or increased stormwater runoff, both of which are higher in the wet season (SKM 2014b).

4.3 WDL150-4 Monitoring Requirement

The WDL requires the monitoring of selected metals and metalloids, nutrients and selected physical parameters in sediments (Table 4-1). In addition, the monitoring of stable isotopes of nitrogen and carbon are also required in support of the biological stable isotope study.

As a result of the findings of the baseline surveys, no hydrocarbon, pesticides, polychlorinated biphenyls or bacterial monitoring of the sediments are included in the sediment monitoring program.

4.4 Sediment Sampling Locations and Parameters

In addition to the WDL150-4 monitoring requirement, the monitoring of Site 1 is included for the purpose of obtaining baseline (pre-construction) data for construction and operational purposes, noting that it is subject to the influence of the discharge from the existing EPO.

The combined suite of sampling sites and all monitored parameters are shown in Table 4-1 and the sampling program is summarised in Appendix A.2-1.

At each site sediments are to be collected as triplicate core samples within a 1 meter square grid. Samples will be collected using the standard methods as outlined in Simpson et.al 2005. as modified by Munksgaard et.al. 2013. The Munksgaard method incorporates modifications to address specific standardised methods recommended for sediment sampling in Darwin Harbour.

Table 4-1 Sediment Sampling Locations and Parameters

Parameter	Site	SLuEP01	SLuEP02	SLuEP03	SLuEP04	SLuLC01	SLuLC03	SLuLC04	SLuEP12 (Site 1)
	Units								
Particle size	μ	All sites dry season							
Total organic carbon	mg/kg	All sites dry season							
pH	pH units	All sites dry season							
Aluminium	mg/kg dry weight	All sites dry season							
Chromium	mg/kg dry weight	All sites dry season							
Copper	mg/kg dry weight	All sites dry season							
Nickel	mg/kg dry weight	All sites dry season							
Zinc	mg/kg dry weight and μg/L pore water	All sites dry season							
Total Phosphorus (TP)	mg/kg	All sites dry season							
Total Nitrogen (TN)	mg/kg	All sites dry season							
Ammonia (as N)	mg/kg and μg/L pore water	All sites dry season							
Chlorophyll-a	mg/kg	All sites dry season							
Stable isotopes of N and C	¹⁵ δ N‰ ¹³ δ C‰	All sites dry season							

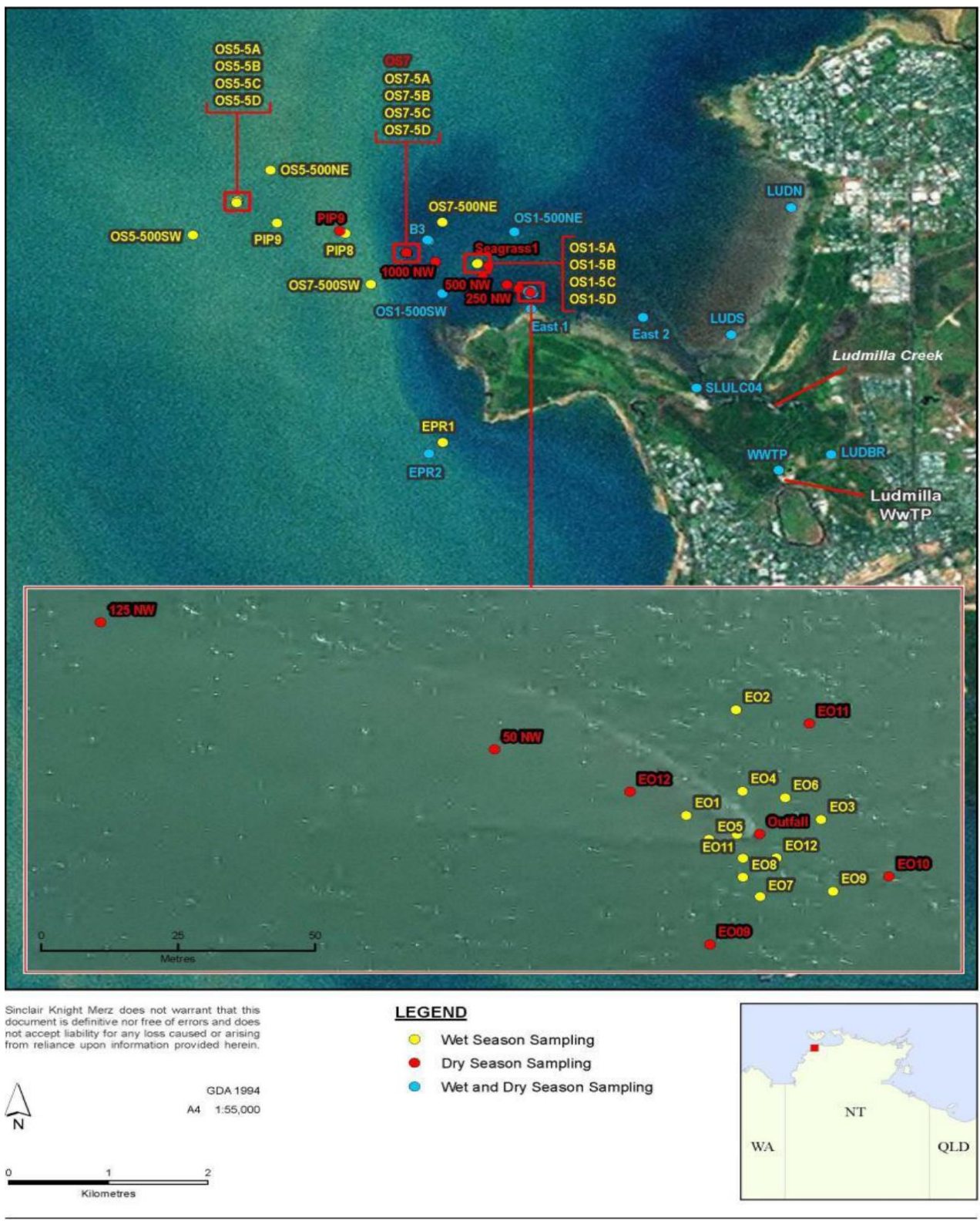


Figure 4-1 Sediment Sampling Sites

4.5 Sediment Sampling Methodology

Samples from Ludmilla Creek intertidal sites will be collected on low tide using core tubes or a plastic trowel to collect surface samples 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 and nutrient samples.

Sediments from harbour sites will be collected on neap tides using a grab (Van Veen or similar) operated from a survey vessel. Sub-samples from the grab sample will be collected by corer, again collecting the top 20 mm of sediment.

To minimise the potential for sample contamination sample collectors will wear a new pair of unpowdered nitrile gloves at each sampling site. Samples will be placed in laboratory prepared containers and stored on ice in insulated containers in the field.

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

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

4.6 Sampling Frequency

Sediments will be sampled once annually in the dry season and will continue during the period of operation of the existing outfall and for a period of no less than 2 years following the closure of the existing outfall to assess any changes in sediment condition following relocation of the current outfall.

4.7 Assessment of Sediment Data

Results of sediment analyses will be compared against the ANZECC (2000) sediment guidelines (or any new guidelines adopted via the national program), data obtained from the baseline sediment investigation (SKM 2014b) and Darwin Harbour reference data as shown in Table 4-3.

The results of the benthic in-fauna surveys will be used to inform a revised sediment monitoring program, once the benthic in-fauna data is assessed to determine the impact of sewage related nitrogen and organic carbon on benthic in-fauna. This review will occur at the end of the first benthic in-fauna survey. However it is proposed to collect representative sediment cores as a reference for stable isotope analysis after the initial assessment of benthic in-fauna.

Table 4-3 Sediment Assessment Criteria

Parameter	Guideline	Assessment
Total Organic Carbon	NA	Comparison to reference site data
Stable isotopes of N and C	Reference condition	$\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ in sediments comparison to reference data. Comparison of C:N ratio ranges in Ludmilla Creek and East Point Outfall to reference sites and assess for significant differences (at 95% confidence level).
Chlorophyll-a	Reference condition	Comparison to 2 x 80 th percentile of reference site data
Total phosphorus	Reference condition	Comparison to 2 x 80 th percentile of reference site data
Total nitrogen	Reference condition	Comparison to 2 x 80 th percentile of reference site data
Aluminium (Al)	NA	Apply normalisation (to 1 mg/kg total sediment dilute acid extracted) to assess spatial distribution patterns of metals
Arsenic	20 mg/kg dry weight	Sediment: Annual report - comparison to ISQG Low and if exceeded subsequently compare Al normalised data to 2 x 80 th percentile of reference site data.
Chromium	80 mg/kg dry weight	Sediment: Annual report - comparison to ISQG Low and if exceeded subsequently compare Al normalised data to 2 x 80 th percentile of reference site data.
Copper	Sediment: 65 mg/kg dry weight and reference condition. Pore water: 3 ug/L and 1.3 ug/L	Sediment: Annual report - comparison to ISQG (Low) and if exceeded, subsequently compare Al normalised data to 2 x 80 th percentile of reference site data. Pore water: SSTV (water quality)
Nickel	21 mg/kg dry weight	Sediment: Annual report - comparison to ISQG Low and if exceeded subsequently compare Al normalised data to 2 x 80 th percentile of reference site data.
Zinc	Sediment: 200 mg/kg dry weight and reference condition. Pore water: 23 ug/L and 15 ug/L	Sediment: Annual report - comparison to ISQG Low and if exceeded subsequently compare Al normalised data to 2 x 80 th percentile of reference site data. Pore water: SSTV (water quality)

4.8 Reporting of Sediment Monitoring Data

The results of the sediment contaminant monitoring program will be reported in the Annual Monitoring Report and will comprise the presentation of that year's data with comparison to previous data and guideline values, noting any exceedance of guideline or reference values.

The monitoring data for intertidal sites sampled within the WDL150-04 compliance monitoring program will also be reported to the relevant authorities in the annual report.

All non-compliances with the relevant guideline trigger values will be reported within 48 hours of becoming aware of the non-compliance.

5 Biological Monitoring Plan

No specific biological monitoring is proposed at the first stage of the WQMMP, the Benthic In-fauna Monitoring and Management Plan (BIMMP) will provide a comprehensive assessment of biota within the vicinity of the existing outfall.

The Compliance monitoring associated with WDL150-04 includes biota monitoring for stable isotopes of nitrogen ($\delta^{15}\text{N}$) and carbon ($\delta^{13}\text{C}$) in mangrove leaves and shellfish tissue and bioaccumulation of toxicants in shellfish in the vicinity of the outfall. The compliance monitoring is summarised below and while it is not a component of the WQMMP the results will be reported in the annual WQMMP report, considered in assessing the impact of any identified exceedances of water quality triggers and will be considered in future reviews of the WQMMP.

5.1 Background to the Biological Monitoring Plan

The present discharge licence, WDL 150-4, contains four biological monitoring elements based on recommendations contained in the first monitoring plan and the subsequent approvals for the augmentation of the ERM. These are:

- ecotoxicological assessment
- stable isotope analysis in biota
- contaminants in biota (*Telescopium telescopium*)
- benthic in-fauna monitoring

Baseline investigation of each of these elements was undertaken in 2013-2014 and the findings are briefly described below. The monitoring of benthic in-fauna is covered in a separate benthic in-fauna monitoring and management plan (BIMMP) (CEE 2015).

5.2 Ecotoxicological Assessment

An ecotoxicological assessment plan for the Ludmilla Wastewater Treatment Plant was developed in 2013 (GHD 2013) and an assessment of treated wastewater from the LWwTP was undertaken on a sample collected on 23 January 2014 (ESA 2014). The effluent exhibited toxic effects across all end-point tests.

5.2.1 WDL150-4 Ecotoxicological Studies

WDL 150-04 requires implementation of the Ecotoxicological Investigation Plan for the Ludmilla Wastewater Treatment Plant (GHD 2013). The Plan was delivered after the completion of the commissioning of the upgrade to the LWwTP; therefore the initial sample collected in 2014 represented the baseline conditions following the treatment plant upgrade as required by the Plan. The plan requires the collection of one dry season 24 hour integrated sample every three years or a sample when there is a major change to plant operations. This can be interpreted as once per licence period or following any major operational change.

The major upgrade to the treatment plant that occurred in 2012 is the type of operational change that would require a resample. This operational change increased the inflow, enhanced the sedimentation process with additional chlorination, pH controls and the addition of ferric and polymer to improve polymerisation of organic matter in the waste stream coupled with the inclusion of additional sedimentation tanks and centrifugation of sludge to improve effluent quality.

An ecotoxicological assessment will be conducted once per licence period and following any major operational changes that changes the chemical or biological characteristics of the discharge.

Table 5.1 Baseline Ecotoxicology Assessment of Ludmilla Effluent

Test	IC ₁₀	EC ₅₀
1 hr. sea urchin fertilisation: <i>Heliocidaris tuberculata</i>	<0.8	1.1
72 hr. sea urchin larval development: <i>Heliocidaris tuberculata</i>	6.6	8.2
48 hr. larval development: milky oyster (<i>Saccostrea echinata</i>)	3.4	5.0
72 hr. marine algal growth: <i>Isochrysis aff. galbana</i>	1.8	2.4
72 hr. macro algal germination: <i>Ecklonia radiata</i>	6.6	9.2
48 hr. acute copepod survival: <i>Parvocalanus crassirostris</i>	1.3	1.9
7 day fish imbalance: <i>Lates calcarifer</i> (barramundi)	21.8	26.8
7 day fish biomass toxicity: <i>Lates calcarifer</i> (barramundi)	13.2	32.5

5.3 Stable Isotope Analysis in Biota

5.3.1 Stable Isotope Baseline Investigation

The stable isotope baseline investigation undertaken in 2013-2014 examined the presence of two stable isotopes, nitrogen-15 ($\delta^{15}\text{N}$) and carbon-13 ($\delta^{13}\text{C}$) in two mid-upper intertidal organisms: mangrove and *Telescopium*, and one lower intertidal-sub tidal organism: seagrass. The objective was to determine the zone of uptake of nutrient (nitrogen) from the wastewater discharge for selected sessile or sedentary organisms and plants. Sediment samples from the EPO and at increasing distances from the outfall were also tested.

Elevated levels of nitrogen-15 ($\delta^{15}\text{N}$), considered an indicator of the effluent discharge, were detected in mangrove leaves at the discharge point into Ludmilla Creek (SLULC03) and at a moderate level at a distance of 20 and 25 m from the discharge point, but at a moderate level in only one of three samples collected further upstream, i.e. upstream of Dick Ward Drive. The other two samples had a low value. It is uncertain whether the elevated level at this site had its origin in the discharge from the LWWTP or whether it represented input from terrestrial sources upstream.

Nitrogen-15 ($\delta^{15}\text{N}$) was also elevated in samples of *Telescopium* collected at SLULC03 and moderately elevated at site EP3 located on the south side of the creek mouth. Nitrogen-15 ($\delta^{15}\text{N}$) at Ludmilla South, located a short distance to the north of the creek mouth were more consistent with reference site data.

The seagrass leaf results were inconclusive with only two samples collected and the nitrogen-15 ($\delta^{15}\text{N}$) values higher at a site 1250 m from the outfall than at a site 500 m from the outfall. The irregular distribution of seagrass in the outfall area suggests it is of limited value as a monitoring organism in this investigation unless sites in closer proximity to the outfall are found that can be routinely sampled.

The sediment results showed only minor variation between the outfall and sites at distances up to 250 metres from the outfall. Nitrogen-15 ($\delta^{15}\text{N}$) was however moderately elevated in comparison to reference sites.

5.3.2 WDL150-4 Isotope Monitoring Sites

WDL150-4 specifies that a stable isotope analysis be conducted on *Telescopium* (a marine snail) flesh and on mangrove and seagrass leaves in the vicinity of the EPO and Ludmilla Creek discharge location and adjacent sites on an annual basis during the dry season.

Telescopium and mangrove leaves are only present at the Ludmilla Creek (SLULC) sites, these sites are not relevant to the change in discharge from the East Point Outfall however the results will be provided in the annual Waste Discharge Licence Monitoring Report.

5.3.3 Additional Isotope Monitoring Sites

The presence of seagrass leaves at the Darwin Harbour (SLUEP) sites will need to be confirmed in the field at the time of each survey. Seagrass has not been reported at, or immediately adjacent to the East Point Outfall location (SLUEP01).

Sparse ephemeral patches of seagrass (*Halophila* spp) have been identified in the shallow sub tidal waters near site SLUEP17; seagrass found at this and other sites identified by the BIMMP seagrass surveys will be monitored for stable isotope profiles.

Seagrasses are a vital marine ecosystem component in the Darwin region. They are an important food source for several protected marine animals such as marine turtles and dugongs and provide nursery and feeding habitats for many commercial and recreation fish species.

Several species of marine turtles and dugongs are frequently sighted in the Darwin Harbour region from Fanny Bay to the upper tributaries of the harbour and marine turtles are occasionally sighted in the vicinity of East Point. They are primarily herbivores and feed on *Halodule uninervis* (lower intertidal zone) and *Halophila* spp (upper sub tidal zone). Distinctive feeding trails are left behind when dugongs uproot entire seagrass plants to access the nutritious rhizomes – if they are accessible. When the rhizomes are deeply buried in the sediment, dugongs feed by cropping the seagrass leaves; similar feeding behaviour to marine turtles.

Seagrasses are sensitive to changes in a range of environmental factors including water quality. Many species show natural seasonal variation in presence, productivity or abundance and inter-annual variation in abundance and distribution are also common.

Seagrasses are susceptible to the effects of reduced light, smothering by algae and sedimentation. Intertidal species of seagrass are also susceptible to desiccation. High levels of nutrients can cause excessive epiphytic growth on the surface of leaves limiting the amount of light reaching the seagrass leaves for photosynthesis. This process can result in decreased seagrass biomass or even seagrass loss. Common sources of nutrients include runoff from agricultural or developed catchments and wastewater discharges. Reduction in seagrass may result in flow-on effects to sensitive receptor animals such as marine turtles and dugongs that rely directly on seagrass for food.

The benthic in-fauna monitoring and management plan includes surveys of seagrass presence and condition in the vicinity of the current and proposed outfall. No additional monitoring is proposed in the WQMMP.

The monitoring of biota in the vicinity of the preferred EPO relocation site, designated as Site 1 (SLUEP12), is included in the monitoring plan to obtain baseline data for the proposed relocated outfall, again subject to seagrass being present at that location.

Table 5-1 identifies the monitoring sites and parameters that comprise the stable isotope monitoring plan. The full sampling schedule is presented in Appendix Table A.3-1.

The collection of seagrass for stable isotope analysis will be conducted in conjunction with the Benthic In-fauna Monitoring and Management Plan seagrass survey rather than as a separate sampling exercise within the WQMMP. Where viable seagrass communities are identified samples will be collected for stable isotope analysis.

Observational assessments of the presence and activity of the sensitive receptor species that are dependent on seagrass will accompany the WQMMP and the BIMMP.

Table 5-2 Isotope Sampling Sites and Test Organisms

Organism	Site	SLUEPO1	SLUEPO2	SLUEPO3	SLUEPO4	SLULCO1	SLULCO3	SLULCO4	Site 1
<i>T. telescopium</i>		No	No	No	No	Yes ¹	Yes ¹	Yes ¹	No
Mangrove leaves		No	No	No	No	Yes ¹	Yes ¹	Yes ¹	No
Seagrass leaves		No	Yes ²	Yes ²	Yes ²	No	No	No	Yes ²

No Species not present at or immediately adjacent to the site.
 Yes¹ Species previously sampled at the location – WDL150-04 monitoring requirement
 Yes² Species not confirmed as being to be present at the location. To be sampled if present.

5.3.4 Methodology

Mangrove leaves:

Perform a pre-trip survey to identify and tag a mangrove species common to each test site for each run i.e. likely candidate is *Rhizophora stylosa*. Select the tree/s in closest proximity to the location of the sediment sampling sites on the creek and at East Point. Collect 10 leaves from each tree (unblemished, mature leaves, avoid newly emerged leaves). Combine leaves if collecting from either bank into one sample.

Place samples into double zip-locked bags, exclude air, place on ice and freeze if samples are not transferred to the laboratory that day

Replication: Take triplicate samples at two sites in each test creek and one site in each reference creek. Triplicate samples should be collected from trees within a distance of 50 m along the creek bank.

Seagrass leaves:

The presence of seagrass in the vicinity of the outfall has not been confirmed and is likely to be restricted by the turbidity of the intertidal waters. Two species have previously been identified in the Kulaluk Bay area *Halodule uninervis* which is replaced by *Halophila ovalis* at greater depths.

If seagrass is located samples will be collected from plants identified in the reference photos. Samples will be collected as 10 leaves mature and undamaged ‘leaves’ are to be collected (blade plus petiole for *Halophila spp* and blade for *Halodule spp*) per plant or if this is not practical then 3 leaves per plant and a minimum of 5 plants per quadrat.

Leaves should be placed in zip lock bags, air excluded and the samples stored on ice or frozen if not delivered to the laboratory on the same day.

Telescopium:

Telescopium telescopium (mud whelks) will be collected in conjunction with the bioaccumulation studies, 5 individual animals per site will be stored in zip lock bags (air excluded) on ice for transportation to the laboratory or frozen if not to be transported on the same day.

Transfer all biota samples to laboratory to be freeze dried, pulverised and analysed for $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$

5.3.5 Sampling Frequency

Species forming part of the isotope monitoring program will be sampled once annually in the dry season at the nominated sites during the period of operation of the existing outfall.

5.3.6 Assessment

Results of isotope analyses will be compared against baseline (PWC 2014b) and historical/reference data (as available) for the same species in Darwin Harbour.

5.3.7 Reporting of the Isotope Survey Data

The results of the stable isotope monitoring program will be reported annually and will comprise the presentation of that year's data with comparison to baseline and Darwin Harbour reference values.

5.4 Contaminants in Biota (*Telescopium telescopium*)

5.4.1 Background

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 or the health of sensitive receptor organisms should be:

- one which is commonly consumed by humans (or other relevant species)
- 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 sessile or sedentary.

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

Although not found in the immediate vicinity of either the existing or proposed outfall, *Telescopium* is present at the mangrove-lined shoreline of Ludmilla Creek and the adjoining bay to the north of the creek entrance (SKM 2014a) 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 (*Saccostrea cucullata*) which occurs on hard substrates, including artificial substrates (pilings, rock walls, etc.). Oysters were sampled in the wet season baseline survey undertaken by SKM in 2013 (SKM 2014a), however the sizes of individual animals and of the populations present were found to be too small to support an ongoing monitoring program and the sampling of oysters was not conducted as part of the dry season survey. Accordingly the collection of oyster samples has been deleted from the monitoring program and this is reflected in WDL 150-4.

The revised monitoring program is therefore limited to monitoring of *Telescopium spp* on soft sediments in the intertidal zone adjacent to Ludmilla Creek and in the mangroves to the north of Ludmilla Creek at East Point.

5.4.2 *Telescopium* Baseline Investigation

The presence of metallic contaminants and faecal bacteria in species used for human consumption, such as *Telescopium*, poses a potential health risk to consumers. Measurement in samples from sites in the vicinity of the existing discharge points is used as a guide to assessing the potential level of risk presented.

In the 2013 - 2014 baseline investigation (SKM 2014a) elevated *E. coli* values were detected in *Telescopium* samples collected in the vicinity of the plant discharge to Ludmilla Creek (SLULC03) in both the wet and dry season surveys. No other *Telescopium* sites either upstream or downstream of SLULC03 recorded a value in excess of the guidelines.

An oyster sample collected at EP1, the most distant site from the outfall, also recorded an *E. coli* value in excess of the guidelines during the wet season survey. The source of the bacteria is uncertain as below guideline values were recorded in the oyster sample from EP2 and the *Telescopium* sample from EP3, both of which are located closer to the outfall. Further oyster sampling was abandoned due to the small population and small sizes of animals at East Point and no dry season data are available.

During the wet season, concentrations of copper and zinc in excess of the guideline and/or reference values for molluscs were detected at sites EP1, EP2 and EP3 (copper) and SLULC03, EP1 and EP2 (zinc). Concentrations of copper were also elevated at SLULC03 and EP3 during the dry season survey. No other metal contaminants were recorded above guideline levels.

No hydrocarbon contaminants were detected in the wet season survey. Based on this finding no hydrocarbon analyses were conducted during the dry season.

5.4.3 WDL150-4 Requirement for Contaminant Monitoring in *Telescopium*

Telescopium will be sampled at all sites (Ludmilla Creek SLULC01, SLULC03 and SLULC04 and East Point SLUEP01, SLUEP02, SLUEP03 and SLUEP04) where the animals are present at or in the near vicinity of the site.

In practice this means only the SLULC sites will be sampled as *Telescopium* does not occur in the vicinity of the lower intertidal outfall (SLUEP01) or more distant sub tidal sites. Shoreline sites close to the outfall will be assessed for *Telescopium* and where present samples collected.

5.4.4 Additional *Telescopium* Monitoring Sites

As the site of the proposed EPO location, Site 1, is more distant (seaward) of the known *Telescopium* populations than the existing outfall, no additional sites have been included in the monitoring plan for the purpose of obtaining baseline data for the proposed relocated outfall.

5.4.5 Sampling Sites and Parameters - *Telescopium*

The sampling sites and parameters to be determined at all sites are shown below in Table 5-3 and the sampling program is summarised in Appendix A3-2.

Table 5-3 Contaminants in *Telescopium* - Sampling Locations and Parameters

Parameters	Units	Site
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		SLuLC01	SLuLC03	SLuLC04
Shell length (longest axis)	mm	Yes	Yes	Yes
Arsenic (Inorganic and total)	mg/kg Wet and dry weight	Yes	Yes	Yes
Copper		Yes	Yes	Yes
Zinc		Yes	Yes	Yes
<i>E. coli</i>	cfu/g	Yes	Yes	Yes
<i>Enterococci</i>				

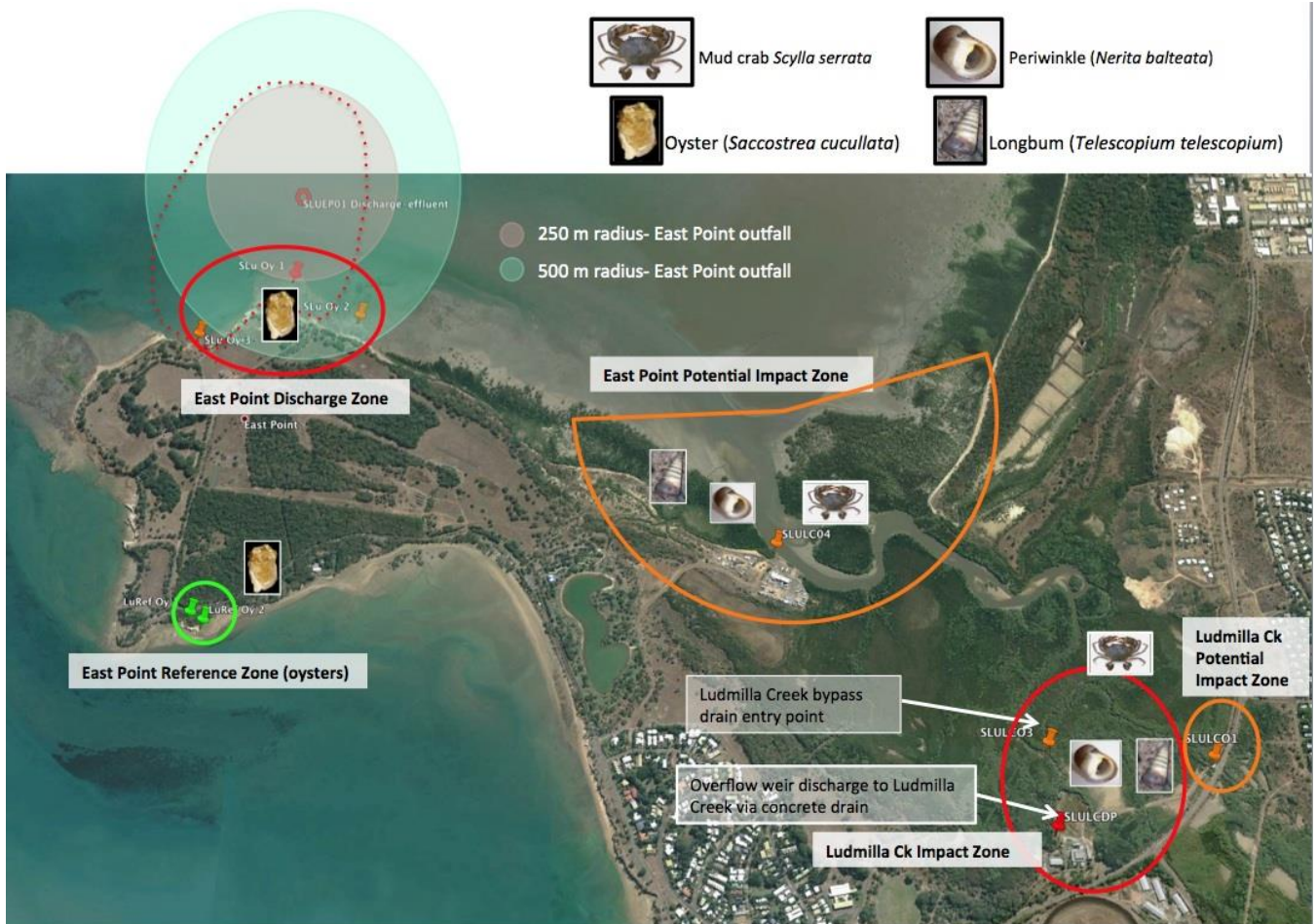


Figure 6: Ludmilla creek and East Point zones for collecting oyster, mud crab, periwinkle and longbum for faecal/pathogen indicator testing.

Figure 5-1 WDL 150-04 Biota Monitoring Sites (Figure 6 in Aquatic Foods Monitoring Program)

5.4.5.1 Sampling Methodology

This program will comprise one composite sample from each of the three nominated sites (assuming *Telescopium* is present in sufficient numbers for sampling at each location).

Sufficient animals will be collected at each site to undertake the analyses described. It is anticipated that this will require approximately 20 animals per sample.

Collectors will wear a fresh pair of un-powdered nitrile gloves when handling animals to minimise the risk of contamination of samples.

Telescopium shells containing live animals will be placed unopened directly into unused zip-lock bags, placed into a second bag (i.e. double bagged) 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 NT EPA. This will include the collection of replicate samples as specified in the ANZECC (2000) guidelines.

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

5.4.6 Sampling Frequency

Telescopium will be sampled once annually in the dry season during the period of operation of the existing outfall.

5.4.7 Assessment of *Telescopium* data

Results of biota analyses will be compared against baseline (SKM 2014a) and historical/reference 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).

5.4.8 Reporting of Contaminant Monitoring in *Telescopium*

The results of the *Telescopium* contaminant monitoring program will be reported Annual Monitoring Report and will comprise the presentation of that year's data with comparison to previous data and guideline values.

6 Administration of the WQMMP

6.1 Responsibilities for the WQMMP

In accordance with Condition 13(b) of the Environmental Approval EPBC 2009/5113 Power and Water Corporation is committed to implementing the WQMMP as described in this document, and as approved by the Minister, until such time as the East Point Outfall is relocated or ceases to operate or an amended WQMMP is approved by the Minister.

In accordance with the requirements of Condition 13(c) of the Environmental Approval EPBC 2009/5113 a table of authorities (based on position rather than the individual) is required to identify responsibilities for actions:

Table 6-1 Program Responsibilities

Task	Responsibility	Organisation
Preparation of the monitoring plan(s) (and any amendments)	Water Quality Officer	PWC
Endorsing the monitoring plan(s) (and any amendments)	Independent Technical Reviewer	External
Approval of the monitoring plan (and any amendments)	Responsible Minister	Commonwealth
Implementation / Conduct of the monitoring program	Senior Water Quality and Treatment Officer	PWC
Preparation of management reports for submission	Water Quality Officer	PWC
Review of monitoring and management reports	Independent Technical Advisor	External
Submission of reports to NT EPA/Department of the Environment	General Manager Water Services	PWC
Notification of exceedances of management triggers	Water Quality Officer	PWC
Implementation of contingency measures	Senior Water Quality and Treatment Officer	PWC
Review and implementation of management measures (corrective actions)	Senior Water Quality and Treatment Officer	PWC
Independent review of implementation and management measures	Independent Technical Advisor	GHD
Review and revision of WQMMP	Water Quality Officer	PWC

6.2 Exceedances of Management Trigger Levels

Management triggers for each element of the WQMMP (water, sediment and biota) are provided in sections 3, 4 and 5, respectively.

All exceedances of management trigger levels will be investigated and an assessment report prepared. If the assessment of the exceedance confirms that the effect is due to the discharge from the East Point Outfall and the effect is predicted to expand Level 1 Alert level exceedances will be reported to the DoE within 10 Business Days of the completion of the assessment; and

Level 2 Assessment level exceedances will be reported to the DoE within 5 Business Days of the assessment. All Level 3 Action level exceedances will be reported to the DoE within 48 hours of PWC becoming aware of the exceedance and a subsequent investigation report will be provided within 5 Business Days of completion of the investigation.

A summary of all Level 1, Level 2 and Level 3 exceedances will be included in the Annual Monitoring Report which will be provided to DoE as the responsible Regulatory Authority within 60 Business Days of the Anniversary of the approval of the WQMMP.

6.3 Contingency Measures

Upon receipt of confirmation of an exceedance of a trigger value PWC will review the operating conditions of the plant at the time of the exceedance (influent flow rates and composition and wastewater treatment regime) and make such adjustments to the treatment process as may be necessary to return the wastewater discharge to an acceptable quality, i.e. below the trigger value for that parameter(s) at the affected site(s).

Follow-up monitoring data will be reviewed to confirm that compliance has been achieved.

Other short-term measures will include the issuing of public notices and placement of signage at potentially impacted locations in the event of detection of a potential health hazard as a result of above guideline bacterial values for recreation or consumption of seafood.

6.4 Corrective Actions

As the Ludmilla WWTP is an essential element of Darwin's wastewater treatment infrastructure and has very limited backup storage capacity; the only alternative to its near continuous operation is the direct discharge of untreated wastewater direct to the harbour. Consequently any management measures (corrective actions) need to be undertaken within the context of an operational facility.

Short-term actions will include adjustments to the treatment regime necessary to meet the licence guidelines for discharged water quality at specified locations.

Medium-term actions will include regular review of plant operations to ensure that the treatment of the wastewater is optimised based on the current plant design and treatment technology.

Longer-term investigations will include reviews of alternate treatment processes and wastewater disposal.

6.5 Reporting

A report addressing each segment of the WQMMP (water sediment and biota) will be submitted annually to the DoE and the NT EPA within 60 Business Days from the date of the approval of the WQMMP (The Anniversary) as required by the Environmental Approval EPBC 2009/5113.

Exceedances of any Level 3 threshold trigger levels within a management plan will be reported to the DoE within 48 hours of PWC becoming aware of the breach.

6.6 Review of the WQMMP

The WQMMP will be reviewed annually and any recommendations endorsed by an independent technical reviewer with the objective of enabling continuous improvement and adaptive management of water quality and benthic in-fauna (Environmental Approval EPBC 2009/5113 condition 15).

The report and advice of the Independent Technical Reviewer will be provided by PWC to the Commonwealth Minister for the Environment and the NT EPA along with an explanation by PWC of how the advice/recommendations of the Independent Technical Reviewer will be incorporated in the management plans or why such advice or recommendations are proposed not to be adopted.

The Independent Technical Review and PWC response will be submitted to the Commonwealth Minister for the Environment when the management plans are submitted for approval.

6.7 WQMMP Monitoring and Reporting Summary

Table 6-2 WQMMP Monitoring and Reporting Summary

Site	Site type	Water	Sediment	Biota	Trigger Level	Reporting
* SLU080 (discharge)	Compliance	✓	–	✓ ¹	NR	Annual
* SLUEP01 (outfall)	Compliance	✓	✓	✓	NR	Annual
* SLUEP02 (250 m)	Compliance and WQMMP	✓	✓	✓	Level 1	Exceedance and Annual
* SLULC01 (Ludmilla Creek)	Compliance	✓	✓	✓	NR	Annual
* SLULC03 (Ludmilla Creek)	Compliance	✓	✓	✓	NR	Annual
* SLULC04 (Ludmilla Creek)	Compliance	✓	✓	✓	NR	Annual
SLUEP03 (500 m)	Compliance and WQMMP	✓	✓	✓	Level 2	Exceedance and Annual
SLUEP04 (850 m)	WQMMP	✓	✓	✓	Level 3	Exceedance and Annual
SLUEP05	WQMMP	✓	–	–	Level 3	Exceedance and Annual
SLUEP06	WQMMP	✓	–	–	Level 3	Exceedance and Annual
SLUEP07	WQMMP	✓	–	–	Level 3	Exceedance and Annual
SLUEP08	WQMMP	✓	–	–	Level 3	Exceedance and Annual
SLUEP09	WQMMP	✓	–	–	Level 3	Exceedance and Annual
SLUEP10 ² (> 2000m)	WQMMP	✓	–	–	Level 3	Exceedance and Annual
SLUEP11 (>2000m)	WQMMP	✓	–	–	Level 3	Exceedance and Annual
SLUEP12 (650 m) (Site 1)	WQMMP and Impact ³	✓+ (profile)	–	–	Level 3	Exceedance and Annual
* SLUEP13 (Site 5)	Impact ³	profile	–	–	NR	Annual
* SLUEP14 (Site 7)	Impact ³	profile	–	–	NR	Annual
* SLUEP15 (EPR1)	Impact ³	profile	–	–	NR	Annual
* SLUEP16 (EPR2)	Impact ³	profile	–	–	NR	Annual
* SLUEP17 (B3 possible seagrass)	Impact ³	profile	–	–	NR	Annual

* NR sites (compliance and WQMMP) used to inform decisions regarding alert (L1) and assessment (L2) and action (L3) triggers to identify contaminant source if exceedances observed at WQMMP sites.

1 Ecotoxicology and stable isotopes of nitrogen ($\delta^{15}\text{N}$) and carbon ($\delta^{13}\text{C}$) in discharge and sludge

2 Darwin Harbour water quality reference site for East Point area

3 Impact sites are used to assess the background and possible impact of the relocation of the outfall.

7 Reference Material

Abbreviations

ANZECC	Australia and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
BIMMP	Benthic In-fauna Monitoring and Management Plan
BOD ₅	Five day Biological Oxygen Demand test
Business Day	business Day: any day from Monday to Friday that is not a public holiday in the Darwin Region of the Northern Territory
CFU	Colony Forming Units
DHWQO	Darwin Harbour Water Quality Objectives
EIS	Environmental Impact Statement
EPBC	Environment Protection and Biodiversity Conservation
EPO	East Point Outfall
EPRM	East Point Rising Main (carries treated effluent from Ludmilla WwTP to EPO)
GELs	Generally Expected Levels
LWwTP	Ludmilla Wastewater Treatment Plant
NATA	National Association of Testing Authorities
NRETAS	Natural Resources, Environment, The Arts and Sport
NT EPA	Northern Territory Environmental Protection Authority
PER	Public Environmental Report
PIZ	Primary Impact Zone
PWC	Power and Water Corporation
SIZ	Secondary Impact Zone
TSS	Total Suspended Solids
WDL	Waste Discharge Licence
WQMMP	Water Quality Monitoring and Management Plan (includes water, sediment and biota)
WwTP	Wastewater Treatment Plant

References

- Anderson, KL, Whitlock, JE & Harwood, VJ 2005: Persistence and Differential Survival of Fecal Indicator Bacteria in Subtropical Waters and Sediments. *Applied and Environmental Microbiology*, vol. 71, no. 6, pp. 3041–3048.
- ANZECC 2000: *Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Australian and New Zealand*, Environment and Conservation Council (ANZECC) & Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ), Canberra.
- Charles Darwin University & Power and Water Corporation 2011: *Hydrodynamic Modelling of Darwin Harbour 2005-2010. History, Development & Interpretation. Report No. 4 (Final)*, 33 pp.
- Charles Darwin University & Power and Water Corporation, 2011a: *Hydrodynamic Modelling Results Summary, Summary of East Point Outfall Far-Field Modelling*.
- Davies, CM, Long, JA, Donald, M & Ashbolt, NJ 1995: Survival of fecal microorganisms in marine and freshwater sediments. *Appl. Environ. Microbiol*, vol 61, pp. 1888–1896.
- Department of Health and Community Services (DHCS) 2007: *Northern Territory Recreational Microbiological Water Quality Guidelines*, document prepared by: David Dettrick, Northern Territory Environment Protection Agency (EPA) with input from Peter Rogers, Dagmar Schmitt and Xavier Schobben, Department Health & Community Services, December 2007.
- Department of Lands Planning and the Environment 2012: Assessment Report 72, East Point Effluent Rising Main Duplication Project, Power and Water Corporation, Environmental Assessment Report and Recommendations by the NT Environment Protection Agency, December 2012.
- ESA 2014: Toxicity Assessment of a Treated Waste Water Discharging into Darwin Harbour Ecotoxicological Services Australasia Test Report January 2014.
- Ferguson, DM, Moore, DF, Getrich, MA & Zhouwandai, MH 2005: Enumeration and speciation of enterococci found in marine and intertidal sediments and coastal water in southern California, *Journal of Applied Microbiology*, vol 99, pp. 598–608.
- Geoscience Australia: Oz Coasts website 2015: http://www.ozcoasts.gov.au/conceptual_mods/geomorphic/tde/tde.jsp Accessed September 5 2015.
- GHD 2009: *Power and Water Corporation, Report for Bathymetric and Benthic Survey of the Proposed East Point Outfall, Part Three Benthic Survey*, January 2009.
- GHD 2013: Ecotoxicological Investigation Plan for the Ludmilla Wastewater Treatment Plant, a plan prepared for Power and Water Corporation December 2013
- Hunter Water Australia Pty Ltd 2011: *Ludmilla WWTP Upgrade Design – Design Basis Report*, report to Power & Water Corporation.
- Hydrosurvey Australia 2008: *Darwin East Point Sewage Outfall – Bathymetric & Topographic Survey Larrakeyah Sewage Outfall – Bathymetric Survey, Survey Report No. 1*. Report to GHD, 28 November 2008.

- INPEX Browse, Ltd 2011: *Ichthys Gas Field Development Project: supplement to the Draft Environmental Impact Statement*. Report prepared by INPEX Browse, Ltd., Perth, Western Australia for the Commonwealth Government, Canberra, ACT, and the Northern Territory Government, Darwin, Northern Territory.
- Jacobs 2014: East Point Outfall Monitoring, Power and Water Corporation, East Point Dry and Wet Season In-fauna Monitoring (2013 – 2014), Revision 2, August 2014.
- Munksgaard, NC; Kaestli, M; Gibb, K; Dostine, P and Townsend, S (2013): Darwin Harbour Baseline Sediment Survey 2012: A report prepared by Charles Darwin University for the Aquatic Health Unit of the Northern Territory Government Department of Land Resource Management.
- NHMRC 2008: Guidelines for managing risks in recreational water. Australian Government National Health and Medical Research Council
- NRETAS 2010: Water Quality Objectives for the Darwin Harbour Region - Background Document. Department of Natural Resources, Environment, the Arts and Sport, Aquatic Health Unit, Darwin, Northern Territory.
- NTG 2010: Declaration of Beneficial Uses and Environmental Objectives for the waters of Darwin Harbour: Northern Territory Government Gazette, G 27, 10 July 2010.
- PWC 2014: Stable isotopes in biota monitoring report for East Point Outfall 2013 and 2014 (unpublished data report).
- Simpson, SL; Batley, GE; Carlton, AA; Stauber, JL; King, CK; Chapman, JC; Hyne, RV; Gale, SA; Roach, AC and Maher, WA. 2005: Handbook for sediment Quality Assessment (CSIRO: Bangor NSW)
- SKM 2014a: East Point Biota Monitoring Report – 2013 Wet (April 3013) and Dry (September 2013) Seasons, July 2014.
- SKM 2014b: East Point Outfall Monitoring, East Point - Sediment Monitoring, DB05855, September 2014.
- URS 2011: *Technical Report, Diffuser Design for the East Point Outfall*. Report to Power and Water Corporation.
- URS 2011b: East Point Outfall Water, Sediment and Biota Monitoring Program. A Report prepared for Power and Water Corporation; Appendix Q Public Environmental Report for the Augmentation of the East Point Rising Main. October 2011.
- Yamahara, KM, Walters, SP & Boehm, AB 2009: Growth of Enterococci in Unaltered, Unseeded Beach Sands Subjected to Tidal Wetting. *Applied and Environmental Microbiology*, Vol. 75, No. 6, pp. 1517–1524.

Appendix A: Water Quality Data and Assessment

Sampling Site Data

Table A.1	Water quality sampling program - Visual observations and physico-chemical and biotic parameters
Table A.2	Water quality sampling program - Nutrients,
Table A.3	Water quality sampling program - metals
Table A.4	Water quality sampling program - Pathogen and Endocrine disrupting chemicals bacteria
Table A.5	Intertidal and sub tidal sediment sampling program – interpretive and nutrients
Table A.6	Intertidal and sub tidal sediments sampling program - metals
Table A.7	Intertidal and sub tidal biota sampling program
Table A-8	Ludmilla Discharge and Receiving Water monitoring data assessment
Table A-9	Water Quality Hazard Assessment against declared Beneficial Uses

Table A-1 Physico-chemical Indicators

Sample Locations/Frequency of Monitoring										
Ludmilla Discharge		Zone of Influence (Management Intent – Highly Disturbed) (ZOI)				Management Intent – Slightly- Moderately Disturbed Aquatic Ecosystem (SMDZ)				
Sampling Site Code	Recarb chamber at overflow weir to Ludmilla Creek	East Point outfall discharge	Ludmilla Creek bypass drain entry point	Darwin Harbour (East Point) and Ludmilla Creek Reporting limits (SSTV)	Compliance/Reporting protocol	East Point and Ludmilla Creek Receiving Water				Compliance/Reporting protocol
	SLU080 = SLULCDP	SLUEP01	SLULC03			SLUEP02	SLUEP03	SLULC01	SLULC04	
Easting	As per Attachment F(iv)				As per Attachment F(iv)					
Northing										
Indicator	Units									
Physico-chemical parameters										
Flow	kL/day	D	Not Relevant	-	Report annual discharge (ML/year) from discharge point from 2014 in Licence reports	Not Relevant				-
pH	pH unit			<7.0 – >8.5 (DHWQO 2010)	Discharge annual reporting – compare 90 th percentile to reporting limits. For sites within the ZOI report individual non-compliances with reporting limits. Annual report compare 95 th percentile to the reporting limits for sites in the ZOI.					<7.0 – >8.5 (DHWQO 2010) Report individual non-compliance of SSTV. Annual reporting – compare 95 th percentile to SSTV.
EC	µS/cm			-	Annual reporting (interpretative only)					- Annual reporting (interpretative only)
DO (primary indicator)	% saturation.			<50 – >110	Report all individual results <30% Report individual non-compliances of reporting limits based on the median of the 12 most recent samples in the ZOI.					<80 – >110 (DHWQO 2010) (ANZECC 2000) Report all individual results <30%. Report individual non-compliances of reporting limits for the median of the 12 most recent samples at sites in the SMDZ.
Temperature	°C	M		-	Annual reporting (interpretative only)	M				- Annual reporting (interpretative only)
TSS	mg/L			>10 SLUEP01 (DHWQO 2010)	Report annual load from discharge (tonnes/year). ZOI sites annual reporting – compare annual median to reporting limits					>6 SLUEP02 & 03 >10 SLULC01 & 04 (DHWQO 2010) Report individual non-compliances with reporting limits for the median of the 12 most recent samples at each site in the SMDZ;
BOD ₅	mg/L			>5	Report annual loads from discharge (tonnes/year). ZOI sites annual reporting based on 90 th percentile and compare to reporting limits.					>5 Annual reporting based on 95 th percentile compared to reporting limits. Interpretative report only.

Table A-2 Nutrient Monitoring Indicators

Sample Locations/Frequency of Monitoring										
Ludmilla Discharge		Zone of Influence (Management Intent – Highly Disturbed) (ZOI)				Management Intent – Slightly- Moderately Disturbed Aquatic Ecosystem (SMDZ)				
Sampling Site Code	Recarb chamber at overflow weir to Ludmilla Creek	East Point outfall discharge	Ludmilla Creek bypass drain entry point	Darwin Harbour (East Point) and Ludmilla Creek Reporting limits (SSTV)	Compliance/Reporting protocol	East Point and Ludmilla Creek Receiving Water				Compliance/Reporting protocol
	SLU080 = SLULCDP	SLUEP01	SLULC03			SLUEP02	SLUEP03	SLULC01	SLULC04	
Easting	As per Attachment F(iv)				As per Attachment F(iv)					
Northing										
Indicator	Units									
Nutrient parameters										
Chlorophyll-a (Primary indicator)	µg/L			>2 (SLUEP01) >4 (SLULC03)	Annual reporting based on median for each site in the ZOI.					>2 (SLUEP02 & 03) >4 (SLULC03 & 04) Report individual non-compliance with the reporting limits based on for the median of the 12 most recent samples for each site in the SMDZ;
Ammonia (Total as N)	µg/L		M	Ammonia pH adjusted marine trigger values Table 6.3.7 (ANZECC/ARMCANZ 2000 HD)	Report annual loads from discharge (tonnes/year). Report individual exceedances of reporting limit for each site within the ZOI based on the 80 th percentile of the 6 most recent samples pH corrected using the median of the 12 most recent pH values for the site.	M				>20 (lower) (DHWQO 2010) >Toxicant (upper trigger) Table 6.3.7 (ANZECC /ARMCANZ 2000 HD)- Ammonia as a toxicant pH adjusted (marine) trigger values Report individual exceedances of the upper (toxicant) reporting limit for each site within the SMDZ based on the 95 th percentile of the 12 most recent samples pH corrected using the median of the 12 most recent pH values for the site.
Total Nitrogen	µg/L			>300	Report annual loads (tonnes/year) from discharge points. Report individual non-compliance					>300 (DHWQO 2010)
Oxidised Nitrogen (NO _x as N)	µg/L			>20		M				>20 (DHWQO 2010)
Total Phosphorous	µg/L		M	>20 (Harbour) >30 (Creek)						>20 (Harbour) >30 (Creek) (DHWQO 2010)
Filterable Reactive Phosphorous	µg/L			>5 (Harbour) >10 (Creek)					>5 (Harbour) >10 (Creek) (DHWQO 2010)	

Nb. WDL150-04 due to transcription error the licence as issued does not include this table but this is what was intended

Table A-3 Metals Indicators

		Sample Locations/Frequency of Monitoring										
		Ludmilla Discharge			Zone of Influence (Management Intent – Highly Disturbed) (ZOI)			Management Intent – Slightly- Moderately Disturbed Aquatic Ecosystem (SMDZ)				
		Recarb chamber at overflow weir to Ludmilla Creek	East Point outfall discharge	Ludmilla Creek bypass drain entry point	Darwin Harbour (East Point) and Ludmilla Creek Reporting limits (SSTV)	Compliance/Reporting protocol	East Point and Ludmilla Creek Receiving Water				East Point (Darwin Harbour) and Ludmilla Creek Reporting Limits (SSTVs)	Compliance/Reporting protocol
Sampling Site Code	SLU080 = SLUICDP	SLUEP01	SLUIC03	SLUEP02			SLUEP03	SLUIC01	SLUC04			
Easting Northing	As per Attachment F(iv)			As per Attachment F(iv)								
Indicator	Units											
Metal Parameters												
Copper (total & dissolved)	µg/L	M			1.3 (SMD)	Report annual loads (kg/year) from the discharge. Report individual exceedances of the reporting limit for copper (dissolved) at sites within the ZOI when the 90 th percentile of the 12 most recent samples exceed the reporting limit.	M	1.3 (95 % level of protection ANZECC 2000)		Annual report – compare 95 th percentile to reporting limit. If the total copper exceeds the reporting limit analyse for dissolved copper. Report individual non-compliance of dissolved copper when the 95 th percentile of the 12 most recent samples exceeds reporting limit.		
Zinc (total & dissolved)	µg/L	M			15 (SMD) (95 % level of protection ANZECC 2000)	Report annual load (kg/year) from the discharge. Report individual exceedances of the reporting limit for zinc (dissolved) at sites within the ZOI.		15 (95 % level of protection ANZECC 2000)		Annual report – compare 95 th percentile to reporting limits. Report non-compliance if 95 th percentile of the 12 most recent samples exceeds the reporting limit.		
Mercury (total & dissolved)	µg/L	M			≤0.4 (SMD) (95 % level of protection ANZECC 2000)	Report annual load (kg/year) from the discharge. Report individual exceedances of the reporting limit for mercury (dissolved) at sites within the ZOI.		≤0.4 (95 % level of protection ANZECC 2000)		Annual report – compare 95 th percentile to reporting limit. Report individual non-compliance if 95 th percentile of the 12 most recent samples exceeds reporting limits.		

Table A-4 Pathogen and Endocrine Disrupting Chemicals Indicators

		Sample Locations/Frequency of Monitoring										
		Ludmilla Discharge			Zone of Influence (Management Intent – Highly Disturbed) (ZOI)			Management Intent – Slightly- Moderately Disturbed Aquatic Ecosystem (SMDZ)				
		Recarb chamber at overflow weir to Ludmilla Creek	East Point outfall discharge	Ludmilla Creek bypass drain entry point	Darwin Harbour (East Point) and Ludmilla Creek Reporting limits (SSTV)	Compliance/Reporting protocol	East Point and Ludmilla Creek Receiving Water				East Point (Darwin Harbour) and Ludmilla Creek Reporting Limits (SSTVs)	Compliance/Reporting protocol
Sampling Site Code	SLU080 = SLUICDP	SLUEP01	SLUIC03	SLUEP02			SLUEP03	SLUIC01	SLUC04			
Easting Northing	As per Attachment F(iv)			As per Attachment F(iv)								
Indicator	Units											
Pathogen Indicators (assessment to exclude data collected from sampling following heavy rainfall)												
<i>Escherichia coli</i>	cfu/100 mL	F			M	>50	M	>14 median >43 90 th percentile		Notify of non-compliance when the median of the most recent 12 samples collected from sites within the SMDZ exceed the reporting limit. Notify of non-compliance when the annual 90 th percentile of samples collected from sites within the SMDZ exceed the reporting limit. Excluding samples collected following heavy rain.		
Enterococci	cfu/100 mL	F			M	>200		>50		Notify of non-compliance where the 95 th percentile (harbour) or 90 th percentile (creek) of the most recent 12 samples exceeds the reporting limit. Excluding samples collected following heavy rain.		
Endocrine Disrupting Chemicals												
4-t-octylphenon	ng/L	S (one sample wet and one sample dry season) per year			-	-	-	-		-		
Nonylphenol		S (one sample wet and one sample dry season) per year			-	-		-		-		
Bisphenol A		S (one sample wet and one sample dry season) per year			-	-		-		-		
Androsterone		S (one sample wet and one sample dry season) per year			-	-		-		-		
Etiocolanalone		S (one sample wet and one sample dry season) per year			-	-		-		-		

Table A-5 Sediment Interpretive and Nutrient Indicators

					Sampling Locations and Monitoring Frequency						
					East Point and Ludmilla Creek – discharge points and benthic infauna impact site ^a		Ludmilla Creek and East Point Outfall Slightly to moderately disturbed sites (reference sites)		Guideline	Assessment & Reporting Protocol	
					Sampling Site Code	SLEP01 (East Point Outfall)	SLEP02	SLEP03	SLEP04		
					Easting	As per Attachment F(iv)					
					Northing						
Indicator	Units	Rationale	Sediment	Pore waters							
Interpretative Indicators											
Total Organic Carbon	%	For determining C:N ratios as recommended in expert review.	✓	×	Dry season				NA	Annual report – comparison of C:N ratio ranges in Ludmilla Creek and East Point Outfall to reference sites and assess for significant differences ($\sigma=0.05$)	
Aluminium	mg/kg	For normalisation of metals data as per ANZECC 2000 as recommended in expert review for comparison with reference sites	✓	×						Apply normalisation to assess spatial distribution patterns of metals	
Stable isotopes of N and C	$\delta^{15}N‰$ $\delta^{13}C‰$	Stable isotopes to identify zone of influence of discharge	✓	×					Reference conditions	$\delta^{13}C$ and $\delta^{15}N$ in sediments for source identification Annual Report comparison to reference data	
Nutrient Indicators											
Chlorophyll a	mg/kg	As recommended in expert review.	✓	×					Reference conditions	Annual report - comparison to 2 nd x 80 th percentile of reference site data	
Total P	mg/kg	Annual trend assessment in comparison to loads.	✓	×					Reference condition	Annual report - comparison to 2 nd x 80 th percentile reference site data	
Total N	mg/kg	Annual trend assessment in comparison to loads and for determining C:N ratios	✓	×					Reference condition	Annual report - comparison to 2 nd x 80 th percentile reference site data	
Ammonia as N	mg/kg and $\mu\text{g/L}$	ANZECC 2000 recommends sampling of ammonia in pore waters due to impacts on benthic fauna (p. 3.5.3 Volume 1). The benthic infauna survey identified ecosystem changes within a primary impact zone of 250 metres (to SLEP02) and less distinct changes along a gradient to 500 m and no impacts beyond 500m no gradient was evident in Ludmilla Creek.	×	✓	Dry season				pH adjusted trigger value in Table 8.3.7 Volume 2 of ANZECC and ARMCANZ (2000) and Comparison to reference site condition data	Annual report - comparison to SSTVs (Appendix 1) based on ANZECC 2000 and subsequently to 2 nd x 80 th percentile reference site data once adequate data exists for calculation of percentiles	
Metals											

A-6 Sediment Metals Indicators

					Sampling Locations and Monitoring Frequency						
					East Point and Ludmilla Creek – discharge points and benthic infauna impact site ^a		Ludmilla Creek and East Point Outfall Slightly to moderately disturbed sites (reference sites)		Guideline	Assessment & Reporting Protocol	
					Sampling Site Code	SLEP01 (East Point Outfall)	SLEP02	SLEP03	SLEP04		
					Easting	As per Attachment F(iv)					
					Northing						
Indicator	Units	Rationale	Sediment	Pore waters							
Arsenic (As)	mg/kg dry weight	There have been no exceedences of ISQG low guidelines for copper or zinc in sediment monitoring. The other metals for continued monitoring are those that have exceeded ISQG-low guidelines in total sediment results, the dilute acid extractable fraction (bioavailable estimate) have not exceed the ISQG low value. The metals to monitor are arsenic, chromium and nickel.		×	Dry season				20 ^a	Sediment: Annual report – comparison to ISQG Low and subsequently compare AI normalised data to 2 nd x 80 th percentile reference site data.	
Chromium (Cr)	mg/kg dry weight	Based on water quality data copper and zinc are the metals identified as posing a medium risk to the protection of beneficial uses in the zone of influence of the discharge.		×					80 ^a	Sediment: Annual report – comparison to ISQG Low and if exceeded subsequently compare AI normalised data to 2 nd x 80 th percentile reference site data.	
Copper (Cu)	mg/kg dry weight and $\mu\text{g/L}$ pore water	Biota monitoring identified elevated levels of Cu and Zn in the tissue of animals harvested for food (gastropod and oysters). Copper and zinc should be monitored in both sediment and pore waters due to the confirmed source signal and biota uptake.	✓ (filtered)						Sediment: 65 ^a and Reference condition Pore water: 3 ^b and 1.3 ^c	Sediment: Annual report - comparison to ISQG (Low) and if exceeded, subsequently compare AI normalised data to 2 nd x 80 th percentile of reference site data. Pore water: SSTV	
Nickel (Ni)	mg/kg dry weight		✓ (total and dilute acid extractable (bioavailable estimate))	×					21 ^a	Sediment: Annual report – comparison to ISQG Low and if exceeded subsequently compare AI normalised data to 2 nd x 80 th percentile reference site data.	
Zinc (Zn)	mg/kg dry weight and $\mu\text{g/L}$ pore water			✓ (filtered)					Sediment: 200 ^a and Reference condition. Pore water: 23 ^b and 15 ^c	Sediment: Annual report - comparison to ISQG Low and if exceeded subsequently compare AI normalised data to 2 nd x 80 th percentile reference site data. Pore water: SSTV in Section 4.1	

a. Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ 2000); Table 3.5.1 Interim Sediment Quality Guidelines (ISQG) Low risk. Section 3.5.4.3 recommends that in the absence of guidelines for a comparison to reference site data a factor of 2 is applied to reference site data. All dry season reference site data will be pooled to determine 80th percentiles.
 b. Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ 2000); 90% species protection applied within the zone of influence (within 250 metres of discharge)
 c. Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ 2000); 95% species protection applied beyond the primary impact zone (beyond 250 metres of discharge)
 * $\delta^{13}C$ and $\delta^{15}N$ is proposed as a preliminary survey focusing on the same sites as used in the biota and water quality monitoring in Ludmilla Creek to identify the zone of influence of sewage sourced nitrogen in the creek as infauna studies did not prove useful in define differences to reference sites for the creeks.

Table A-7 Biota Monitoring Indicators

				Sampling Locations and Monitoring Frequency									
				East Point Outfall and Ludmilla Creek impact zone				Guideline	Assessment & Reporting Protocol	A reference sites (outside the identified impact zone of discharge)			
				SLU080	SLUEP01	SLUEP02	SLULC03			SLUEP03	SLUEP04	SLULC01	SLULC04
				Easting									
				Northing									
Indicator	Units	Rationale	Sampling period										
Ecotoxicological Assessment													
		As required by Environmental approval EPRM	Discharge wastewater in accordance with Ecotoxicology Assessment Plan. 24 hour integrated dry season flow.	✓	x	x	x	ANZECC (2000) and Ecotox		x	x	x	x
Stable Isotope Analysis in Biota													
<i>T. telescopium</i>		Indicates extent of uptake zone Recommended in expert review and Environmental Approval.	Dry season	x			✓	SKM 2013 and Munksgaard 2014	Annual Report comparison to reference sites and 2013 PWC survey data			✓	✓
Mangrove leaves				x	✓ ^a		✓				✓	✓	
Seagrass leaves ^a				x	✓ ^a	✓ ^a					✓ ^a	✓ ^a	
Contaminants in Biota (<i>Telescopium telescopium</i>)													
Copper	ma/ka wet weight		Dry season	x	✓ ^a	✓ ^a	✓ ^a	FSANZ 2005 Standard 1.4.1 supplementary material (GEL)	Annual Report comparison to Food Standard 1.4.1 Maximum Levels (ML), supplementary material Generally Expected Levels (GEL) in molluscs.	✓ ^a	✓ ^a	✓	✓
Zinc				x	✓ ^a	✓ ^a	✓ ^a				✓ ^a	✓ ^a	✓
Arsenic (inorganic and total)	cfu/g			x	✓ ^a	✓ ^a	✓ ^a	FSANZ 2005 Standard 1.4.1 supplementary material	Cu GEL 5 (median) 30 (90%ile) Zn GEL 130 (median) 290 (90%ile) As (inorganic) 1 (ML) 2.3 org/g of tissue DHWQO reference sites and 2013 PWC survey data	✓ ^a	✓ ^a	✓	✓
<i>E. coli</i>				x	✓ ^a	✓ ^a	✓ ^a				✓ ^a	✓ ^a	✓
Enterococci		x	✓ ^a	✓ ^a	✓ ^a			✓ ^a	✓ ^a	✓	✓	✓	
Benthic Infauna Survey													
The design and implementation of a benthic infauna monitoring and management plan is a requirement of the Commonwealth Government. Environmental approval for the EPRM augmentation. The Plan is to be developed based on the 2013 benthic infauna survey (BIFS) (SKM 2014), reviewed by an independent technical expert and approved by the responsible Commonwealth Minister.			Wet and Dry season commencing 2014			✓	x		Comparison to reference data and community and diversity identified trigger values as per approved plan		✓		x

^a Samples to be collected as close as possible to the water quality and sediment monitoring sites (limited by the availability of the required species at the monitoring location). Where a species is not present on site the collection location will be recorded for future collection.

Table A-8 Water Quality Data Assessment for Ludmilla Discharge and Receiving Waters

Water Quality Assessment: Ludmilla WwTP Discharge and East Point and Ludmilla Creek Receiving Waters and Rapid Creek; Comparison against Guidelines																																		
Indicator type	Pathogen indicators			Physico-chemical indicators													Nutrient indicators						Toxicant indicators						EDCs					
	E. coli	fecal coliform	fecal streptococci	pH	EC	DO	Turbidity	TSS	BOD	FRP	TP	NH3-N	TN	NOx	Chl-a	NH3-N	As (D)	Cu (D)	Hg (D)	Ni (T)	Zn (D)	Cr	Fe	Fe	4-cyclophenol (ng/L)	Nonyl phenol (ng/L)	Bis phenol A (ng/L)	Androstene (ng/L)	Biotransformation (ng/L)					
Unit	cfu/100 ml	cfu/100 ml	cfu/100 ml	pH units	µS/cm	% sat	Ntu	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L				
DHWDO Outer Estuary/ Mid Estuary ^a	14	43	40 ^b	7.0-8.5 6.5-8.5 ^c	80	100	1-20	10	165 ^d	10 ¹ 5 ^e	20 ¹ 30 ²	20	270 ¹ 300 ²	17 ¹ 20 ²	2 ¹ 4 ²																			
ANZECC level of species protection	Not applicable			7.0-8.5	80-120	1-20	<2 ^f	5	20	15	250	30	2			910	2.3 ³ -SMD 13 (D)	1.3-SMD 3.0 (D)	0.4 (SMD) 0.7 (D)	7-SMD	15-SMD	4.4 (Cr-V) More toxic	300 ³											
Assessment criteria percentile	50 ^g	90 ^g	95 ^g	50 ^h	50 ^h	Low 20 ^h	High 95 ^h	50 ^h	95 ^h	50 ^h	50 ^h	50 ^h	50 ^h	50 ^h	50 ^h	95 ^h	95 ^h	95 ^h	95 ^h	95 ^h	95 ^h	95 ^h	95 ^h											
Discharge point and treated effluent (receiving water quality guidelines is not directly applicable). ^a Guidelines for Managing Risks in Recreational Water (National Health and Medical Research Council) 2008 ^b PER approved treatment plant design criteria, no guideline values for receiving waters <2 is desirable for rivers and marine waters, no guidance available for estuaries due to natural dissolved organic matter availability. ^c ANZECC Low Reliability Trigger Values, Section 3 of ANZECC/ARMCANZ Guidelines for Fresh and Marine Waters. Colour code for comparison: Compliant to ANZECC 2000 and Darwin Harbour Water Quality Objectives (DHWQO) Green ; Yellow exceeds NHMRC, pink exceeds DHWQO, not ANZECC objectives; ANZECC trigger values Pale orange exceeds slightly to moderately (SMD), Orange exceeds all objectives and disturbed (D) triggers.																																		
SLU080	245	25700	1345	7.99	1254	47.5	97.0	44	34	92	857	2470	31885	34100	93	1.46	47050	1.50	77	0.150	4.85	16.1	4.9	3.1	5070									
Discharge (SLU/CDP) entry point to Ludmilla Creek receiving waters during bypass discharges																																		
SLUCO3 ¹	58	2240	9325	7.30	56630	51.6	91.6	12.2	16	1.0	11	77	23	940	14	5.97	4980	3.20	1.95	0.210	4.8	12.6	2.00	0.50	842									
Discharge to receiving waters: Ludmilla Creek (bypass drain entry point, upstream and downstream of discharge point)																																		
SLUCO1 ¹	59.5	1140	1140	7.46	61064	35.4	98.7	11.1	13	1.0	23	72	66	910	29	2.56	350	2.30	1.75	0.200	6.5	5.00	2.00	0.50	1580									
SLUCO4 ¹	5.8	70	3200	8.30	56220	84.7	113	3.2	23.5	1.0	5	26	2.5	555	4.0	1.42	67.8	3.40	1.80	0.190	3.8	7.6	3.70	0.50	2260									
East Point Outfall within Darwin Harbour receiving waters																																		
SLUEP1 ¹ -outfall	10	1104	206	8.12	54960	90.0	107	7.2	4.0	1.0	22	166	2330	3360	6.0	0.80	7080	2.03	4.90	0.150	2.00	8.9	0.98	0.50	717	10.4								
Darwin Harbour receiving waters																																		
SLUEP2 ¹	0	32	140	8.19	55135	89.4	105	2.2	3.0	1.0	6.0	19	10.5	450	4.0	0.91	158	4.40	0.50	0.150	3.85	3.9	1.20	0.50	1390	14.3								
SLUEP3 ¹	0	15	66	8.12	55165	91.5	104	2.5	4.0	1.0	8.0	22	20	450	6.0	0.75	125	5.45	0.50	0.150	5.00	4.0	2.00	0.50	1240	6.82								
SLUEP4 ¹	0	4.4	39	8.11	55267	89.2	103	2.2	4.0	1.0	6.0	22	5.0	420	5.0	0.80	21	3.08	0.50	0.150	3.00	5.0	0.55	0.50	688	5.52								
SLUEP5 ¹	0	6.8	63	8.11	55167	88.9	104	2.4	4.0	1.0	6.0	25	2.5	440	4.0	0.84	76	4.00	0.50	0.150	1.00	4.0	0.55	0.50	887	7.10								
SLUEP6 ¹	0	5.8	31	8.11	55072	88.9	102	2.6	4.0	1.0	5.0	19	2.5	430	4.0	0.95	20	5.00	0.50	0.150	2.00	1.5	1.05	0.50	902	10.2								
SLUEP7 ¹	0	2.2	28	8.10	55075	88.8	100	3.1	4.0	1.0	6.0	21	2.5	495	5.0	0.73	15	2.63	0.50	0.150	2.00	3.0	1.10	0.50	889	2.50								
SLUEP8 ¹	0	5.6	26	8.11	54885	88.9	102	2.6	4.0	1.0	6.0	21	2.5	390	4.5	0.80	13	2.18	0.50	0.150	3.00	4.2	1.10	0.50	1130	7.71								
SLUEP9 ¹	0	5.8	11	8.12	54890	89.5	100	3.8	6.0	1.0	7.0	19	2.5	460	1.5	0.82	11	2.63	0.50	0.150	2.00	3.0	1.05	0.50	691	13.0								
SLUEP10 ¹	0	2.2	13	8.11	54880	89.2	102	3.5	7.0	1.0	5.0	18	2.5	430	1.5	0.74	11	2.63	0.50	0.150	1.00	3.0	0.53	0.50	502	6.07								
SLUEP11 ¹	0	4.6	12	8.11	55480	89.4	102	3.3	7.0	1.0	6.0	20	2.5	420	1.5	0.85	8.0	2.63	0.50	0.150	9.00(11 F)	7.00	0.55	0.50	487	5.52								
Rapid Creek 1 ¹	500	2550	1700	6.89	11500	60.1	87.4	2.75	3.5	1.0	7.0	18	22	295	33	0.77	74.4	1.50	1.48	0.300(T)	2.0	11.6	2.0	-	1388	-								
Rapid Creek 2 ¹	860	5500	1370	7.09	7400	70.2	95.0	5.78	4.0	1.0	6.5	25	25	330	31	1.35	81.2	1.50	0.50	0.30(T)	2.0	8.3	2.0	-	917	-								
Rapid Creek 3 ¹	415	3470	1690	7.58	2300	76.5	103	7.27	12.0	1.0	6.0	33	16	510	59.5	2.18	30.7	1.50	1.48	0.617(T)	1.0	1.50	3.0	-	1173	-								
Rapid Creek 4 ¹	120	800	395	7.79	30000	91.3	121	5.75	7.0	1.0	6.5	26.5	16	290	36.0	1.16	50.6	1.50	0.50	0.460(T)	1.0	1.50	3.0	-	486	-								
Comment																See also as nutrient																		

Table A-9 Water Quality Data Hazard Assessment against Declared Beneficial Uses

Hazard Quotient determinations for Ludmilla WwTP Discharge to Darwin Harbour and Ludmilla Creek and comparison with Rapid Creek																																			
Hazard quotient: Ratio of test statistics to guideline where < 1 indicates the assessment statistic is compliant with the guideline and > 1 indicates exceedance of the guidelines: Ranked by Green <1.0 Pink (low) >1.0 to <1.5, Orange (moderate) exceeds by a factor >1.5 to 10, Red (high) exceeds by factor >10																																			
Hazard Quotient applied to treated effluent and East Point Outfall discharge point, however the correlation is not directly relevant. While aquaculture and primary contact recreation is assessed the use is not permitted in the vicinity of East Point Outfall under the Port Bylaw Section 5A.																																			
parameter	E. coli	Faecal coliform	Faecal streptococci	pH	EC	DO	Turbidity	TSS	BOD	FRP	TP	NH3-N	TN	NOx	Chl-a	NH3-N	As (D)	Cu (D)	Hg (D)	Ni (T)	Zn (D)	Cr	Fe	Fe	4-cyclophenol (ng/L)	Nonyl phenol (ng/L)	Bis phenol A (ng/L)	Androstene (ng/L)	Biotransformation (ng/L)						
SLU080	17.5	509	34			1.7	1.7	3.4	48	36	124	1580	963	5.5		51.7		58.2			1.1	1.1		16.9											
Hazard Quotient Applied to Receiving Waters: Ludmilla Creek																																			
Aquatic food: 1 st Rec ¹ Ecosystem protection: Stressors - Physico-chemical Ecosystem Protection: Stressors - Nutrients Ecosystem Protection: Toxicants																																			
SLUCO3	4.1	52	235			1.6			1.6	2.2	2.6	1.1	3.1	3.1	1.49	2.7	1.3	1.5																	
SLUCO1	4.2	27	23			2.3			1.3	4.6	2.4	3.3	3.0	1.5				1.5	1.4																
SLUCO4			80			1.1			2.3					1.8					1.4																
Hazard Quotient Applied to Receiving Waters: Rapid Creek																																			
Rapid Creek 1	25.7	39.3	42.5			1.33						1.1	1.1	1.1																					
Rapid Creek 2	45.4	120	14.5			1.14						1.25	1.1	1.09																					
Rapid Creek 3	29.6	50.7	42.3			1.04	1.03					1.1	1.7	1.98					1.14	1.5															
Rapid Creek 4	8.6	19.6	9.6			1.2														1.15															
SLUEP1	26	5.1				1.1				2.2	8.3	116	12.4			9.4			9.8																
Hazard Quotient Applied to Receiving Waters: Darwin Harbour at East Point																																			
SLUEP2			3.5			>1.0																													
SLUEP3			1.7			>1.0						1.1	1.3	1.7																					
SLUEP4						>1.0						1.1		1.6																					
SLUEP5						>1.0						1.3		1.6																					
SLUEP6			1.6			>1.0								1.6																					
SLUEP7						>1.0						1.1		1.8																					
SLUEP8						>1.0																													

Appendix B Water Quality and Site-specific Trigger Values

Table B-1 WDL150-04 Site Specific Trigger Values

Water Quality Assessment discharge and Receiving Waters and Site Specific Trigger Value determination. Data set Larrakeyah closure 28 May 2012 to 31 July 2014																						
Monitoring data assessment for Site Specific trigger value determination													WDL 150 licence period 31 Oct 2012 to 31 October 2014				Proposed Reporting limit (SSTV)	Compliance Reporting				
Indicator	units	Guideline or objective	Source of trigger value	Zone	Site	n	minimum	20 th percentile	Median	80 th percentile	90 th percentile	95 th percentile	maximum	median	80 th percentile	90 th percentile			95 th percentile			
Pathogen Indicators																						
<i>E. coli</i>	cfu/100 ml	Recreation 200 (non-compliance pink) Food collection 14 median 43 90 th percentile (non-compliance yellow)	DHWQO (2010) primary contact	discharge	SLU080	56	1.0	1.0	60	6120	30 000	260 300	7000 000	84	10 000	51 200	352 000	-	Annual reporting of data against long term 90 th percentile			
					SLUEP01	38	0	1.0	21	378	1 201	2 495	3 100	10	404	706	2507	-	-			
					ZOI	SLUEP02	36	0	0	0	1.0	17.5	24.5	110	0	3.0	20.6	30.2	>-100	Notify of exceedance when median or 90 th percentile of most recent 6 samples exceeds reporting limits		
					SMDZ	SLUEP03	40	0	0	0	0.8	11.2	20	63	0	1.6	12.4	26.1	-	-		
						SLUEP04	38	0	0	0	0	2.8	4.8	12	0	0.4	4.2	5.7	-	-		
						SLUEP05	39	0	0	0	2	7	9.5	15	0	2	6.4	8.7	-	-		
						SLUEP06	37	0	0	0	1	6	17.5	26	0	1.0	5.2	7.3	-	-		
						SLUEP07	40	0	0	0	1.0	3.5	9.5	29	0	1.0	2.3	5.3	-	-		
						SLUEP08	37	0	0	0	0	6.0	17	28	0	0.2	4.4	9.0	-	-		
						SLUEP09	36	0	0	0	0	1.0	5.9	31	0	1.0	1.0	8.0	-	-		
						SLUEP10	38	0	0	0	0	0.5	3.3	41	0	0	1.3	5.9	-	-		
						SLUEP11	38	0	0	0	0	1.5	6.0	48	0	0	3.8	11.1	-	-		
						ZOI	SLULC03	17	8	26	74	260	880	13000	100 000	74	260	880	13 000	>-100	Notify of non-compliance when the median or 90 th percentile of most recent 6 samples exceeds the reporting limit.	
					SMDZ	SLULC01	54	0	25.6	250	608	5700	8525	20000	370	1 002	6 320	9 650	-	-		
						SLULC04	46	0	1.8	14	35	70	3331	26 000	14.5	34	70	4 518	>-14 median >-43 90 th percentile	Notify of non-compliance when the median or 90 th percentile of most recent 6 samples exceeds the reporting limit.		
					Creek Ref.	SNLRC01	32	50	378	500	1580	2110	3375	21 000								
						SNLRC02	29	50	286	860	2700	4500	20000	30 000								
						SNLRC03	24	5	118	415	1160	2940	4745	7 000								
						SNLRC04	29	1	5	120	558	800	1220	2 200								
					Enterococci	cfu/100 ml	Recreation 50 (non-compliance pink)	DHWQO (2010) Primary contact	discharge	SLU080	56	1.0	1.0	10	616	2 880	5 350	200 000	13	626	410	5 880
SLUEP01	38	0	0	4						28	68	117	430	3	25	49	107	-	Annual reporting of data against long term 90 th percentile			
ZOI	SLUEP02	36	0	0						0	7	43.5	93.8	200	0.5	8.8	77.5	105	>-50	Notify of non-compliance where the 95 th percentile of 6 most recent sample (excluding samples following heavy rainfall) exceeds the reporting limit.		
DMZ	SLUEP03	40	0	0						0	3.2	21.4	29.0	110	0	8.2	26	38	-	-		
	SLUEP04	38	0	0						0	1.2	6.8	25.6	50	0	3.2	12.4	32	-	-		
	SLUEP05	39	0	0						0	3.8	31.9	65.7	98	0	2.8	17.6	60.6	-	-		
	SLUEP06	37	0	0						0	1.0	4.5	16.3	45	0	2.4	6.5	21.3	-	-		
	SLUEP07	40	0	0						0	2.0	7.0	14.8	41	0	4.4	8.9	18.2	-	-		
	SLUEP08	37	0	0						0	3.0	14.0	21.5	31	0	5.6	20.2	22.5	-	-		
	SLUEP09	36	0	0						0	1.0	4.4	6.4	16	0	2.0	5.0	7.0	-	-		
	SLUEP10	38	0	0						0	1.0	5.5	7.0	20	0	3.2	7.0	7.7	-	-		
	SLUEP11	38	0	0						0	0	3.5	5.5	20	0	1.2	4.4	7.4	-	-		
	ZOI	SLULC03	17	26						50	80	110	550	1 100	34 000	80	110	550	1100	>-200	Notify of non-compliance where the median of most recent 6 samples (excluding samples following heavy rainfall) exceeds the reporting limit.	
SMDZ	SLULC01	54	3	40						155	458	2 770	6 310	9 100	210	640	4000	6760	-	-		
	SLULC04	46	1	3.8						10.5	31.6	116	682	7 100	10	50	140	868	>-50	Notify of non-compliance when the 90 th percentile of most recent 6 samples (excluding samples following heavy rainfall) exceeds the reporting limit.		
Creek Ref.	SNLRC01	32	74	164						365	658	793	1 385	7 000								
	SNLRC02	29	14	78						320	688	732	1 092	2 700								
	SNLRC03	24	51	234						475	798	921	1 594	1 900								
	SNLRC04	29	7	18						88	244	383	560	880								

Water Quality Assessment discharge and Receiving Waters and Site Specific Trigger Value determination. Data set Larrakeyah closure 28 May 2012 to 31 July 2014																						
Site Specific trigger value determination													WDL 150 31 Oct 2012 to 31 October 2014				Proposed Reporting limit (SSTV)	Compliance Reporting				
Indicator	units	Guideline or objective	Source of trigger value	Zone	Site	n	minimum	20 th percentile	Median	80 th percentile	90 th percentile	95 th percentile	maximum	median	80 th percentile	90 th percentile			95 th percentile			
Physico-chemical Indicators																						
pH		7.0 to 8.5 (non-compliance pink)	DHWQO (2010) mid- estuary	Discharge	SLU080	56	5.99	7.22	8.25	8.79	8.95	9.08	9.17	8.31	8.87	8.99	9.09	-	Annual report compare 90 th percentile to SSTV			
					SLUEP01	38	7.76	7.94	8.10	8.22	8.25	8.27	8.79	7.76	8.13	8.23	8.26	-	-			
					ZOI	SLUEP02	36	7.77	8.01	8.11	8.16	8.23	8.25	8.26	8.13	8.18	8.24	8.25	<-7.0 to >8.5	Report annual compliance based on 95 th percentile compared to SSTV. Report individual non-compliance with reporting limits based on median of most recent 6 samples		
					SMDZ	SLUEP03	40	7.77	8.02	8.11	8.15	8.23	8.25	8.27	8.13	8.17	8.23	8.26	-	-		
						SLUEP04	38	7.77	8.02	8.10	8.16	8.25	8.26	8.28	8.11	8.18	8.25	8.26	-	-		
						SLUEP05	39	7.78	8.01	8.10	8.16	8.24	8.25	8.29	8.11	8.18	8.25	8.25	-	-		
						SLUEP06	37	5.81	7.98	8.09	8.16	8.21	8.24	8.28	8.10	8.16	8.23	8.25	-	-		
						SLUEP07	40	7.76	8.00	8.10	8.19	8.24	8.25	8.37	8.11	8.24	8.25	8.25	-	-		
						SLUEP08	37	7.77	7.99	8.11	8.19	8.24	8.26	8.28	8.12	8.20	8.25	8.27	-	-		
						SLUEP09	36	7.77	8.00	8.11	8.19	8.24	8.26	8.43	8.12	8.20	8.25	8.27	-	-		
						SLUEP10	38	7.79	8.00	8.11	8.19	8.22	8.25	8.29	8.11	8.19	8.21	8.24	-	-		
						SLUEP11	38	7.70	7.98	8.11	8.17	8.19	8.23	8.27	8.11	8.19	8.20	8.24	-	-		
						ZOI	SLULC03	17	7.09	7.46	7.64	7.92	8.05	8.07	8.83	7.64	7.92	8.05	8.07	<-7.0 to >8.5	Report annual compliance based on 95 th percentile compared to SSTV. Report individual non-compliance with reporting limits based on median of most recent 6 samples	
					SMDZ	SLULC01	54	6.87	7.31	7.48	7.62	7.75	7.78	7.93	7.48	7.70	7.76	7.18	-	-		
						SLULC04	46	7.67	7.99	8.09	8.16	8.18	8.32	8.41	8.09	8.17	8.23	8.32	-	-		
					Creek Ref.	SNLRC01	32	5.97	6.52	6.89	7.10	7.40	7.68	8.82								
						SNLRC02	29	6.06	6.62	7.03	7.22	7.34	7.30	7.52								
						SNLRC03	24	6.46	7.40	7.58	7.75	7.81	7.87	7.91								
						SNLRC04	29	6.50	7.48	7.79	7.93	7.97	7.98	8.00								
					EC	µS/cm			Discharge	SLU080	56	260	760	980	1 110	1 230	1 900	54 740	970	1070	1 230	1 960
SLUEP01	38	41 170	47 990	50 300						52 590	53 610	53 640	59 100	50 400	52 350	53 250	53 330	-	-			
ZOI	SLUEP02	36	46 500	50 720						52 400	54 090	54 440	54 540	61 300	52 200	53 500	54 100	54 550	-	-		
SMDZ	SLUEP03	40	46 500	50 700						52 350	53 460	54 410	54 520	61 700	52 250	53 400	53 540	54 820	-	-		
	SLUEP04	38	46 800	50 900						52 400	54 200	54 490	54 630	61 900	52 200	53 610	54 390	54 990	-	-		
	SLUEP05	39	34 690	50 700						52 200	53 930	54 440	54 640	61 900	52 050	53 510	54 070	54 910	-	-		
	SLUEP06	37	47 300	50 940						52 540	54 140	54 410	54 500	61 400	52 400	53 500	54 360	54 540	-	-		
	SLUEP07	40	47 600	50 800						52 400	53 980	54 410	54 550	61 400	52 200	53 500	54 460	54 590	-	-		
	SLUEP08	37	33 490	50 630						52 300	54 020	54 390	54 530	61 200	52 300	53 510	54 390	54 590	-	-		
	SLUEP09	36	33 290	50 640						51 800	53 580	54 350	54 570	61 400	52 000	53 530	54 160	54 680	-	-		
	SLUEP10	38	47 300	51 010						52 680	54 080	54 480	59 530	61 600	52 300	53 600	54 690	61 600	-	-		
	SLUEP11	38	47 600	50 920						52 520	54 140	54 320	55 140	61 600	52 250	53 710	54 320	55 720	-	-		
	ZOI	SLULC03	17	1 630						19 700	44 800	52 400	54 600	55 330	56 700	44 800	52 400	54 600	55 330	-	-	
SMDZ	SLULC01	54	1 010	9 630						48 450	56 420	61 100	63 140	63 520	39 600	53 100	58 160	60 295	-	-		
	SLULC04	46	5 230	49 900						52 340	54 930	55 050	58 600	61 000	52 200	54 636	55 544	59 520	-	-		
Creek Ref.	SNLRC01	32	120	280						8 310	36 860	47 320										

Water Quality Assessment discharge and Receiving Waters and Site Specific Trigger Value determination. Data set Larrakeyah closure 28 May 2012 to 31 July 2014

Site Specific trigger value determination																	WDL 150 31 Oct 2012 to 31 October 2014				Proposed Reporting limit (SSTV)	Compliance Reporting	
Indicator	units	Guideline or objective	Source of trigger value	Zone	Site	n	minimum	20 th percentile	Median	80 th percentile	90 th percentile	95 th percentile	maximum	median	80 th percentile	90 th percentile	95 th percentile						
Dissolved Oxygen	% saturation	80- 100	Note: ANZECC Tropical Estuaries (80-120) (orange)	DHWQO (2010) mid- and upper estuary (pink)	Discharge	SLU080	56	31.40	46.70	57.80	65.70	76.70	82.80	105.7	53.90	63.30	73.50	86.80	Report all results <30% saturation Report individual non-compliance with reporting limits for the median of the 6 most recent samples .				
						SLUEP01	38	75.10	90.50	96.50	101.8	103.9	106.2	111.5	96.10	101.3	105.3	106.9					
					ZOI	SLUEP02	36	83.80	93.56	98.50	103.4	104.6	106.2	106.4	96.80	102.0	104.28	105.5		Report all results <30% saturation Report individual non-compliance with reporting limits for the median of the 6 most recent samples .			
						SLUEP03	40	86.60	92.28	99.20	103.0	103.7	105.1	105.5	97.15	102.6	103.5	104.0					
					SMDZ	SLUEP04	38	83.20	88.98	97.85	101.5	103.8	105.4	106.0	92.15	100.0	101.8	103.4			Report all results <30% saturation Report individual non-compliance with reporting limits for the median of the 6 most recent samples .		
						SLUEP05	39	87.20	90.88	100.0	102.3	104.4	108.4	114.5	94.90	101.4	102.2	103.6					
						SLUEP06	37	80.70	89.08	98.30	100.4	102.3	102.6	106.7	93.10	98.70	100.7	102.6					
						SLUEP07	40	47.40	87.82	95.10	99.30	101.2	102.4	102.5	89.30	98.06	99.30	100.3					
						SLUEP08	37	84.80	87.68	95.50	99.16	101.7	102.	102.8	89.70	97.30	99.52	101.7					
						SLUEP09	36	84.90	88.84	96.80	100.1	101.1	102.6	103.4	91.00	98.40	99.10	100.0					
				ZOI	SLUEP10	38	85.10	89.40	97.02	101.3	102.6	103.3	103.4	93.30	99.48	101.4	102.3	Report all results <30% saturation Report individual non-compliance with reporting limits for the median of the 6 most recent samples .					
					SLUEP11	38	88.90	89.90	99.50	101.5	101.8	102.6	103.6	96.90	100.5	101.5	101.7						
				SMDZ	SLULC03	17	34.90	50.00	62.10	76.70	83.10	84.50	100.5	62.10	76.70	83.10	84.50					Report all results <30% saturation Report individual non-compliance with reporting limits for the median of the 6 most recent samples .	
					SLULC01	54	23.4	35.9	48.0	64.9	83.30	90.80	102.2	44.50	56.20	69.8	80.00						
					SLULC04	46	71.6	85.1	97.2	105.0	114.3	115.6	120.1	96.80	104.6	114.1	115.1						
					Creek Ref.	SNLRC01	32	3.60	60.10	70.50	77.60	83.00	87.40	92.20									
						SNLRC02	29	34.50	70.16	76.70	84.80	91.81	92.99	94.50									
						SNLRC03	24	63.10	76.54	83.90	92.10	96.52	102.1	115.3									
						SNLRC04	29	10.44	62.30	99.25	113.50	118.40	120.6	121.8									

Site Specific trigger value determination																	WDL 150 31 Oct 2012 to 31 October 2014				Proposed Reporting limit (SSTV)	Compliance Reporting
Indicator	units	Guideline or objective	Source of trigger value	Zone	Site	n	minimum	20 th percentile	Median	80 th percentile	90 th percentile	95 th percentile	maximum	median	80 th percentile	90 th percentile	95 th percentile					
TSS	mg/L	6.0 (mid) 10 (upper)	DHWQO (2010) mid- and upper estuary	Discharge	SLU080	56	3.0	26	40	75	105	132	190	37	50	68	84	Annual load based on median. Annual reporting interpretive only				
					SLUEP01	38	1.0	3.0	10.5	16.0	22.0	35.5	72.0	9.5	12.8	17.2	20.0					
					ZOI	SLUEP02	36	0.5	2.0	3.0	6.0	9.5	18	57	3.0	6.2	12.8		22	Report individual non-compliance based on the median of the most recent 6 samples compared to the reporting limit.		
						SLUEP03	40	0.5	2.0	3.0	4.2	6.0	16	37	4.0	5.4	8.6		21			
					SMDZ	SLUEP04	38	0.5	2.0	3.0	5.0	8.4	10	19	4.0	5.4	10		11		Report individual non-compliance based on the median of the most recent 6 samples compared to the reporting limit.	
						SLUEP05	39	0.5	2.0	3.0	5.0	7.0	15	27	4.0	6.0	9.8		18			
						SLUEP06	37	0.5	2.0	4.0	6.0	9.5	20	29	4.0	6.2	13		22			
						SLUEP07	40	1.0	3.0	4.0	6.0	13	21	57	5.0	7.2	18		24			
						SLUEP08	37	1.0	3.0	4.0	7.0	13	18	40	5.5	8.0	15		20			
						SLUEP09	36	1.0	3.0	6.0	9.0	12	20	35	6.0	12	12		23			
				ZOI	SLUEP10	38	2.0	2.0	4.0	9.0	14	17	25	4.5	9.6	15	18		Report individual non-compliance based on the median of the most recent 6 samples compared to the reporting limit.			
					SLUEP11	38	1.0	2.0	4.0	6.0	8.2	13	17	4.0	6.4	10	17					
				SMDZ	SLULC01	54	4.0	8.0	12	19	20	24	36	12	19	21	25					Report individual non-compliance based on the median of the most recent 6 samples compared to the reporting limit.
					SLULC03	17	1.0	8.0	13	20	28	34	34	13	20	28	34					
					SLULC04	46	0.5	3.0	6.0	20	26	34	78	5.5	18	27	34					
					Creek Ref.	SNLRC01	32	0.5	1.0	3.5	6.0	8.5	11	20								
				SNLRC02		29	0.5	3.0	4.0	7.8	9.4	11	24									
				SNLRC03		24	0.5	5.0	12	16	18	26	26									
				SNLRC04		29	1.0	3.0	6.0	8.0	8.4	9.7	14									

Water Quality Assessment discharge and Receiving Waters and Site Specific Trigger Value determination. Data set Larrakeyah closure 28 May 2012 to 31 July 2014

Site Specific trigger value determination																	WDL 150 31 Oct 2012 to 31 October 2014				Proposed Reporting limit (SSTV)	Compliance Reporting
Indicator	units	Guideline or objective	Source of trigger value	Zone	Site	n	minimum	20 th percentile	Median	80 th percentile	90 th percentile	95 th percentile	maximum	median	80 th percentile	90 th percentile	95 th percentile					
BOD	Mg/L	-	ANZECC Tropical Estuaries	Discharge	SLU080	56	1.0	59.4	106	140	167	218	235	92	120	146	153	Annual load based on median				
					SLUEP01	38	1.0	1.0	3.0	14.0	17.5	18.8	24	1.5	5.0	6.9	15					
					ZOI	SLUEP02	36	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		1.0	Annual report interpretive only Compare annual median to reporting limit.		
						SLUEP03	40	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		1.0			
					SMDZ	SLUEP04	38	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		1.0		Annual report interpretive only Compare annual median to reporting limit.	
						SLUEP05	39	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		1.0			
						SLUEP06	37	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		1.0			
						SLUEP07	40	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		1.0			
						SLUEP08	37	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		1.0			
						SLUEP09	36	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		1.0			
				ZOI	SLUEP10	38	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		Annual report interpretive only. Compare annual median to reporting limit.			
					SLUEP11	38	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0					
				SMDZ	SLULC03	17	1.0	1.0	1.0	3.2	5.6	9.6	24	1.0	3.2	5.6	9.6					Annual report interpretive only. Compare annual median to reporting limit.
					SLULC01	54	1.0	1.0	1.0	1.0	3.0	3.5	10	1.0	1.0	2.5	3.8					
					SLULC04	46	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0					
					Creek Ref.	SNLRC01	32	1.0	1.0	1.0	1.0	1.7	2.7	3.0								
				SNLRC02		29	1.0	1.0	1.0	1.0	1.0	1.7	2.0									
				SNLRC03		24	1.0	1.0	1.0	1.0	1.9	2.8	3.0									
				SNLRC04		29	1.0	1.0	1.0	2.0	2.0	2.0	2.0									

Water Quality Assessment discharge and Receiving Waters and Site Specific Trigger Value determination. Data set Larakeyah closure 28 May 2012 to 31 July 2014

Indicator	units	Guideline value or objective	Source of trigger value	Zone	Site	n	Site Specific trigger value determination							WDL 150 31 Oct 2012 to 31 October 2014				Proposed Reporting limit (SSTV)	Compliance Reporting	
							minimum	20 th percentile	Median	80 th percentile	90 th percentile	95 th percentile	maximum	median	80 th percentile	90 th percentile	95 th percentile			
FRP (Filterable reactive phosphorus)	µg/L	5	DHWQO (2010) mid-estuary	Discharge	SLU080	56	1.5	286	746	2138	3768	4302	4960	703	1612	2129	2672	-	Report annual loads (tonne/year) from discharge points	
					SLUEP01	38	1.5	8.0	110	402	725	903	1020	16	205	372	481			
					ZOI	SLUEP02	36	1.5	4.0	7.5	11	13	17.5	25	6.0	10	11.2			13.3
						SLUEP03	40	1.5	4.0	8.0	12	16	22	48	8.0	12	17.6			26.4
						SLUEP04	38	1.5	4.0	7.0	10.2	15.4	17.0	24	5.0	8.0	10.0			10.1
					SMDZ	SLUEP05	39	1.5	4.0	6.5	10	12	13.8	14	6.0	8.4	10.0			10.4
						SLUEP06	37	1.5	4.0	5.5	8.0	11	12	16	5.0	8.0	10.2			12.0
						SLUEP07	40	1.5	4.0	5.5	9.0	11.5	12.8	16	5.5	7.4	10.1			11.1
						SLUEP08	37	1.5	4.0	7.0	11	14.5	15.0	16.0	7.0	10.2	12.3			15.0
						SLUEP09	36	1.5	4.2	6.0	10.8	18.2	20.7	21.0	7.0	8.0	11.0			17.0
						SLUEP10	38	1.5	4.0	5.0	11.0	12.0	12.8	16.0	5.0	8.0	10.2			12.1
				SLUEP11	38	1.5	4.0	6.0	9.2	11.2	13.6	22.0	6.0	6.4	8.0	8.4				
				10	ZOI	SLULC03	17	1.5	5.0	10.5	29.2	69.4	112	114	11	32	73	114		
						SMDZ	SLULC01	54	1.5	9.0	15	34	47	69.5	2050	18	39	58	69	
							SLULC04	46	1.5	4.0	6.0	10	11	16	21	5.0	8.0	10	16	
					Creek Ref.	SNLRC01	32	1.5	3.4	7.0	10.0	12.6	15.3	20.0						
						SNLRC02	29	1.5	3.0	6.5	8.6	12.3	15.0	17.0						
						SNLRC03	24	1.5	4.4	6.0	8.8	11.8	17.4	22.0						
						SNLRC04	29	1.5	4.0	6.5	11.0	12.0	14.5	15.0						

Indicator	units	Guideline value or objective	Source of trigger value	Zone	Site	n	Site Specific trigger value determination							WDL 150 31 Oct 2012 to 31 October 2014				Proposed Reporting limit (SSTV)	Compliance Reporting		
							minimum	20 th percentile	Median	80 th percentile	90 th percentile	95 th percentile	maximum	median	80 th percentile	90 th percentile	95 th percentile				
NH3-N (Total Ammonia)	µg/L	(lower - nutrient stressor trigger) 20 (Upper - toxicant trigger) 910 pH 8.0 (see ANZECC/ARMC ANZ 2000 Table 8.3.7)	DHWQO (2010) mid and upper estuary (pink non-compliance) and ANZECC (2000) SMD marine ecosystem (orange non-compliance)	Discharge	SLU080	56	4678	21476	32290	37244	38432	40582	47510	30790	37432	38848	40842	-	Report annual loads (tonne/year) from discharge points		
					SLUEP01	38	2.5	1220	2790	5114	7386	7587	19800	2339	3366	6972	7564				
					ZOI	SLUEP02	36	2.5	2.5	11	125	191	249	337	10.5	71	138			162	
						SMDZ	SLUEP03	40	2.5	2.5	19	38	72.5	119	350	25	38			92.8	150
							SLUEP04	38	2.5	2.5	5.0	10.6	18.2	44.2	227	5.0	11.2			15.4	23.9
					SLUEP05	39	2.5	2.5	2.5	9.0	19.5	62.8	390	2.5	11.8	33.9	107				
					SLUEP06	37	2.5	2.5	2.5	2.5	7.0	16.8	20.0	2.5	6.2	8.3	20.0				
					SLUEP07	40	2.5	2.5	2.5	7.0	10.0	14.0	20.0	2.5	8.2	11.4	15.3				
					SLUEP08	37	2.5	2.5	2.5	9.0	11.0	12.5	38.0	2.5	9.4	11.2	14.3				
					SLUEP09	36	2.5	2.5	2.5	6.8	9.0	10.4	33.0	2.5	8.0	9.0	11.0				
					SLUEP10	38	2.5	2.5	2.5	5.0	7.0	8.0	43.0	2.5	6.0	8.0	9.8				
				SLUEP11	38	2.5	2.5	2.5	5.0	7.5	8.0	9.0	2.5	7.0	8.0	8.1					
				ZOI	SLULC03	17	2.5	2.5	13	722	2200	2747	21300	13	722	2200	2750				
					SMDZ	SLULC01	54	2.5	2.5	46	143	215	333	441	54	120	214	320			
						SLULC04	46	2.5	2.5	2.5	14.6	18.3	52.9	110	2.5	17.0	20.0	65.0			
				Creek Ref.	SNLRC01	32	2.5	14	22	43.6	61.4	74.4	113								
					SNLRC02	29	2.5	15.0	25	42.6	58.2	81.2	102								
					SNLRC03	24	2.5	8.4	14.0	21.2	27.0	30.7	58.0								
					SNLRC04	29	2.5	9.0	16.0	21.6	37.8	50.6	55.0								
				TN (Total nitrogen)	µg/L	270	DHWQO (2010) mid-estuary (pink non-compliance)	Discharge	SLU080	56	8570	26020	36500	45460	47040	49840	212000	34100	42640	46220	49860
SLUEP01	38	760	1596						4050	6534	9588	10690	10900	3360	4760	6820	9180				
ZOI	SLUEP02	36	100						250	430	600	705	915	1220	480	658	746	992			
	SMDZ	SLUEP03	40						100	258	310	552	734	946	1050	450	608	814	996		
		SLUEP04	38						30	208	370	522	572	600	610	420	530	600	601		
SLUEP05	39	110	220						330	480	505	580	690	440	484	536	609				
SLUEP06	37	100	214						410	518	604	772	910	430	556	639	815				
SLUEP07	40	100	260						410	600	640	678	970	495	602	645	704				
SLUEP08	37	30	200						380	610	775	1013	1250	390	690	811	1098				
SLUEP09	36	100	202						370	616	820	890	930	460	670	820	920				
SLUEP10	38	110	230						380	640	770	1095	1990	430	652	874	1120				
SLUEP11	38	30	180					305	480	575	635	1320	420	560	602	717					
300	ZOI	SLULC03	17					400	560	940	1790	3190	3220	27000	940	1790	3190	3220			
		SMDZ	SLULC01					54	280	540	880	1040	1170	1315	2740	910	1130	1220	1340		
			SLULC04					46	110	278	505	686	828	900	1040	535	680	860	900		
	Creek Ref.	SNLRC01	32					110	230	295	378	439	700	1020							
		SNLRC02	29					140	212	330	492	624	692	860							
		SNLRC03	24					35.0	282	510	634	670	742	840							
		SNLRC04	29					110	240	290	360	450	483	550							

Water Quality Assessment discharge and Receiving Waters and Site Specific Trigger Value determination. Data set Larrakeyah closure 28 May 2012 to 31 July 2014

Site Specific trigger value determination														WDL 150 31 Oct 2012 to 31 October 2014				Proposed Reporting limit (SSTV)	Compliance Reporting	
Indicator	units	Guideline value or objective	Source of trigger value	Zone	Site	n	minimum	20 th percentile	Median	80 th percentile	90 th percentile	95 th percentile	maximum	median	80 th percentile	90 th percentile	95 th percentile			
Nutrient Indicators (continued)																				
NOx as N (oxides of nitrogen)	µg/L		DHWQO (2010) mid-estuary	Discharge	SLU080	56	24.0	38.8	80.5	140	179	248	576	83.5	153	186	366	>17	Report annual loads (tonne/year) from discharge points	
					SLUEP01	38	1.5	4.0	6.0	9.0	10.5	11.8	40	6.0	9.2	11.1	13.4			
					ZOI	SLUEP02	36	1.5	1.5	4.0	6.0	7.5	22.3	37	4.0	7.0	9.9			27.5
					SMDZ	SLUEP03	40	1.5	1.5	5.0	8.0	8.0	22.4	27	6.0	8.0	11.6			26.1
						SLUEP04	38	1.5	3.5	6.0	10.0	13.4	19.8	2.30	6.0	10.4	16.2			21.2
						SLUEP05	39	1.5	1.5	4.0	6.2	8.6	9.8	12.0	4.0	10.4	16.2			21.2
						SLUEP06	37	1.5	1.5	4.0	7.0	7.6	8.0	13.0	4.0	7.0	8.0			8.5
					ZOI	SLUEP07	40	1.5	1.5	4.0	7.0	9.5	13.0	15.0	5.0	7.0	9.1			10.2
						SLUEP08	37	1.5	1.5	4.0	9.0	12.4	24.4	28.0	5.0	9.4	16.6			27.1
						SLUEP09	36	1.5	1.5	1.5	6.0	8.0	10.3	17.0	2.3	6.4	8.3			11.3
						SLUEP10	38	1.5	1.5	1.5	6.2	8.2	14.6	16.0	3.5	7.0	10.4			16.0
					SMDZ	SLUEP11	38	1.5	1.5	1.5	6.2	7.6	8.8	9.0	1.5	6.0	7.0			7.2
						SLULC03	17	1.5	1.5	14.5	81.6	158	184	184	14.5	81.6	158			184
						SLULC01	54	1.5	2.5	27	48	103	125	141	31	63	103			131
						SLULC04	46	1.5	1.5	4.0	14.4	27.3	28.7	94	4.0	13.6	25.8			27.9
					Creek Ref.	SNLRC01	32	1.5	2.2	33	61	88	107	123						
SNLRC02	29	4.0	20	31		62	71.8	91	119											
SNLRC03	24	1.5	15.6	59.5		232	362	368	450											
SNLRC04	29	1.5	6.4	16.0		39.0	76.8	92.8	150											

Site Specific trigger value determination														WDL 150 31 Oct 2012 to 31 October 2014				Proposed Reporting limit (SSTV)	Compliance Reporting			
Indicator	units	Guideline value or objective	Source of trigger value	Zone	Site	n	minimum	20 th percentile	Median	80 th percentile	90 th percentile	95 th percentile	maximum	median	80 th percentile	90 th percentile	95 th percentile					
Metals and Metalloids in licence (continued)																						
Cu (T) (Copper - total)	µg/L	1.3 (SMD) (light orange non-compliance) 3.0 (D) (orange non-compliance) 8.0 (HD) (red non-compliance)	ANZECC (2000) SMD marine ecosystem	Discharge	SLU080	56	27.7	57.6	70.7	140	177	208	383	65.9	97.4	115	159	>8 µg/L	Report annual load (kg/year) from discharge Annual Report to compare annual trend in 95 th percentile to SSTV			
					SLUEP01	38	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5			0.5		
					ZOI	SLUEP02	36	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5			0.5	0.5	
						SMDZ	SLUEP03	40	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5			0.5	0.5	0.5
							SLUEP04	38	0.5	0.5	0.5	0.5	0.5	0.5	1.7	3.0	0.5			0.5	0.5	0.5
							SLUEP05	39	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.0	0.5			0.5	0.5	0.5
					ZOI		SLUEP06	37	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.63	4.0			0.5	0.5	0.5
						SLUEP07	40	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.88	2.0	0.5			0.5	0.5	0.5
						SLUEP08	37	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	2.0	0.5			0.5	0.5	0.5
						SLUEP09	36	0.5	0.5	0.5	0.5	0.5	1.5	2.0	2.0	0.5	0.6			2.0	2.0	
					SMDZ	SLUEP10	38	0.5	0.5	0.5	0.5	0.5	0.5	0.68	2.0	0.5	0.5			0.5	0.5	
						SLUEP11	38	0.5	0.5	0.5	0.5	0.5	1.5	2.0	2.0	0.5	0.5			1.2	2.0	
						SLULC03	17	0.5	0.5	0.5	1.6	3.6	5.8	38.0	0.5	2.0	4.0			6.0		
						SLULC01	54	0.5	0.5	2.0	2.0	2.0	2.6	4.0	0.5	1.2	2.0			2.0		
					Creek Ref.	SLULC04	46	0.5	0.5	0.5	2.0	3.0	4.3	13.0	0.5	2.0	2.7			4.7		
						SNLRC01	32	0.05	0.50	0.70	2.00	2.90	3.45	7.00								
SNLRC02	29	0.30	0.50	0.50		0.94	2.00	2.60	3.20													
SNLRC03	24	0.30	0.50	0.50		1.00	1.70	2.00	2.00													
Cu (D) (Copper - dissolved)	µg/L	1.3 (SMD) 3.0 (D) 8.0 (HD)	ANZECC (2000) SMD marine ecosystem	Discharge	SLU080	32	2.40	4.30	11.8	44.8	73.6	86.8	155	9.3	35.8	54.7	62.1	>1.3 µg/L (slightly to moderately disturbed)	Report annual load (kg/year) from discharge Annual Report to compare 95 th percentile to SSTV			
					SLUEP01	10	0.5	0.5	1.0	6.0	10.0	12.3	13.0	0.5	1.0	4.0	5.0					
					ZOI	SLUEP02	10	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5			0.5		
						SMDZ	SLUEP03	10	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.0	0.5			0.5	0.5	
							SLUEP04	10	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.0	0.5			0.5	0.5	
							SLUEP05	10	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5			0.5	0.5	
					ZOI		SLUEP06	10	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5			0.5	0.5	
						SLUEP07	10	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5			0.5		
						SLUEP08	10	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5			0.5		
						SLUEP09	10	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5			0.5		
					SMDZ	SLUEP10	10	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5			0.5		
						SLUEP11	10	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.0	0.5	0.5			0.5		
						SLULC03	10	0.5	0.5	0.5	0.5	1.3	4.6	16.0	0.5	0.5	1.3			4.6		
						SLULC01	10	0.4	0.5	0.5	0.5	0.75	1.75	4.0	0.5	0.5	0.5			1.0		
					Creek Ref.	SLULC04	10	0.5	0.5	0.5	0.5	0.75	1.00	11.0	0.5	0.5	0.98			3.9		
						SNLRC01	8	0.30	0.50	0.50	0.50	0.95	1.48	2.00								
SNLRC02	8	0.50	0.50	0.50		0.50	0.50	0.50	0.50													
SNLRC03	8	0.50	0.50	0.50		0.50	0.95	1.48	2.00													
Creek Ref.	SNLRC04	8	0.50	0.50	0.50	0.50	0.50	0.50	0.50													

Water Quality Assessment discharge and Receiving Waters and Site Specific Trigger Value determination. Data set Larrakeyah closure 28 May 2012 to 31 July 2014

Site Specific trigger value determination															WDL 150 31 Oct 2012 to 31 October 2014				Proposed Reporting limit (SSTV)			
Indicator	units	Guideline value or objective	Source of trigger value	Limit of reporting	Site	n	minimum	20 th percentile	Median	80 th percentile	90 th percentile	95 th percentile	maximum	median	80 th percentile	90 th percentile	95 th percentile					
Hg (T) (Mercury – Total)	µg/L	0.4 (SMD) 0.7 (D) 1.4 (HD)	ANZECC (2000) SMD marine ecosystem	Discharge	SLU080	56	0.015	0.030	0.060	0.120	0.150	0.150	0.400	0.060	0.110	0.150	0.150	>0.4 µg/L	Report annual load (kg/year) from discharge. Annual report compare 95 th percentile to SSTV			
					SLUEP01	38	0.150	0.150	0.150	0.150	0.150	0.325	0.505	0.150	0.150	0.150	0.150					
					ZOI	SLUEP02	36	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.338	0.600	0.150			0.150	0.150	0.150
						SLUEP03	40	0.150	0.150	0.150	0.150	0.150	0.150	0.278	0.400	0.150	0.150			0.150	0.173	
					SMDZ	SLUEP04	38	0.150	0.150	0.150	0.150	0.150	0.240	0.300	0.400	0.150	0.150			0.300	0.310	
						SLUEP05	39	0.150	0.150	0.150	0.340	0.480	0.640	0.800	0.150	0.300	0.520			0.660		
						SLUEP06	37	0.150	0.150	0.150	0.150	0.150	0.338	0.600	0.150	0.150	0.150			0.163		
						SLUEP07	40	0.150	0.150	0.150	0.150	0.150	0.263	0.300	0.150	0.150	0.150			0.158		
						SLUEP08	37	0.150	0.150	0.150	0.150	0.150	0.263	0.400	0.150	0.150	0.150			0.163		
						SLUEP09	36	0.150	0.150	0.150	0.150	0.150	0.338	0.500	0.150	0.150	0.150			0.163		
						SLUEP10	38	0.150	0.150	0.150	0.150	0.300	0.375	0.700	0.150	0.150	0.300			0.305		
						SLUEP11	38	0.150	0.150	0.150	0.150	0.300	0.375	0.700	0.150	0.150	0.180			0.310		
						ZOI	SLULC03	17	0.150	0.150	0.150	0.150	0.270	0.390	0.400	0.150	0.150			0.300	0.400	
							SLULC01	54	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150			0.150	0.150	
					SMDZ	SLULC04	46	0.150	0.150	0.150	0.150	0.360	0.500	0.500	0.150	0.150	0.440			0.500		
						SNLRC01	32	0.015	0.015	0.015	0.015	0.015	0.300	0.400								
					Creek Ref.	SNLRC02	29	0.015	0.150	0.150	0.150	0.180	0.360	0.400								
						SNLRC03	24	0.015	0.150	0.150	0.150	0.150	0.617	1.500								
						SNLRC04	29	0.030	0.150	0.150	0.150	0.400	0.660									

Site Specific trigger value determination															WDL 150 31 Oct 2012 to 31 October 2014				Proposed Reporting limit (SSTV)		
Indicator	units	Guideline value or objective	Source of trigger value	Limit of reporting	Site	n	minimum	20 th percentile	Median	80 th percentile	90 th percentile	95 th percentile	maximum	median	80 th percentile	90 th percentile	95 th percentile				
Metals and Metalloids in licence (continued)																					
Zn (T) (Zinc – total)	µg/L	15 smd 23 d 43 hd	ANZECC (2000) SMD marine ecosystem	Discharge	SLU080	56	3.50	10.3	15.7	47.0	72.4	85.4	165	14.5	29.4	47.0	54.2	>15 µg/L	Report annual load (kg/year) from discharge		
					SLUEP01	38	1.50	1.50	4.00	10.4	12.6	18.5	20.0	1.5	5.0	8.0	11.0				
					ZOI	SLUEP02	36	1.50	1.50	1.50	1.50	3.50	4.75	8.00	1.50	1.50	3.00			3.10	
						SLUEP03	40	1.50	1.50	1.50	3.00	4.60	5.00	7.00	1.50	3.40	5.00			5.20	
					SMDZ	SLUEP04	38	1.50	1.50	1.50	4.20	5.00	9.00	25.0	1.50	4.40	6.00			11.50	
						SLUEP05	39	1.50	1.50	1.50	3.00	4.00	4.75	11.0	1.50	3.40	4.20			5.60	
						SLUEP06	37	1.50	1.50	1.50	1.50	4.00	6.25	27.0	1.50	3.20	4.30			8.00	
						SLUEP07	40	1.50	1.50	1.50	1.50	3.00	3.75	5.00	1.50	1.50	3.10			4.05	
						SLUEP08	37	1.50	1.50	1.50	1.50	3.50	4.75	6.00	1.50	1.50	1.75			4.05	
						SLUEP09	36	1.50	1.50	1.50	1.50	4.00	4.50	5.00	9.00	1.50	3.20			4.10	
						SLUEP10	38	1.50	1.50	1.50	4.00	4.50	8.00	11.0	1.50	4.00	5.40			9.10	
						SLUEP11	38	1.50	1.50	1.50	7.00	7.50	9.50	12.0	1.50	4.00	6.40			8.40	
						ZOI	SLULC03	17	1.50	1.50	4.00	6.80	11.6	13.9	17.0	4.50	7.20			12.2	14.2
							SLULC01	54	1.50	1.50	3.10	8.00	9.20	11.2	36.0	2.30	6.20			8.00	9.7
					SMDZ	SLULC04	54	1.50	1.50	1.50	5.80	6.80	8.70	10.0	1.50	4.60	6.00			8.70	
						SNLRC01	32	0.15	2.20	8.00	11.0	13.8	14.8	15.0							
					Creek Ref.	SNLRC02	29	1.50	3.02	5.00	9.00	11.0	12.8	15.0							
						SNLRC03	24	1.50	1.50	4.00	6.00	7.70	8.00	8.00							
						SNLRC04	29	1.50	1.50	1.50	4.00	4.40	7.20	9.00							

Indicator	units	Guideline value or objective	Source of trigger value	Limit of reporting	Site	n	minimum	20 th percentile	Median	80 th percentile	90 th percentile	95 th percentile	maximum	median	80 th percentile	90 th percentile	95 th percentile
4-t-octylphenol	ng/L	No guidelines	Discharge	SLU080	56	<10							1300	<10			
				SLUEP01	38	<10									46	<10	
Nonylphenol	ng/L	No guidelines	Discharge	SLU080	56	<100							3400	<100			
				SLUEP01	38	<100									710	230	
Bisphenol A	ng/L	No guidelines	Discharge	SLU080	56	<10							680	<10			
				SLUEP01	38	<10									34	13	
Androsterone	ng/L	No guidelines	Discharge	SLU080	56	<5							6900	<5			
				SLUEP01	38	<5									570	<5	
Etiocanolone	ng/L	No guidelines	Discharge	SLU080	56	<5							4500	<5			
				SLUEP01	38	<5									1300	420	

Stable Isotope ratios in biota and sediments																			
Indicator	units	Guideline value or objective	Source of trigger value	Limit of reporting	Site	n	minimum	20 th percentile	Median	80 th percentile	90 th percentile	95 th percentile	maximum	median	80 th percentile	90 th percentile	95 th percentile		
δN14:15 ratio	‰	Based on SEQ Report Card Criteria for macro-algae	Discharge	SLULC01	17													>8	
				SLULC03	17														>6
				SLULC04	17														