EPL228 Annual Environmental Monitoring Report 2018-2019

REP - Report (Reviews-Study-Survey)

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ABBREVIATION AND DEFINITIONS

Abbreviation	Details
AEMR	annual environmental monitoring report
AGRU	acid gas removal unit
aMDEA	activated methyl diethanolamine
AOC	accidently oil contaminated
AQMS	air quality monitoring stations
ASU	artificial settlement unit
BTEX	benzene, toluene, ethylbenzene, xylenes
CCPP	combined cycle power plant
CCR	central control room
CFI	calibrated field instrument
CFU	colony-forming unit
COA	certificate of analysis
EPL228	Environment Protection Licence 228 (as amended)
GEP	gas export pipeline
HM	hinterland margin
HRSG	heat recovery steam generators
LNG	liquified natural gas
LOR	limit of reporting
LPG	liquified petroleum gas
MEG	mono ethylene glycol
MDEA	methyl diethanolamine
MPN	most probable number
NATA	National Association of Testing Authorities, Australia
NCW	non-contaminated water
NGERS	National Greenhouse and Energy Reporting Scheme
NPI	National Pollutant Inventory
NSW	New South Wales
NT	Northern Territory
NT DPIR	Northern Territory Department of Primary Industry and Resources
NT EPA	Northern Territory Environment Protection Authority
OEMP	Onshore Operations Environmental Management Plan
PAH	polycyclic aromatic hydrocarbons
PCS	program control system
QA/QC	quality assurance/quality control
REMP	Receiving Environment Monitoring Program

Abbreviation	Details
SQGV	sediment quality guideline value
SWL	standing water level
TC	tidal creek
TEG	Triethylene glycol
TF	tidal flat
TKN	total Kjeldahl nitrogen
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TRH	total recoverable hydrocarbons
UV	ultraviolet

EXECUTIVE SUMMARY

Ichthys LNG Pty Ltd was issued Environment Protection Licence 228 (as amended; EPL228) on 13 December 2017. Activation of EPL228 occurred on 14 September 2018 triggering several EPL228 monitoring conditions and Onshore Operations Environmental Management Plan monitoring commitments.

This Annual Environmental Monitoring Report (AEMR) has been developed to meet Condition 90 of EPL228. Condition 90 requires an AEMR to be submitted to the Northern Territory Environment Protection Authority (NT EPA) for each year of the licence unless otherwise agreed, for scheduled activates conducted during the preceding 12 months (e.g. the reporting period). For the purpose of this AEMR and as agreed with NT EPA, the reporting period is defined as 14 September 2018 (EPL228 activation) to 30 June 2019.

Monitoring undertaken during the reporting period found that liquid effluent discharges were typically within EPL228 discharge limits and these discharges had no discernible impact on Darwin Harbour. No data was collected for three of the four emissions to air monitoring programs as they were either not triggered during the reporting period or once triggered, monitoring commenced outside the reporting period. Dark-smoke event monitoring was the only emissions to air monitoring program required during the reporting period, with no dark-smoke events reported. All other monitoring programs (e.g. groundwater, mangroves, weeds) found that monitoring results were consistent with those reported for Ichthys LNG during the construction phase and/or there were no Ichthys LNG attributable impacts. Based on monitoring results for the reporting period, there were no adverse affects to the declared beneficial uses and objectives of Darwin Harbour or Elizabeth-Howard River Region Groundwater.

1 INTRODUCTION

Ichthys LNG Pty Ltd (hereafter referred to as INPEX) was issued Environment Protection Licence 228 (as amended and hereafter referred to as the EPL228; L290-AH-LIC-60001) on 13 December 2017 with a validity of five years for the purposes of:

> *Operating premises for processing hydrocarbons so as to produce, store and/or despatch liquefied natural gas or methanol, where:*
>
> *a) the premises are designed to produce more than 500,000 tonnes annually of liquefied natural gas and/or methanol; and*
>
> *b) no lease, licence or permit under the Petroleum Act or the Petroleum (Submerged lands) Act relates to the land on which the premises are situated.*
>
> *All the activities in relation to onshore production design capacity of 12.15 million tonnes per annum of hydrocarbons, being up to:*
>
> - *8.9 million tonnes of liquefied natural gas per annum from two LNG processing trains;*
> - *1.65 million tonnes of liquefied petroleum gas per annum; and*
> - *20,000 barrels of condensate per day (1.6 million tonnes of condensate per annum).”*

On 14 September 2018 the Licensed Activity commenced after receipt of offshore Ichthys Field gas to the Licensed Premises through the gas export pipeline (GEP). From 14 September 2018 to 19 June 2019 onshore liquified natural gas (LNG) trains 1 and/or 2 operated in accordance with the definition of First Start-up. On 19 June 2019 INPEX reached First Steady State for LNG trains 1 and 2.

1.1 Purpose

The purpose of this annual environmental monitoring report (AEMR) is to satisfy Condition 91 of the EPL228 for the Ichthys LNG. The reporting period for this AEMR is 14 September 2018 to 30 June 2019[1].

1.2 Condition 91 requirements

Table 1-1 provides details of Condition 91 of EPL228 as it relates to the annual environmental monitoring report requirements and the relevant section for where it has been addressed within this AEMR.

Table 1-1: Annual environmental monitoring report condition requirements

EPL228 Condition #	Condition detail	Section
91	The Annual Environmental Monitoring Report must:	-
91.1	report on monitoring required under this licence;	This AEMR

[1] AEMR reporting period was agreed with NT EPA via email on 10 August 2019 to cover a 12-month period from 1 July to 30 June. However, as EPL228 was only activated part way through the reporting period on 14 September 2018, the reporting period for this AEMR only covers the nine and a half month period from EPL228 activation until 30 June 2019.

EPL228 Condition #	Condition detail	Section
91.2	summarise performance of the authorised discharge to water, compared to the discharge limits and trigger values specified in Table 3 in Appendix 2;	2.1 and 2.2
91.3	summarise performance of the authorised emissions to air, compared to the emission limits and targets specified in Table 5 in Appendix 3, when the fuel burning or combustion facilities for the Scheduled Activity have operated under normal and maximum operating conditions for the annual period;	3.2
91.4	summarise operating conditions of each emission source and the resulting air emission quality;	3.2
91.5	provide total emissions to air in tonnes per year for the air quality parameters listed in Table 6 in Appendix 3;	3.2
91.6	assess the contribution of the authorised emissions on the Darwin region ambient air quality during periods not affected by bushfire smoke for Wet and Dry seasons;	3.1
91.7	report on outcomes of the Receiving Environment Monitoring Program (REMP) monitoring and assessment;	2 to 5
91.8	summarise measures taken to reduce waste;	6
91.9	consider the NT EPA Guideline for Reporting on Environmental Monitoring;	Appendix A
91.10	be reviewed by Qualified Professional(s); and	Appendix B
91.11	be provided to the Northern Territory Environment Protection Authority (NT EPA) with the Qualified Professional(s) written, certified review(s) of the Annual Environmental Monitoring Report.	Appendix B

1.3 Program objectives

An overview of the environmental monitoring programs, their objectives and cross-references to sections within the AEMR which provide more detail, are listed in Table 1-2.

Table 1-2: Monitoring program objectives

Program	Objective	Section
Commingled treated effluent (750-SC-003)	To ensure commingled treated effluent does not exceed discharge criteria specified in EPL228	2.1
Jetty outfall	To determine if liquid discharges from the jetty outfall are within acceptable limits	2.2
Harbour sediment	To detect changes in surficial sediment quality in the vicinity of the jetty outfall and determine if changes are attributable to Ichthys LNG operations	2.3
Ambient air quality	To assess the potential impact of Ichthys LNG air emissions on the Darwin region	3.1
Point source emissions to air	To determine if air emissions from stationary point sources are within acceptable limits	3.2
Dark-smoke events	To determine if air emissions from the flare systems are within acceptable limits	3.3

Program	Objective	Section
Airborne noise	To validate the noise model and confirm model predictions at sensitive locations	3.4
Groundwater quality	To detect changes in groundwater quality and determine if these changes are attributable to Ichthys LNG operations	4.1
Mangrove health, intertidal sediment and bio-indicator	To informatively monitor mangroves adjacent to the Ichthys LNG Plant. To detect changes in intertidal sediment quality attributable to Ichthys LNG Plant operations To determine through bio-indicator monitoring if changes in seafood quality is occurring and if so determine if it is attributable to Ichthys LNG Plant operations.	5.1
Nearshore marine pests	To assess the presence/absence of invasive marine pest at the Ichthys LNG product loading jetties, through a coordinated approach with the NT Biosecurity Unit	5.2
Introduced terrestrial fauna	To determine the presence, location and methods used to control nuisance species	5.3
Weed survey	To identify the abundance and spatial distribution of known and new emergent weed populations, especially in areas susceptible to weed invasion, to inform weed management control activities.	5.4
Weed management	To manage invasive weeds onsite	5.6
Vegetation rehabilitation monitoring	To determine if vegetation recovery through natural processes has occurred	5.6
Cultural heritage	To determine if there has been any interference to cultural heritage sites.	5.7

1.4 Site information

1.4.1 Ichthys LNG operations

Throughout the reporting period Ichthys LNG was in a number of operating states (e.g. start-up, steady state) based on the definitions provided in EPL228. This is important to note as different operating states trigger different EPL228 Conditions and associated monitoring requirements which are further discussed in the relevant monitoring programs. Table 1-3 provides an overview of the Ichthys LNG facility key milestones for the reporting period

Table 1-3: Ichthys LNG key milestones during the reporting period

Date	Report
13 Dec 2017	EPL228-01 issued
14 Sep 2018	EPL228-01 was activated to cover the operational phase of the facilities (LNG Train 1, Train 2, associated utilities and three of the combined cycle power plant (CCPP) gas turbines in open cycle)
01 Oct 2018	Offshore feed gas introduced to Ichthys LNG inlet facilities
03 Oct 2018	First condensate rundown
12 Oct 2018	First LNG Train 2 rundown
17 Oct 2018	Final two of the CCPP gas turbines in open cycle transferred across to EPL228-01
22 Oct 2018	First LNG cargo
05 Nov 2018	First LNG Train 1 rundown
21 Dec 2018	Inclusion of the sewage treatment plant into EPL228-01, following the issue of the Department of Health approval to cover the operational phase of the sewage treatment plant
04 Feb 2019	CCPP open cycle in steady state operations
19 Jun 2019	LNG Train 1 and 2 both in steady state operations

1.4.2 Environmental context

Ichthys LNG is located on Bladin Point, on the northern side of Middle Arm Peninsula in Darwin Harbour (Figure 1-1). Bladin Point is a low-lying peninsula in Darwin Harbour, which is separated from the mainland by a mudflat. Ichthys LNG is approximately 4 km from Palmerston (the nearest residential zone) and approximately 10 km south-east of the Darwin CBD, across Darwin Harbour waters.

Ichthys LNG lies in the monsoonal tropics of northern Australia, which has two distinct seasons; a hot wet season from November to April and a warm dry season from May to October. April and October are transitional months between the wet and dry seasons with an overall mean annual rainfall of around 1,730 mm. Rainfall during the reporting period was well below average with only 1,020 mm recorded over the wet season, more than 500 mm below average (Figure 1-2 and Table 1-4). The 2018/2019 wet season was also the driest wet season on record since monitoring commenced at Ichthys LNG (Figure 1-2).

Figure 1-1: Location of Ichthys LNG

Table 1-4: Bladin Point wet season and transition month rainfall

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Darwin average	70.6	141.7	250.8	426.3	374.6	319.0	102.2
2012/2013	36.8	199.8	232.4	282.8	291.2	415.2	141.6
2013/2014	134.8	352	268	780	335	14.4	111
2014/2015	13	226.4	175.4	630	492.2	233.8	54.2
2015/2016	12.6	140.6	709.4	243.2	213.4	231.8	63.8
2016/2017	83.8	265.4	469.8	614.2	736	515.8	220.6
2017/2018	93	249.2	125.4	1031.6	380.4	423.4	39
2018/2019	2.6	183.8	91.6	311.4	159.6	147.8	125.8

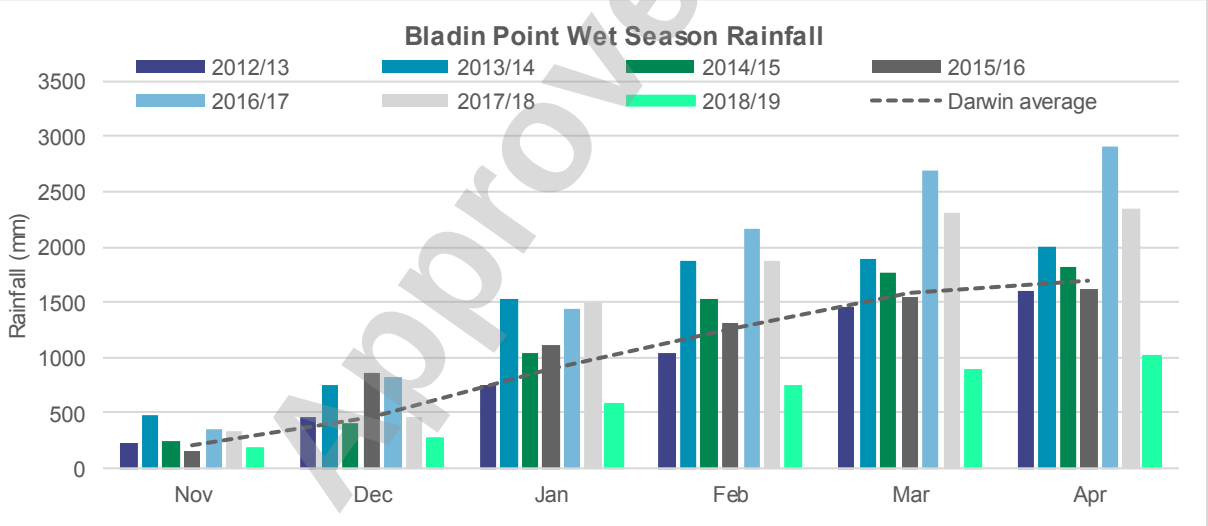


Figure 1-2: Bladin Point cumulative wet season rainfall

2 DISCHARGES TO WATER

2.1 Commingled treated effluent (750-SC-003)

The key objective of commingled treated effluent sampling from commingled sample point (750-SC-003) is to ensure commingled treated effluent does not exceed discharge criteria specified in Table 3, Appendix 2 of EPL228, and is the second tier in the approach to environmental monitoring for the wastewater discharge. Monitoring frequency, as specified in Table 3, Appendix 2 of EPL228 is weekly during start-up and monthly once Ichthys LNG reaches steady state. As such, weekly monitoring was undertaken during the reporting period until 19 June 2019, when the sampling frequency was reduced to monthly following reaching steady state for LNG Trains 1 and 2[2].

Table 2-1 provides a summary of commingled treated effluent sample collection dates for the reporting period.

Table 2-1: Commingled treated effluent sampling dates

Sample month	Sample collection date
Sep-18	18, 25
Oct-18	2, 8, 17, 23, 29
Nov-18	6, 13, 21, 27
Dec-18	4, 11, 17, 22, 27
Jan-19	2, 8, 15, 21, 30
Feb-19	5, 13, 19, 26
Mar-19	5, 12, 19, 26
Apr-19	2, 9, 16, 23, 30
May-19	7, 16, 22, 28
Jun-19	4, 11, 18, 25

Data collected as part of commingled treated effluent sampling will also be used to inform the Ichthys Onshore LNG Facilities Jetty Outfall Commissioning Monitoring Plan (L750-AH-PLN-60001), which has been developed to meet Condition 61 of EPL228. The final component of this plan will be implemented once the last discharge stream to the jetty outfall comes online. It is anticipated that discharge of the steam blowdown from the CCPP (in combine cycle) will commence in Q4 2019. As such, the outcomes of the commissioning jetty outfall monitoring plan will be reported on in the 2019/2020 AEMR.

[2] Following the activation of EPL228, sampling commenced weekly for all parameters with the exception of aMDEA and glycol which is only required monthly. Sampling frequency was reduced to monthly when LNG Trains 1 and 2 reached steady state as this triggered jetty outfall monitoring (see Section 2.2). When the CCPP (in combined cycle) starts up, sampling will revert back to weekly as a new discharge stream will have been introduced to 750-SC-003. Once the CCPP reaches steady state, sampling will then revert to monthly.

2.1.1 Method overview

The commingled treated effluent sampling point (750-SC-003) is located downstream of treated effluent observation basin (750-SU-404) and upstream of the jetty outfall. Samples collect from 750-SC-003 represent liquid effluent that is discharged to Darwin Harbour via the jetty outfall. The sampling point consists of two values, an isolation valve and a sample needle valve, with the latter used to regulate flow for sample collection. Sampling from the commingled treated effluent sample point was conducted by trained laboratory analysts using National Association of Testing Authority, Australia (NATA) accredited analysis methods by both the INPEX onshore laboratory and external third-party laboratories. A summary of sampling parameters and discharge limits is provided in Table 2-2.

Table 2-2: Commingled treated effluent analysis methods

Parameter	Sampling method[#]	Unit	LOR	Discharge limit
Volumetric flow rate	CFI	m^3/hr	n/a	180
pH	INPEX Lab	pH Unit	n/a	6.0 - 9.0
Electrical conductivity (EC)	INPEX Lab	µS/cm	10	n/a
Temperature	CFI	°C	-	35°C
Turbidity	INPEX Lab	NTU	0.5	n/a
Dissolved oxygen	CFI	%	-	n/a
TPH as oil and grease	INPEX Lab	mg/L	1.0	6
Total recoverable hydrocarbons (TRH; C10-C40)	External lab	µg/L	100	n/a
Total suspended solids (TSS)	INPEX Lab	mg/L	5	10
Biochemical oxygen demand (BOD)	External lab	mg/L	2	20
Chemical oxygen demand (COD)	INPEX Lab	mg O_2/L	10	125
Ammonia	INPEX Lab	mg N/L	2	n/a
Total nitrogen*	Calculation	mg N/L	2	10
Total phosphorus	INPEX Lab	mg P/L	0.2	2
Filterable reactive phosphorus (FRP)	INPEX Lab	mg P/L	0.2	n/a
Cadmium (total)	External lab	µg/L	0.1	n/a
Chromium (total)	External lab	µg/L	1	n/a
Copper (total)	External lab	µg/L	1	n/a
Lead (total)	External lab	µg/L	1	n/a
Mercury (total)	External lab	µg/L	0.1	n/a

Parameter	Sampling method[#]	Unit	LOR	Discharge limit
Nickel (total)	External lab	µg/L	1	n/a
Silver (total)	External lab	µg/L	1	n/a
Zinc (total)	External lab	µg/L	5	n/a
Enterococci	External lab	cfu/100mL	1	n/a
Escherichia coli	External lab	cfu/100mL	1	100
Faecal coliforms	External lab	cfu/100mL	1	400
Anionic surfactants	External lab	mg/L	0.1	n/a
Activated methyl diethanolamine (aMDEA)[##]	INPEX lab	mg/L	5	n/a
Glycol**	External lab	mg/L	4	n/a

[#]CFI = calibrated field instrument

*Total nitrogen is a sum of Nitrite, Nitrate and total Kjeldahl nitrogen (TKN). TKN analysis was completed by both INPEX onshore laboratory and external laboratory interchangeable, depending on INPEX onshore laboratory equipment availability. Nitrate and nitrite were measured by INPEX onshore laboratory.

[##]Methyl diethanolamine (MDEA with a LOR of 1 µg/L) was measured instead of aMDEA as there are no NATA accredited labs for aMDEA

**Measured as mono-ethylene glycol (MEG) and Triethylene glycol (TEG)

2.1.2 Results and discussion

The results for 750-SC-003 sampling for the reporting period are presented in Appendix C. Results that exceeded discharge limits are highlighted and in bold text.

All results are reported through the INPEX onshore laboratory database systems (laboratory information management system) that produce sample Certificates of Analysis (COA) inclusive of laboratory NATA accreditation number. To enable the identification of an exceedance, the discharge limits specified in Table 3, Appendix 2 of EPL228 have been input into the laboratory information management systems. Sample results are compared to their respective discharge limits in the COA. If a result exceeds the discharge limit, it is highlighted in the COA and the onshore laboratory generate an out of specification report.

There were some exceedances of wastewater quality above discharge limits, which are discussed in Section 2.1.3. Overall, there was generally little variability of the wastewater quality, with the majority of results below EPL228 discharge limits. This demonstrates the wastewater treatment system were operating effectively, and there weren't any unreported spills that impacted wastewater quality.

As per EPL228, the jetty outfall volumetric discharge is to be less than 180 m^3/h. In the reporting period, 750-SC-003 flow meter was not operational from 14 September 2018 until 14 May 2019 due to a fault. During this period estimates of the volume of wastewater discharged were calculated using pump run times and pit/tank volumes (Table 2-3). The maximum flow rate during this period is dependent on the two pumps which discharge to the jetty outfall. The two pumps are 750-P-550 (treated sewage from the irrigation tank to the jetty outfall) rated at 25 m^3/hr and 750-P-402-A/B (observation basin to jetty outfall) rated at 70 m^3/hr. Note that reject brine was directed into the accidently oil contaminated (AOC) system and not directly discharged to the jetty. Therefore, the combined maximum rated flow was 95 m^3/hr. It is noted that periods of increased flow/surge (i.e. greater than rated pump capacity) can be experienced, as maximum measured flow after 14 May 2019 was 108 m^3/hr (see Figure 2-1). A new flow meter was installed on 14 May 2019 with data collected until the end of the reporting period shown in Figure 2-1. Based on the calculated discharge volumes and flow meter, the discharge limit was not exceeded for the reporting period.

Table 2-3: Calculated monthly wastewater discharge

Month	Total volume discharged (m^3)	Volume discharged (m^3/hr) *
Sep-18	3,510	4.9
Oct-18	7,865	10.6
Nov-18	11,078	15.4
Dec-18	9,281	12.5
Jan-19	16,322	21.9
Feb-19	15,970	23.8
Mar-19	17,318	23.3
Apr-19	12,981	18.0
May-19	3,836	5.2

*total monthly volume discharged converted to hourly discharge rate

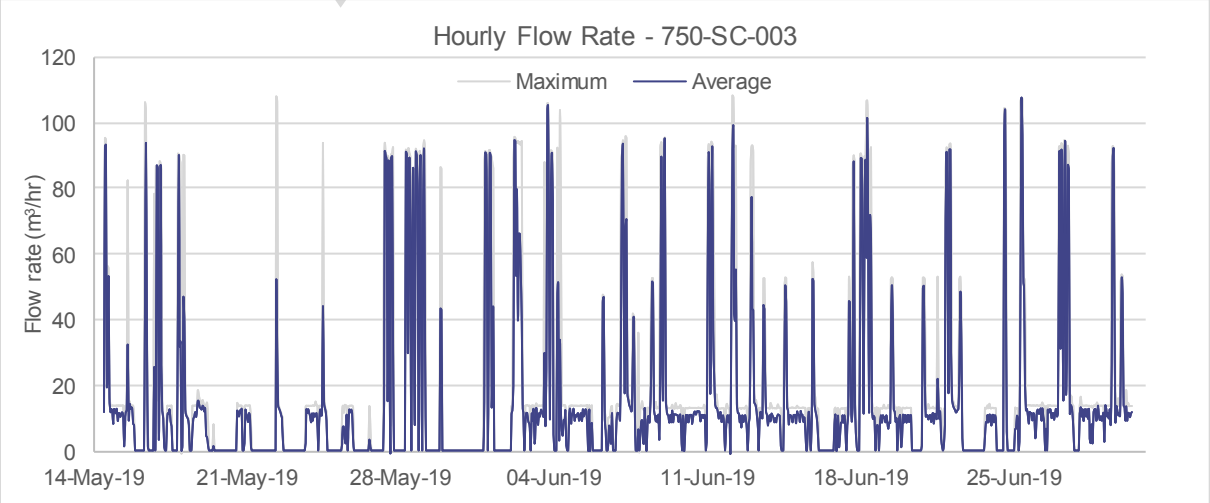


Figure 2-1: Hourly maximum and average flow rate measured by 750-SC-003 flow meter

Quality assurance/quality control (QA/QC)

The QA/QC procedures specific to the collection and analysis of samples from sample location 750-SC-003 included:

- NATA accredited analytical laboratories were used for all analysis
- Laboratory designated sample holding times
- Chain of custody forms were completed and accompanied the samples
- INPEX laboratory QA/QC procedures as followed were completed:
  - Laboratory blanks
  - Replicates/duplicate
  - Spikes
  - Calibration against standard reference materials
  - INPEX laboratory review of external laboratory QA/QC analysis reports
  - annual sampling verification, which involves the collection of two samples and trip blanks
- Calibration of all field-testing equipment using the standard method

Two holding time breaches were identified. One was due to an external laboratory error (18 September 2018) where TKN and nitrate where not analysed within the holding time. The second breach was associated with a chain of custody error (23 April 2019), analysis subsequently occurred outside of the holding time for amine and glycol. Note a self-imposed holding time was placed on amine and glycol due to no reference material being available. Following the identification of the holding time breaches resampling occurred within a seven-day period to confirm results. Holding time breaches are noted on the corresponding INPEX laboratory COAs.

Holding time breaches were handled as a laboratory non-conformance event prompting a cause analysis investigation on laboratory sample handling procedures. Table 2-4 outlines non-conformance event descriptions and corrective actions for the reporting period.

Table 2-4: INPEX onshore laboratory holding time non-conformance events

Non-conformance description	Corrective action
Sample ID L1803234 was sampled from L-750-SC-003 on 18/09/2018 and analysed for suite of tests including TKN and Nitrate. These tests were not performed within holding time and samples were not preserved.	Re-sample was completed within a 7 day period for Nitrate and TKN and results were reported to stakeholders 27/09/2018 on Laboratory report L1803282. Other analytes were reported on original Laboratory report L1803234.
Amine and glycol were not requested to be analysed by external laboratory on sample L1804000, sample point L-750-SC-003 EPA discharge.	Client contacted and confirmed to test samples even though out of holding time. Holding time breach mentioned on COA as a disclaimer. Re-sample was then completed within a seven-day reporting period.

2.1.3 Limit exceedances assessment outcomes

Throughout the reporting period and displayed on the COAs there were four discharge limit exceedances. A summary table of all discharge limit exceedances including corrective action is provided in Table 2-5.

Table 2-5: Summary of commingled treated effluent sample point exceedance events

Date sampled	Exceedance Reported	Parameter	Result	Limit	Cause and/or contributing factors	Corrective actions
8-Oct-18	10-Oct-18	Total phosphorus	2.2 mg P/L	2.0 mg P/L	On investigation, it was determined that at the time of sampling the reject brine was the only waste stream discharging into the jetty outfall line, and no discharge was occurring from the AOC or sewage treatment system. The reject brine from the demineralisation plant contained an anti-scalant product, high in TP (>2 mg P/L). Previous sampling on 28 September 2018 and 2 October 2018 also reported TP above the EPL228 limit, however these were considered part of the same event.	Following identification of the reject brine as the source of the exceedance, the reject brine was diverted from directly discharging to the jetty outfall line into the AOC drainage network, where the reject brine stream could commingle with additional wastewater. INPEX will continue to divert the reject brine into the AOC drainage system so the wastewater streams are commingled, and the reject brine is not directly discharged to the jetty outfall.
12-Mar-19	21-Mar-19	*E. coli*	160 cfu/ 100mL	100 cfu/ 100mL	There is a possibility that the source of the *E. coli* was the sewage treatment plant, where the final treatment of *E. coli* is ultraviolet (UV) light disinfection. Through a review of SAP maintenance request notification (Notification # 10008405) and panel alarms it was identified that the UV light filter reported a low-level light alarm on 8 August 2018 which required the UV filter light bulbs be replaced. Animal waste such a bird, frog or mammal being deposited in the AOC drainage network is another potential source, as there is no treatment process in the AOC for *E. coli*.	Following the replacement of the UV steriliser bulb a sample was taken from the combined jetty outfall line (sample location 750-SC-003) on 19 March 2019, with pumps L-750-550-A/B (ex-observation basin) and L-750-402-A/B (ex-irrigation tank) both running which reported a *E. coli* level of <2 cfu/100mL on 22 March 2019. The investigation did not determine the exact cause of the exceedance of *E. coli*, due to the two wastewater streams discharging into the combine jetty outfall at the time of sampling. Either animal waste could have entered into the AOC system or the more credible scenario is that the UV filters on the sewage treatment plant were faulty and did not disinfect the treated sewage wastewater stream.

Date sampled	Exceedance Reported	Parameter	Result	Limit	Cause and/or contributing factors	Corrective actions
30-Apr-19	9-May-19	*E. coli*	300 cfu/ 100mL	100 cfu/ 100mL	The investigation found that the most probable cause of the elevated *E. coli* levels was due to contamination within the AOC treatment system. This was determined by undertaking extensive sampling from various locations within both the sewage and AOC treatment plants, AOC post dissolved air flotation (750-SC-001), AOC post walnut shell filter (750-SC-002), treated sewage post UV (750-SC-009) and treated sewage post irrigation tank (750-SC-004).	To prevent reoccurrence of the event, chlorine shock dosing of the system occurred between 18 to 20 May 2019, this resulted in the successful disinfection of *E. coli* from within the AOC treatment packages.
16-May-19	23-May-19	Total Nitrogen	11 mg N/L	10 mg N/L	The investigation identified the potential cause of the total nitrogen exceedance was likely due to poor performance of the sewage treatment plant, because of missed regular manual sugar dosing to maintain the plant's health. In the week prior to the exceedance, the required sugar dosing did not occur over the weekend and potentially on night shift. Following the closure of the project's temporary sewage treatment plant. There is potential this may have increased the sugar dosing requirement, however as there is no regular influent testing this was not detected. Subsequent sampling conducted on 22 May 2019 reported TN above the EPL228 limit, this result was considered part of the same event.	A permanent sugar dosing system has been installed and routine sugar dosing into the sewage treatment plant has been re-established and the rate of sugar dosing has increased to deal with the additional wastewater volumes.

2.1.4 Program rationalisation

Following commencement of steady state operations for LNG Train 1 and 2 on 19 June 2019, the frequency of sampling reduced from weekly to monthly in accordance with EPL228[2]. The sampling frequency will be increased to weekly when the CCPP discharge stream is introduced to 750-SC-003 and will revert back to monthly once the CCPP reaches steady state[2].

2.2 Jetty outfall

The key objective of the jetty outfall water quality monitoring program is to detect changes in water quality attributable to liquid discharges from the jetty outfall. Monitoring frequency as specified in Appendix 2 of EPL228 is quarterly for the first 24 months following completion of first start-up of LNG Train 2. Start-up of LNG Train 2 was completed 19 June 2019 when steady state operations were achieved as detailed in Table 1-3 of Section 1.4.1. As such, no compliance monitoring was undertaken during the reporting period. However, as previously discussed with NT EPA, INPEX has undertaken quarterly informative monitoring since EPL activation (14 September 2018) to ensure there are no data gaps. Results of this informative monitoring have been presented in this AEMR for information purposes only.

Table 2-6 provides a summary of jetty outfall surveys completed during the reporting period.

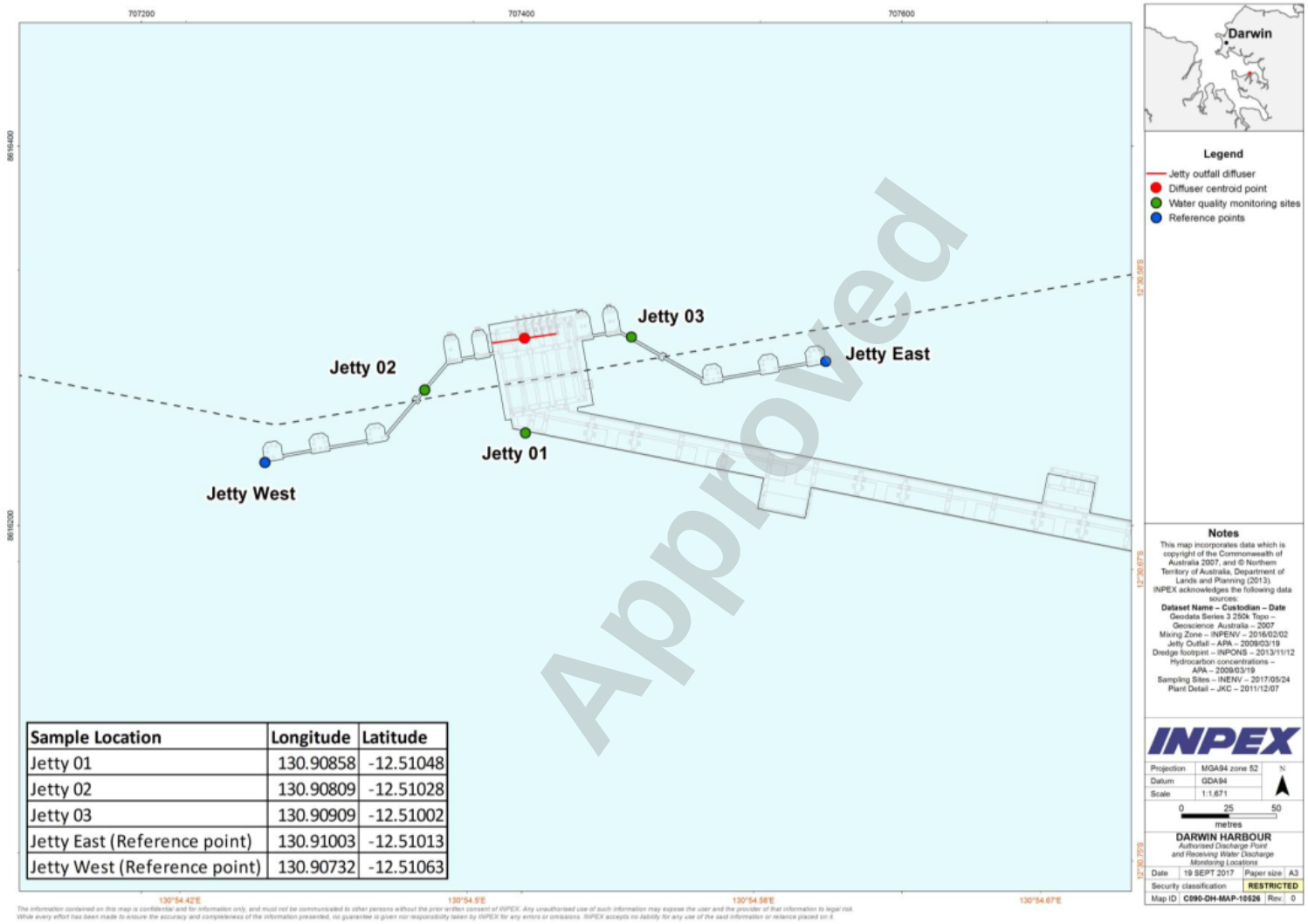
Table 2-6: Jetty outfall survey details

Survey	Date	Report	INPEX Doc #
1	17 Oct 2018	Jetty Outfall Monitoring – Interpretative Report No. 1	F280-AB-REP-60027
2	29 Jan 2019	Jetty Outfall Monitoring – Interpretative Report No. 2	F280-AB-REP-60026
3	29 Apr 2019	Jetty Outfall Monitoring – Interpretative Report No. 3	F280-AB-REP-60025

2.2.1 Method overview

Jetty outfall surveys were performed in accordance with the INPEX approved Jetty Outfall Monitoring Plan (F280-AB-PLN-60002), which was developed in consideration of the monitoring requirements specified in EPL228. In short, surficial water samples were collected from the five sampling locations (three impact and two reference sites) shown in Figure 2-2 during slack water on a neap high tide[3]. Following sample collection, calibrated field instruments were used to measure parameters that could be measured in situ and for those that couldn't, samples were taken and sent to NATA accredited laboratory for analysis. Table 2-7 provides a summary of parameters, sampling methods and trigger values. Note trigger values are provided for information only (see Section 2.2).

[3] Slack water is defined as 1.5 hours either side of low or high tide while neap tide is defined as <3 m of tide range as this aligns with Northern Territory Department of Environment and Natural Resources (DENR) water quality monitoring protocol



Sample Location	Longitude	Latitude
Jetty 01	130.90858	-12.51048
Jetty 02	130.90809	-12.51028
Jetty 03	130.90909	-12.51002
Jetty East (Reference point)	130.91003	-12.51013
Jetty West (Reference point)	130.90732	-12.51063

Figure 2-2: Jetty outfall sampling locations

Table 2-7: Jetty outfall monitoring parameters, methods and trigger values

Parameter	Unit	Sampling method*	Trigger value
pH	pH units	SFLA	Outside 6.0 and 8.5
Electrical conductivity (EC)	µS/cm	SFLA	n/a
Temperature	°C	CFI	±3 from ambient
Turbidity	NTU	CFI	±10 from ambient
Dissolved oxygen	%	CFI	Outside 80 to 100
Visual clarity and colour	n/a	O	No change from background
Surface films	n/a	O	None observed
TPH as oil and grease	mg/L	SFLA	No visible sheen or emulsion, no odour
TPH/TRH	µg/L	SFLA	Greater than reporting limit
Total suspended solids (TSS)	mg/L	SFLA	10
Ammonia	µg N/L	SFLA	20
Total nitrogen	µg N/L	SFLA	300
Total phosphorus	µg P/L	SFLA	30
FRP	µg P/L	SFLA	10
Cadmium[#]	µg/L	SFLA	0.7
Chromium[#]	µg/L	SFLA	4.4
Copper[#]	µg/L	SFLA	1.3
Lead[#]	µg/L	SFLA	4.4
Mercury[#]	µg/L	SFLA	0.05
Nickel[#]	µg/L	SFLA	7
Silver[#]	µg/L	SFLA	1.4
Zinc[#]	µg/L	SFLA	15
Enterococci	cfu/100mL	SFLA	50

*SFLA = sample for laboratory analysis, CFI = calibrated field instrument, O = observation

[#]analysed for total metals

2.2.2 Results and discussion

Impact and reference site results for the three informative surveys undertaken in the reporting period are summarised in Table 2-8 (see Appendix D for all results). Results for all parameters in all three surveys show little variability between impact and control, indicating the commingled treated effluent being discharged had no discernible influence on samples collected. As such, discharges have not adversely affected the declared beneficial uses or objective for Darwin Harbour.

Table 2-8: Average impact and reference site sample results for informative surveys 1, 2 and 3

Parameter	Unit	Survey 1		Survey 2		Survey 3	
		Impact	Reference	Impact	Reference	Impact	Reference
pH	pH units	8.00	7.90	8.00	7.95	8.17	8.17
EC	µS/cm	53900	54115	44487	48035	56467	51515
Temperature	°C	30.31	30.36	29.43	29.60	30.24	30.25
Turbidity	NTU	2.3	2.1	4.3	4.6	1.7	1.4
Dissolved oxygen	%	93	93	94	92	99	99
Visual clarity & colour	n/a	No change	No change	No change	No change	No change	No change
Surface films	n/a	None	None	None	None	None	None
TPH as oil and grease	mg/L	13	7	<5	<5	<5	<5
	n/a	None	None	None	None	None	None
TPH/TRH	µg/L	<50	<50	<50	<50	<50	<50
TSS	mg/L	2	5	2	5	<1	<1
Ammonia	µg N/L	7	5	7	8	3	<3
Total nitrogen	µg N/L	160	135	137	135	127	125
Total phosphorus	µg P/L	23	22	20	19	18	18
FRP	µg P/L	8	7	8	7	5	5
Cadmium[#]	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium[#]	µg/L	0.5	0.2	0.4	0.5	0.2	0.2
Copper[#]	µg/L	0.5	0.4	0.6	0.7	0.4	0.4
Lead[#]	µg/L	0.2	0.2	0.3	0.9	0.1	0.6

Parameter	Unit	Survey 1		Survey 2		Survey 3	
Mercury[#]	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nickel[#]	µg/L	1.3	0.5	0.5	0.4	0.4	0.4
Silver[#]	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc[#]	µg/L	1	<1	2	3	<1	2
Enterococci	cfu/100mL	<10	<10	-*	-*	10	10

*Enterococci not measured in Survey 2 die to mistake on laboratory chain of custody

[#]analysed for total metals

2.2.3 Trigger assessment outcomes

As stated in Section 2.2, no compliance monitoring was required during the reporting period, as such no trigger assessment outcomes are reported.

2.2.4 Program rationalisation

No program rationalisation is proposed as implementation in accordance with EPL228 did not commence during the reporting period. However, it was noted during informative monitoring that the sample frequency may not always be achievable, and delays may occur. This is because there is only a small sampling window (i.e. slack water on a neap high tide) and if this coincides with an LPG or condensate offtake due to a late change in the shipping schedule, sampling cannot occur due to safety. Further, to ensure sample integrity and holding times can be met, sampling should only be undertaken Monday to Wednesday, as this allows samples to be transported to respective laboratories in accordance with required holding times and preservation requirements. This further reduces the sampling window as the neap tide has to align with these days, noting there would also have to be no LPG or condensate offtake occurring as well.

2.3 Harbour sediment

The purpose of the harbour sediment quality monitoring program is to provide an early warning of potential accumulation of contaminants from wastewater discharges from Ichthys LNG in surficial sediments surrounding the outfall, located on the condensate/LPG jetty. The key objective is to detect changes in surficial sediment quality in the vicinity of the jetty outfall and determine if changes are attributable to Ichthys LNG operations.

As per the Onshore Operations Environmental Management Plan (OEMP; L060-AH-PLN-60005), harbour sediment quality is required to be monitored annually for the first 36 months of operations (i.e. EPL activation) with longer term requirements assessed based on a review of these results. Table 2-9 provides a summary of the harbour sediment quality survey completed during the reporting period.

Table 2-9: Harbour sediment quality survey details

Survey	Date	Report	INPEX Doc #
1	24-25 June 2018	Harbour Sediment Quality Monitoring – Trigger Assessment Report No. 1	F280-AH-REP-60052

Survey	Date	Report	INPEX Doc #
		Harbour Sediment Quality Monitoring – Interpretative Report No. 1	F280-AH-REP-60055

2.3.1 Method overview

The harbour sediment quality survey was performed in accordance with the INPEX approved Harbour Sediment Quality Monitoring Plan (F280-AQ-PLN-60002). Surficial sediment samples were collected using a grab sampler from 16 potential impact sites radiating away from the jetty outfall and four control sites in East Arm (Figure 2-3). The sediment grab sampler and QA/QC procedures followed were in accordance with the Harbour Sediment Quality Monitoring Plan, which was developed in consideration of the National Assessment Guidelines for Dredging (NAGD; Commonwealth of Australia 2009). The use of NAGD ensures consistency in sediment characterisation programs and is largely adopted for use in the Northern Territory (NT EPA 2013).

Following collection, surficial sediment samples were sent to NATA accredited laboratory for analysis for parameters listed in Table 2-10. Laboratory results were then compared to benchmark levels to ascertain whether a trigger exceedance had occurred. Exceedance of a benchmark level is defined as a measured analyte exceeding its relevant recommended sediment quality guideline value (SQGV; also referred to guideline value) as per Simpson et al. (2013) and the same analyte also exceeding the background level for Darwin Harbour sediment. Background levels were calculated based on results presented in Darwin Harbour Baseline Sediment Survey 2012 (Munksgaard et al. 2013). Note, where measured metal or metalloids exceeded SQGVs, results where possible will be normalised for aluminium concentrations based on the methods described in Munksgaard (2013) and Munksgaard et al. (2013) [4] and compared to background levels (i.e. baseline or reference levels).

[4] Aluminium normalised metal concentrations can be calculated as the equivalent metal concentration at an aluminium concentration of 10,000 mg/kg (1% by weight)

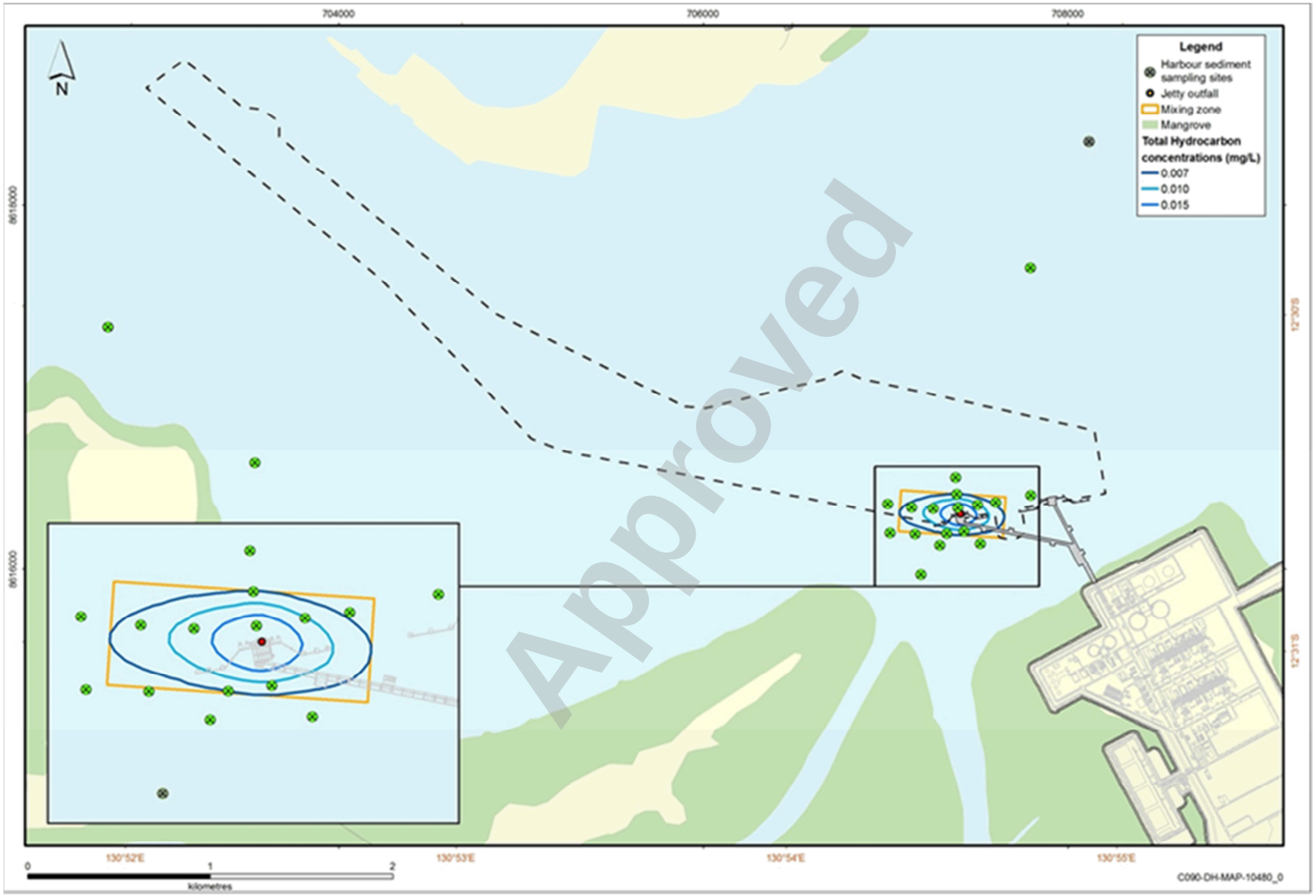


Figure 2-3: Harbour sediment quality sampling locations

Table 2-10: Harbour sediment quality monitoring parameters, trigger and background values

Parameter	Unit	Trigger value*	Background value#
Total organic carbon (TOC)	%	n/a	n/a
TPH	mg/kg	280	n/a
PAH	µg/kg	10,000	n/a
BTEX	mg/kg	n/a	n/a
Aluminium (Al)	mg/kg	n/a	n/a
Antimony (Sb)	mg/kg	2	n/a
Arsenic (As)	mg/kg	20	16.0
Cadmium	mg/kg	1.5	0.07
Chromium	mg/kg	80	17.5
Copper	mg/kg	65	4.7
Lead	mg/kg	50	8.8
Mercury	mg/kg	0.15	n/a
Nickel	mg/kg	21	8.7
Zinc	mg/kg	200	21.4
Particle size distribution (PSD)	µm	n/a	n/a

* Simpson et al (2013) recommended sediment quality guideline value

Background levels are from Munksgaard et al. (2013), using the average of non-normalized sediment samples collected from intertidal (n=247) areas within the Darwin Harbour

2.3.2 Results and discussion

Metal and metalloid results for harbour sediment quality are presented in Table 2-11. Three arsenic trigger exceedances were recorded; one impact site and two control sites. High levels of arsenic are known to naturally occur in Darwin Harbour and are considered a reflection of local geology rather than anthropogenic activities (Padovan 2003). Further, as the trigger exceedances were reported at both impact and control sites, elevated levels of arsenic were not attributed to Ichthys LNG operations.

Table 2-11: Harbour sediment quality survey metal and metalloid results.

Site[1]	Aluminium (Al)	Antimony (Sb)	Arsenic (As)[2]	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Lead (Pb)	Nickel (Ni)	Zinc (Zn)	Mercury (Hg)
Guideline values	NA	2	20	1.5	80	65	50	21	200	0.15
Background level	NA	NA	16.0	0.071	17.5	4.7	8.8	8.7	21.4	NA
I1	8750	<0.50	9.4	<0.1	20.1	4.3	6.1	6.1	15.8	0.03
I2	11700	<0.50	10.2	<0.1	27.9	6.0	7.8	8.2	21.6	0.03
I3	8250	<0.50	7.8	<0.1	20.1	4.2	5.8	6.0	15.5	0.01
I4	10300	<0.50	10.0	<0.1	25.0	5.5	7.7	7.3	21.2	0.01
I5	8050	<0.50	7.3	<0.1	18.9	4.1	5.2	5.4	15.3	<0.01
I6	11500	<0.50	8.9	<0.1	26.6	5.8	7.5	7.8	21.5	0.01
I7	12700	<0.50	9.6	<0.1	29.4	6.3	8.0	8.8	23.4	0.01
I8-1	9740	<0.50	8.7	<0.1	23.2	5.2	6.8	6.9	19.4	0.01
I8-2	9120	<0.50	8.8	<0.1	22.5	5.0	6.7	6.7	18.6	0.01
I8-3	11400	<0.50	10.6	<0.1	26.4	5.9	8.1	7.9	21.6	0.01
I9	6850	<0.50	6.7	<0.1	16.5	3.6	4.6	4.8	13.5	<0.01
I10	8630	<0.50	7.6	<0.1	21.0	4.5	6.0	6.3	16.9	<0.01
I11	10600	<0.50	10.1	<0.1	24.7	5.3	7.3	7.5	20.2	0.01
I12	7250	<0.50	7.4	<0.1	17.6	4.2	5.3	5.5	14.3	<0.01
I13-a	7150	<0.50	9.6	<0.1	20.2	8.1	5.8	8.0	20.1	<0.01
I13-b	7100	<0.50	11.6	<0.1	21.1	7.1	6.2	7.6	17.6	0.01
I13-c	12000	<2.00	15.0	0.2	28.0	12.0	10.0	13.0	32.0	0.01
I14	6800	<0.50	**25.3 (37.2)**	<0.1	48.1	4.6	7.6	5.7	13.7	<0.01
I15	10000	<0.50	11.0	<0.1	24.2	6.0	7.2	7.7	19.6	0.01
I16	3540	<0.50	13.6	<0.1	9.6	1.7	3.2	2.6	6.8	<0.01
C1-1	4120	<0.50	17.4	<0.1	18.5	2.7	5.4	3.2	7.6	<0.01
C1-2	4710	<0.50	10.7	<0.1	14.0	3.2	3.9	3.8	9.7	<0.01
C1-3	4260	<0.50	13.8	<0.1	13.8	2.5	3.8	3.3	9.0	0.01
C2	7940	<0.50	12.6	<0.1	22.2	6.0	6.9	6.7	18.8	0.01
C3	4400	<0.50	**58 .0 (132)**	<0.1	28.8	1.5	6.7	3.0	6.5	<0.01
C4	3930	<0.50	**23.9 (60.8)**	<0.1	44.0	2.0	4.3	2.3	5.5	<0.01

[1] C = Control Site, I = Impact site

[2] Bold values indicate trigger exceedance and results in brackets have been normalised for aluminium concentrations as per Munksgaard (2013)[4].

All impact and control locations were below the laboratory LOR for BTEX and PAH (Table 2-12), with the exception of PAH at impact site I2 (10 µg/kg) and I3 (5 µg/kg), which were well below the guideline value (10,000 µg/kg). All sampling locations had at least one result above the LOR for TPH, within the fraction range of C15 – C36. However, none of the results exceeded the guideline value of (280 mg/kg). The presence of TPH in all samples likely indicates the presence of non-petrogenic hydrocarbons of biological origin (e.g. vegetable/animal oils and greases, humic and fatty acids). Non-petrogenic hydrocarbons of biological origin are known to occur in Darwin Harbour with 63 of 171 mangrove sediment samples analysed during the construction phase returning positive results for TPH. Fifty-nine of these samples were reanalysed following silica gel clean-up, with 57 of the samples subsequently returning a result below LOR, thus indicating the presence of non-petrogenic hydrocarbons.

Table 2-13 provides a summary of the particle size distribution for impact and control sites. Impact sites contain a higher proportion of fines (i.e. silts and clays <63 µm) compared to control sites. It is important to consider this difference when comparing impact and control site data as fine particles such as clay and silt are more likely to absorb organic and heavy metal contaminants (Simpson et al. 2013). To address this difference, metals should be normalised to aluminium (Munksgaard 2013) and organics to TOC (Simpson et al. 2013), as done for potential trigger exceedances in this survey.

Overall, there were no changes to harbour sediment quality associated with Ichthys LNG activities. As such, discharges have not adversely affected the declared beneficial uses or objective for Darwin Harbour.

Table 2-12: Harbour sediment quality survey organic results

Site[1]	TOC (%)	TPH (mg/kg)	BTEX (mg/kg)	Total PAH (µg/kg)
Guideline values	n/a	280	n/a	10,000
Background level	n/a	n/a	n/a	n/a
I1	0.66	114	<0.2	<4
I2	0.88	140	<0.2	10
I3	1.10	81	<0.2	5
I4	0.63	90	<0.2	<5
I5	0.66	55	<0.2	<4
I6	0.63	66	<0.2	<5
I7	0.65	61	<0.2	<5
I8-1	0.60	76	<0.2	<5
I8-2	0.73	59	<0.2	<4
I8-3	0.72	60	<0.2	<5
I9	0.66	44	<0.2	<4
I10	0.59	46	<0.2	<4
I11	0.59	62	<0.2	<4
I12	0.61	50	<0.2	<4
I13-a	0.45	48	<0.2	<4
I13-b	0.36	49	<0.2	<4
I13-c	0.80	<100	<25	<5
I14	0.28	39	<0.2	<4
I15	0.66	90	<0.2	<4

Site[1]	TOC (%)	TPH (mg/kg)	BTEX (mg/kg)	Total PAH (µg/kg)
I16	0.28	76	<0.2	<4
C1-1	0.34	42	<0.2	<4
C1-2	0.43	48	<0.2	<4
C1-3	0.40	54	<0.2	<4
C2	0.59	61	<0.2	<4
C3	0.08	24	<0.2	<4
C4	0.20	35	<0.2	<4

[1] C = Control Site, I = Impact site

Table 2-13: Harbour sediment quality survey average particle size distribution

Sites	Clay (<4 µm)	Silt (4-63 µm)	Sand (63-2,000 µm)	Gravel (>2,000 µm)
Impact	10.4%	58.6%	29.7%	1.3%
Control	5.5%	33.9%	48.8%	11.9%

2.3.3 Trigger assessment outcomes

A potential arsenic trigger exceedance was reported for impact site I14. However, given the arsenic exceedance was limited to one impact site and was also recorded at two control sites, the exceedance is unlikely to be attributable to Project activities. In addition, high levels of arsenic are known to naturally occur in Darwin Harbour and are considered a reflection of local geology rather than anthropogenic activities (Padovan 2003). As such, no further investigation was undertaken.

2.3.4 Program rationalisation

No program rationalisation is proposed following Survey 1. As per the OEMP, once monitoring has been undertaken annually for the first 36 months, the results will be reviewed, and program frequency reassessed.

3 EMISSIONS TO AIR

As detailed in Section 1.4.1, start-up of Ichthys LNG occurred on 14 September 2018. Following the start-up of each LNG train until steady state, the plant and equipment (including fuel burning equipment/stationary emission sources) within the LNG trains were being commissioned and tuned (i.e. not operating in steady state). This involved bringing the equipment on and offline and experiencing a number of train trips and planned emergency shutdowns. On 19 June 2019 LNG train 1 and 2 reached steady state. A summary of emission source operating conditions and air quality is provided in Table 3-1.

Point source emission monitoring is triggered to commence within two months of steady-state following completion of first start-up of the first LNG (Condition 67 of EPL228). As this occurred on 19 June 2019, no monitoring occurred during the reporting period. Monitoring of point source emissions is scheduled to commence in August 2019 and outcomes of this will be reported on in the 2019/2020 AEMR.

As per the requirements of EPL228 Condition 57, ambient air quality and air toxic monitoring is triggered to commence once both LNG trains and the CCPP (in combined cycle) have reached steady-state. During the reporting period the steam component of the CCPP was still under construction and commissioning and covered under Environmental Protection Approval 7 (as amended). It is anticipated that the CCPP will be operational in September 2019 and will reach steady state in late Q4 2019. As such, no monitoring occurred during the reporting period. Monitoring will commence in Q4 2019 and outcomes of this will be reported on in the 2019/2020 AEMR.

As mentioned above, no point source emission, ambient air quality and air toxic monitoring was undertaken during the reporting period as it was not triggered. Although no monitoring was undertaken, INPEX is required (Condition 91.5 of EPL228) to provide total emissions of air quality parameters listed in Table 6, Appendix 3 of EPL228. Estimated total emissions to air for the reporting period are provided in Table 3-2, which are based on INPEX's Commonwealth emission reporting requirements (National Pollutant Inventory (NPI) and National Greenhouse and Energy Reporting Scheme (NGERS).

Table 3-1: Stack emission status and air quality

Release Point Number	Emission Source	Status	Air quality
A1	Compressor turbine WHRU West 1 (Frame 7)	Start-up/intermittent	n/a
A2	Compressor turbine WHRU West 2 (Frame 7)	Start-up/intermittent	n/a
A3	Compressor turbine WHRU East 1 (Frame 7)	Start-up/intermittent	n/a
A4	Compressor turbine WHRU East 2 (Frame 7)	Start-up/intermittent	n/a
A5-1	Power generation turbine 1 (Frame 6)	Start-up/intermittent	n/a
A6-1	Power generation turbine 2 (Frame 6)	Start-up/intermittent	n/a
A7-1	Power generation turbine 3 (Frame 6)	Start-up/intermittent	n/a
A8-1	Power generation turbine 4 (Frame 6)	Start-up/intermittent	n/a
A9-1	Power generation turbine 5 (Frame 6)	Start-up/intermittent	n/a
A5-2	Power generation turbine 1 HRSG (Frame 6)	Start-up/intermittent	n/a

Release Point Number	Emission Source	Status	Air quality
A6-2	Power generation turbine 2 HRSG (Frame 6)	Start-up/intermittent	n/a
A7-2	Power generation turbine 3 HRSG (Frame 6)	Start-up/intermittent	n/a
A8-2	Power generation turbine 4 HRSG (Frame 6)	Start-up/intermittent	n/a
A9-2	Power generation turbine 5 HRSG (Frame 6)	Start-up/intermittent	n/a
A10	Utility boiler #1	Start-up/intermittent	n/a
A11	Utility boiler #2	Start-up/intermittent	n/a
A12	Utility boiler #3	Start-up/intermittent	n/a
A13-1	AGRU Incinerator – LNG Train 1	Start-up/intermittent	n/a
A13-2	AGRU Hot Vent – LNG Train 1, prior to release at A3	Start-up/intermittent	n/a
A14-1	AGRU Incinerator – LNG Train 2	Start-up/intermittent	n/a
A14-2	AGRU Hot Vent – LNG Train 2, prior to release at A4	Start-up/intermittent	n/a
A15	Heating medium furnace 1	Start-up/intermittent	n/a
A16	Heating medium furnace 2	Start-up/intermittent	n/a

Table 3-2: Estimated total emissions to air for reporting period

Parameter	Emission (t/yr)
NO_x as nitrogen dioxide (NO_2)	1,746
Nitrous oxide (N_2O)	42
Mercury (Hg)	0.00001
Particle matter 2.5 ($PM_{2.5}$)	87
Particle matter 10 (PM_{10})	87
Carbon monoxide (CO)	4,956
Benzene	24
Toluene	15
Ethylbenzene	2
Xylenes	5
Hydrogen sulphide (H_2S)	97

3.1 Ambient air quality

As described in Section 3, no ambient air quality monitoring occurred during the reporting period, as Condition 57 had not been triggered. This monitoring program is scheduled to commence in Q4 2019 and outcomes of this will be reported on in the 2019/2020 AEMR.

3.1.1 Method overview

Ambient air quality monitoring data will be collected from the Northern Territory (NT) government's ambient air quality monitoring stations (AQMS). Data will be analysed to assess the potential impact of production activities at Ichthys LNG facility on the broader air environment once both LNG trains and the CCPP are operating at steady state. The location of the AQMS are shown in Figure 3-1. The AQMS have appropriate apparatus in accordance with Schedule 3 of the National Environment Protection (Ambient Air Quality) Measure 2015. The following parameters are monitored at each AQMS:

- carbon monoxide (CO)
- nitrogen dioxide (NO_2)
- ozone (O_3)
- sulphur dioxide (SO_2)
- particle matter 10 (PM_{10})
- particle matter 2.5 ($PM_{2.5}$)

In addition to ambient air quality parameters, air toxic parameters (benzene, ethylbenzene, toluene and xylenes) will also be monitored through the installation of a sampling canister at the AQMS.

3.1.2 Results and discussion

No results to report, see Section 3.1.

3.1.3 Program rationalisation

No rationalisation proposed as program has not commenced, see Section 3.1.

Figure 3-1: Ambient air quality monitoring stations

3.2 Point source emissions to air

As described in Section 3, no point source emissions monitoring was undertaken during the reporting period as Condition 67 had not been triggered. This monitoring program is scheduled to commence in August 2019 and outcomes of this will be reported in the 2019/2020 AEMR. Note a first start-up emissions test plan (Section 3.8.1 of the OEMP) was implemented during the reporting period as per Condition 73 of EPL228.

3.2.1 Method overview

Monitoring of each of the authorised stationary emission release points specified in Table 4, Appendix 3 of EPL228 will be undertaken using the approved methods for stack emissions as specified in:

- New South Wales (NSW) Department of Environment and Conservation - Approved Methods for the Sampling and Analysis of Air Pollutants in NSW;
- NSW - Protection of the Environment Operations (Clean Air) Regulation, Schedule 5 Test methods, averaging periods and reference conditions for scheduled premises; and,
- United States Environmental Protection Agency - Method 30B for mercury emissions.

3.2.2 Results and discussion

No results to report, see Section 3.2.

3.2.3 Trigger assessment outcomes

No results to complete trigger assessment, see Section 3.2.

3.2.4 Program rationalisation

No rationalisation proposed as program has not commenced, see Section 3.2.

3.3 Dark-smoke events

Ichthys LNG has been designed to minimise dark-smoke events. However, dark-smoke can result during flaring due to incomplete combustion of hydrocarbons. The environmental impacts from smoke emitted from an LNG plant are considered negligible; though smoke could cause a visual amenity impact and community concern.

3.3.1 Method overview

Visual monitoring and closed-circuit television monitoring of flares is undertaken to detect possible dark-smoke events. If dark smoke is produced during operations, the shade (or darkness) of the smoke will be estimated using the Australian Miniature Smoke Chart (AS 3543:2014 Use of standard Ringelmann and Australian Standard miniature smoke charts). The shade and duration of the dark-smoke event will be recorded. Dark smoke monitoring targets and limits for all the flare systems are provided in Table 3-3.

Table 3-3: Dark smoke monitoring targets and limits

Emission source	Pollutant	Target	Limit
Flares	Smoke	<Ringelmann 1	Visible smoke emissions darker than

Emission source	Pollutant	Target	Limit
			Ringelmann shade 1

Flaring and other data is stored in the site's Process Control System (PCS). The PCS serves as the primary means to control and monitor the plant and automatically maintains operating pressures, temperatures, liquid levels and flow rates within the normal operating envelope with minimal intervention from operator consoles in the central control room (CCR). The system has built in redundancy in communication, control and human interface. Information from the PCS is displayed on visual display units in the CCR. During process upset conditions, the system has detailed alarm handling and interrogation functions to minimise operator overload. The PCS is also equipped with a database function that permits operations personnel to investigate a historical sequence of events. In addition, volatile organic compound emissions are estimated by use of the NPI and NGERS reporting tools.

3.3.2 Results and discussion

No dark smoke events greater than Ringelmann 1 occurred during the reporting period.

3.3.3 Program rationalisation

No program rationalisation proposed.

3.4 Airborne noise

The OEMP commitment to undertake an airborne noise survey was not triggered during the reporting period, as both LNG trains and CCPP were not in steady state operations. Steady state was only reached for both LNG trains on 19 June 2019. It is anticipated that the CCPP will be operational in September 2019 and will reach steady state in late Q4 2019. Outcomes of the airborne noise survey will be reported on in the 2019/2020 AEMR.

During the start-up there was community concern regarding the flaring noise associated with the start-up activities. INPEX undertook a detailed noise analysis of the continuous noise monitoring data acquired under the construction environmental management plan. The results of this assessment confirmed the noise generated from start-up flaring was under NT noise criteria. Subsequent to the community concern being raised around start-up flaring, INPEX held several community information briefing sessions to inform the public of the start-up activities and associated flaring during this period.

3.4.1 Method overview

Survey not required during the reporting period, see Section 3.4. Method overview will be described in the 2019/2020 AEMR.

3.4.2 Results and discussion

No results to report, see Section 3.4.

4 UNPLANNED DISCHARGES TO LAND

4.1 Groundwater quality

The key objective of the groundwater monitoring program is to detect changes in groundwater quality and determine if these changes are attributable to Ichthys LNG operations. Note there are no planned discharges directly to groundwater, other than clean rainfall and non-contaminated water (NCW); however, there is potential for groundwater to become contaminated as a result of an accidental spill, leak or rupture during Ichthys LNG start-up and operations.

As per the OEMP, groundwater quality is required to be monitored quarterly for the first 12 months of operations (i.e. EPL activation) and following a review of the first year's monitoring data may revert to six-monthly sampling. Table 4-1 provides a summary of the groundwater quality surveys completed during the reporting period.

Table 4-1: Groundwater quality monitoring survey details

Survey	Sampling period	Report	INPEX Doc #
1	22-30 Oct 2018	Groundwater Quality Monitoring – Trigger Assessment Report No. 1	F280-AH-REP-60066
		Groundwater Quality Sampling Report No. 1	F280-AH-REP-60074
2	21-30 Jan 2019	Groundwater Quality Monitoring – Trigger Assessment Report No. 2	F280-AH-REP-60067
		Groundwater Quality Sampling Report No. 2	F280-AH-REP-60075
3	4-11 Apr 2019	Groundwater Quality Monitoring – Trigger Assessment Report No. 3	F280-AH-REP-60068
		Groundwater Quality Sampling Report No. 3	F280-AH-REP-60076

4.1.1 Method overview

The groundwater quality monitoring surveys were undertaken in accordance with the INPEX approved Groundwater Quality Monitoring Plan (F280-AQ-PLN-60003), which includes monitoring at 20 wells (Figure 4-1). The Groundwater Quality Monitoring Plan was developed in consideration of Australian, State and Territory groundwater sampling standards and guidelines. A high-level summary of methods is provided here, detailed methodology can be found in the Groundwater Quality Monitoring Plan.

Prior to sampling, groundwater wells were gauged with an interface probe to determine the standing water level (SWL) and to determine the presence of light non-aqueous phase liquid. Following gauging, groundwater wells were purged using a low flow micro purge pump with SWL and in situ parameters being measured every 3-5 minutes. Once the well had been purged and in situ parameters were stable, groundwater samples were then collected for analysis.

Following sample collection, groundwater samples were sent to NATA accredited laboratories for analysis of parameters listed in Table 4-2. Results were then compared to benchmark levels to ascertain whether a trigger exceedance had occurred. Exceedance of a benchmark level is defined as a measured analyte exceeding its relevant trigger value (see Table 4-2) and the same analyte also exceeding the background level for each groundwater well. Well specific background level low risk trigger values were calculated using the approach described in ANZECC/ARMCANZ (2000). In short, the 80th and/or 20th percentile value for each parameter was determined using the monthly groundwater data collected during the construction phase of Ichthys LNG between 2013 and 2018.

Table 4-2: Groundwater quality monitoring parameters, methods and trigger values

Parameter	Unit	Sampling method*	Trigger value
pH	pH units	CFI	Outside 6.0 and 8.5
EC	µS/cm	CFI	n/a
Dissolved oxygen	%	CFI	n/a
Redox	mV	CFI	n/a
Temperature	°C	CFI	n/a
Total dissolved solids (TDS)	mg/L	SFLA	n/a
Oxides of nitrogen	µg N/L	SFLA	20
Ammonia	µg N/L	SFLA	20
Total nitrogen	µg N/L	SFLA	300
Total phosphorus	µg P/L	SFLA	30
Filterable reactive phosphorus (FRP)	µg/L	SFLA	10
Phenols	µg/L	SFLA	n/a
TRH	µg/L	SFLA	600
Benzene	µg/L	SFLA	500
Ethylbenzene	µg/L	SFLA	5
Toluene	µg/L	SFLA	180
Xylenes	µg/L	SFLA	75
Aluminium	µg/L	SFLA	24
Arsenic	µg/L	SFLA	2.3
Cadmium	µg/L	SFLA	0.7
Chromium III	µg/L	SFLA	10
Chromium VI	µg/L	SFLA	4.4
Cobalt	µg/L	SFLA	1
Copper	µg/L	SFLA	1.3
Lead	µg/L	SFLA	4.4
Manganese	µg/L	SFLA	390

Parameter	Unit	Sampling method*	Trigger value
Mercury	µg/L	SFLA	0.1
Nickel	µg/L	SFLA	7
Silver	µg/L	SFLA	1.4
Vanadium	µg/L	SFLA	100
Zinc	µg/L	SFLA	15
Biological oxygen demand (BOD)[#]	mg/L	SFLA	n/a
Faecal coliform[#]	cfu-100mL	SFLA	n/a
Escherichia coli[#]	cfu-100mL	SFLA	n/a

*SFLA = sample for laboratory analysis, CFI = calibrated field instrument

[#] Only at BPGW19A and BPGW27A

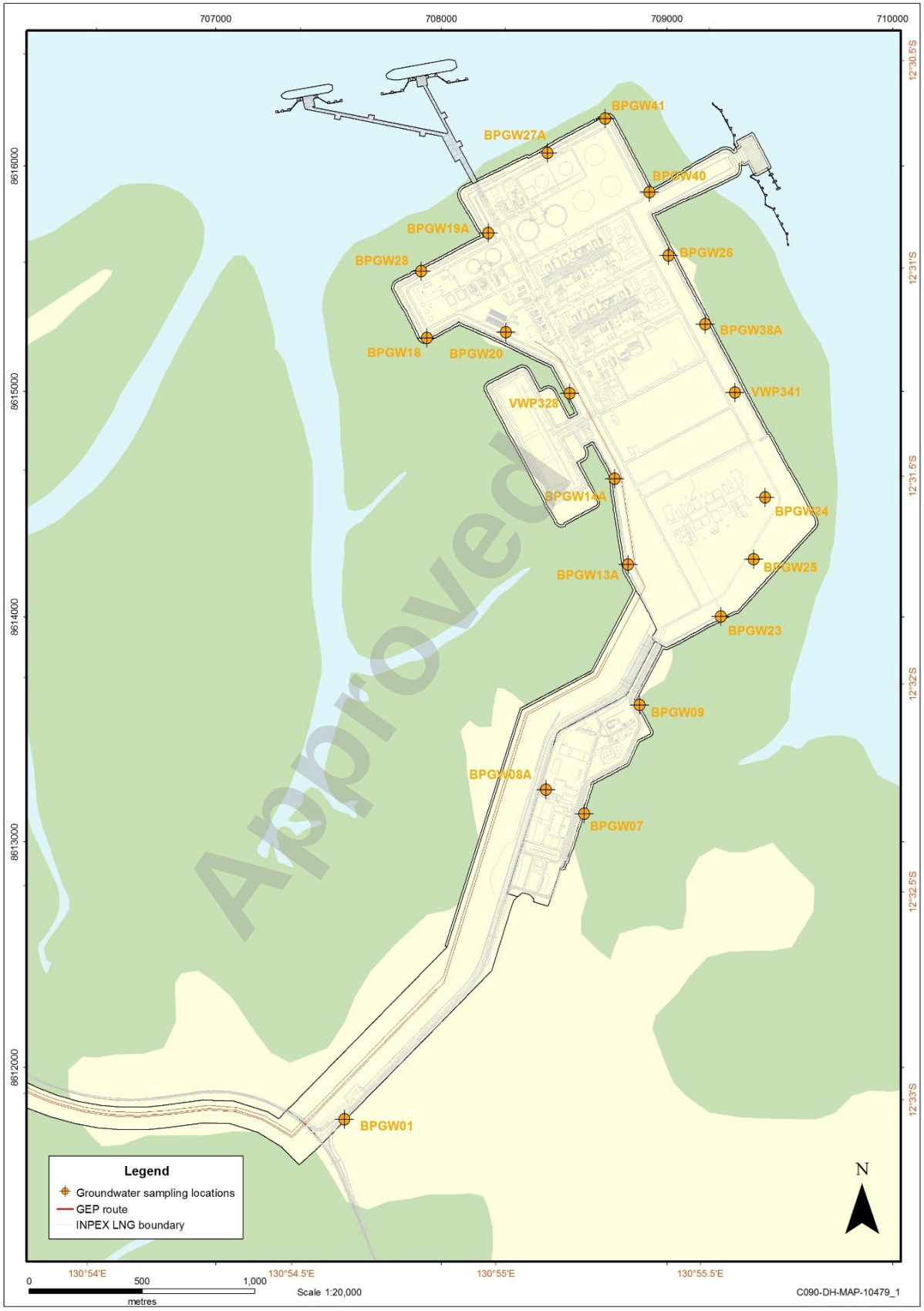


Figure 4-1: Groundwater quality sampling locations

4.1.2 Results and discussion

A high-level summary of groundwater results and trends is provided below. Groundwater data collected for the reporting period is provided in Appendix E. Note presentation of groundwater data trends include data collected during the construction phase. Groundwater surveys undertaken in accordance with the OEMP are specified in Table 4-1.

Physio-chemical

Physio-chemical monitoring results measured during the reporting period are consistent with those from the construction period. Ichthys LNG is located on low-lying peninsula connected to the mainland by a small isthmus. Most of the groundwater wells are located around the perimeter of Ichthys LNG and are saline with average electrical conductivity of 35,000 to 40,000 µS/cm (Figure 4-2). Groundwater is also acidic to neutral with average pH typically between 5.0 and 5.5 (Figure 4-3).

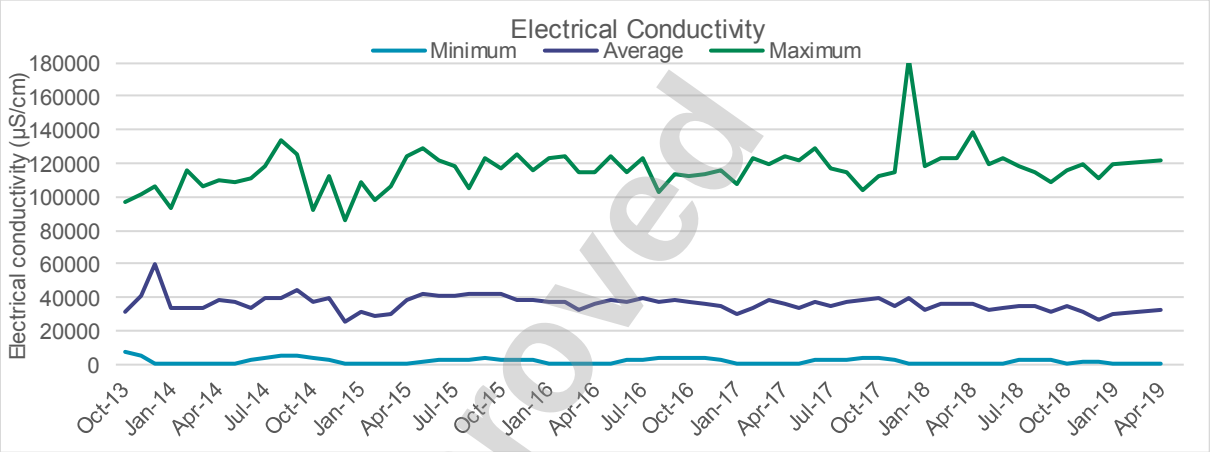


Figure 4-2: Average, minimum and maximum electrical conductivity for Ichthys LNG groundwater wells

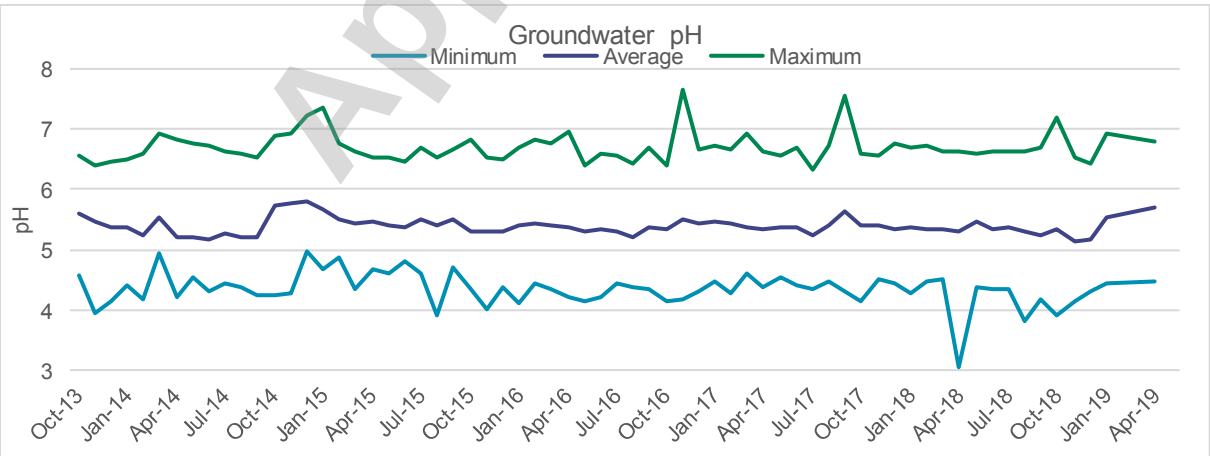


Figure 4-3: Average, minimum and maximum pH for Ichthys LNG groundwater wells

Nutrients

Nutrient monitoring results measured during the reporting period were generally consistent with those from the construction period. Nutrient concentrations are known to vary inter-annually and seasonally (see Figure 4-4 and Figure 4-5). Nutrients can also be highly variable between groundwater wells (Figure 4-6).

During the reporting period ammonia was the nutrient that had the greatest number of trigger exceedances and had a strong seasonal trend, whereby concentrations increase during the dry season and typically decrease in the wet season (Figure 4-4). Interannual variability is likely to be associated with natural factors such as rainfall; both the total rainfall and timing of rain (e.g. early in the season or late in the season). As mentioned in Section 1.4.2, the 2018/2019 wet season rainfall was well below average and the driest wet season since construction of Ichthys LNG began. The dry and late onset of the 2018/2019 wet season has likely contributed the concentrations and subsequently the number of ammonia exceedances recorded during the reporting period.

Overall the variations in nutrient concentrations measured are considered to be the result of natural variations and not attributable to Ichthys LNG activities.

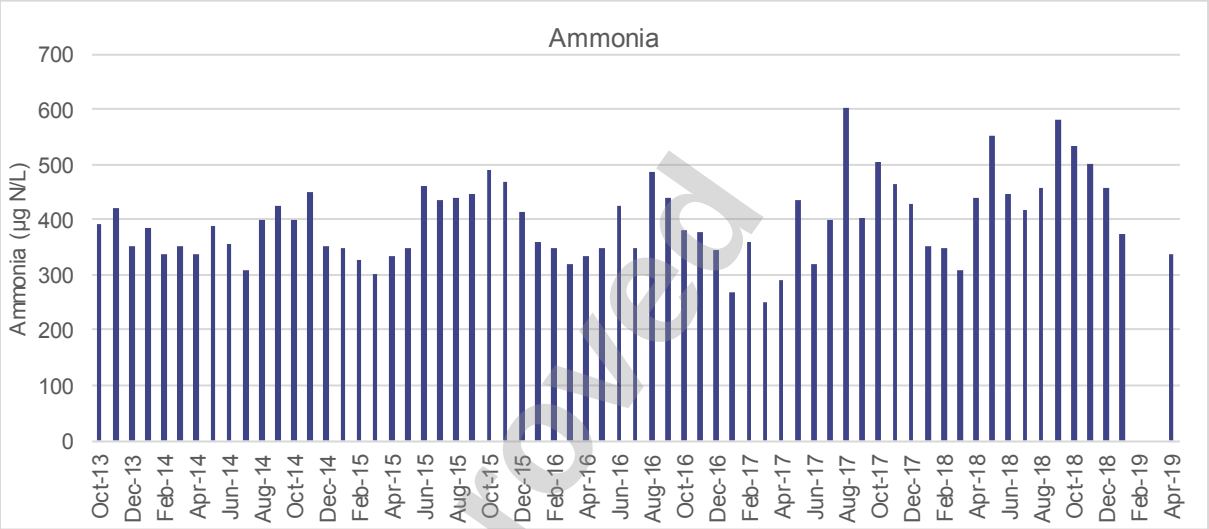


Figure 4-4: Average ammonia concentrations for all groundwater wells

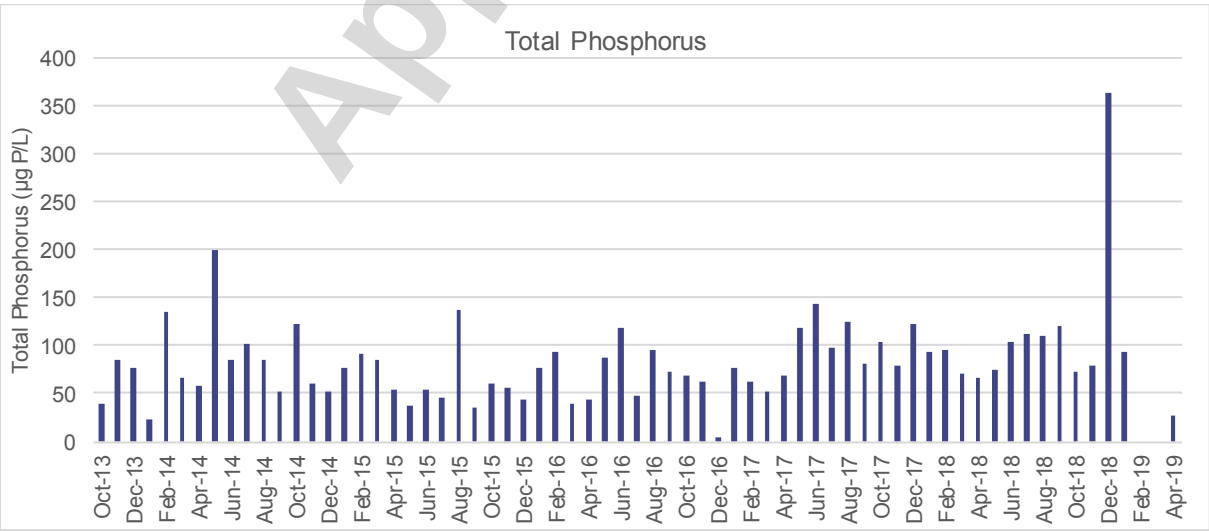


Figure 4-5: Average total phosphorus concentrations for all groundwater wells

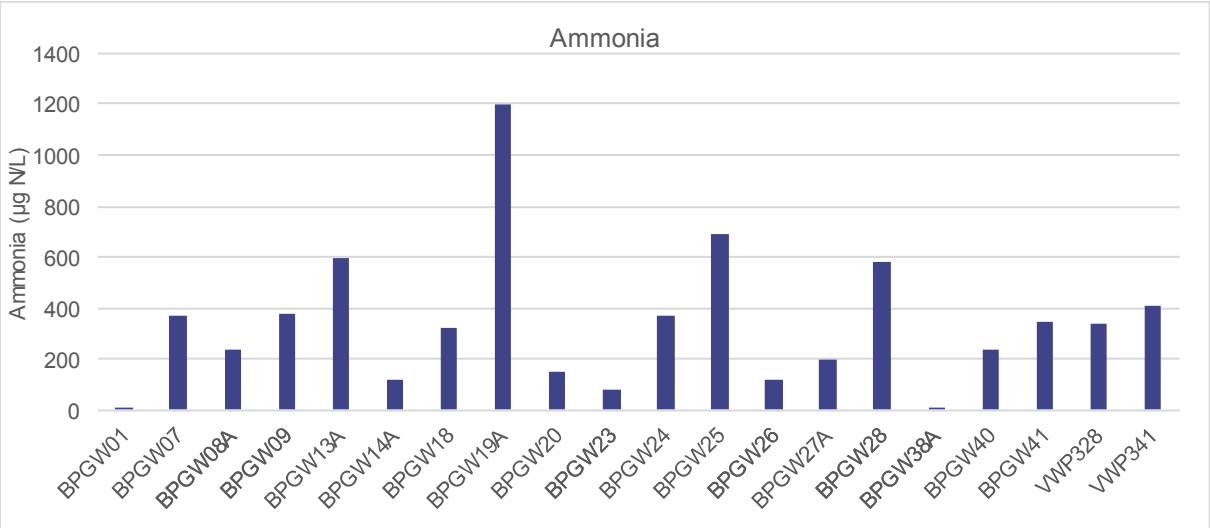


Figure 4-6: Groundwater survey 3 ammonia concentrations

Metals and metalloids

Groundwater metal concentrations measured during the reporting period were generally consistent with those from the construction period. Similar to nutrients, metal concentrations are known to vary inter-annually and seasonally (see Figure 4-7 for an example). Metals can also be highly variable between groundwater wells (see Figure 4-8 for an example).

During the reporting period zinc was the metal that had the greatest number of trigger exceedances and has a strong seasonal trend, whereby concentrations typically increase during the dry season and typically decrease in the wet season following the onset of wet season rainfalls (see Figure 4-9 for example of seasonality at a well). Interannual variability is likely to be associated with natural factors such as rainfall; both the total rainfall and timing of rain (e.g. early in the season or late in the season). As mentioned in Section 1.4.2, the 2018/2019 wet season rainfall was well below average and the driest wet season since construction of Ichthys LNG began. The dry and late onset of the 2018/2019 wet season has likely contributed the concentrations and subsequently the number of zinc exceedances recorded during the reporting period.

Overall the variations in metal and metalloid concentrations measured are considered to be the result of natural variations and not attributable to Ichthys LNG activities.

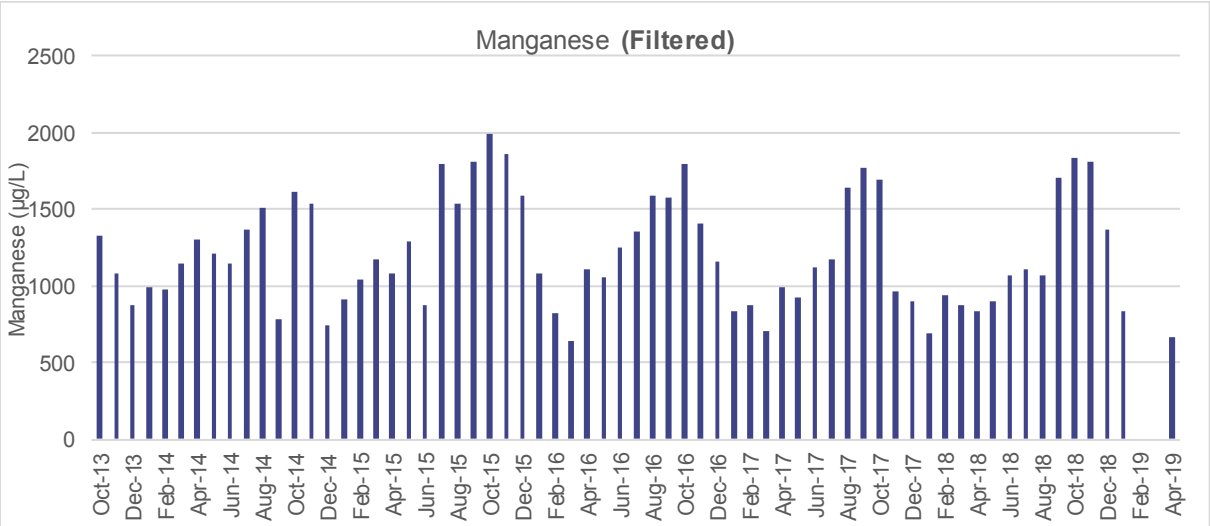


Figure 4-7: Average manganese concentrations for all groundwater wells

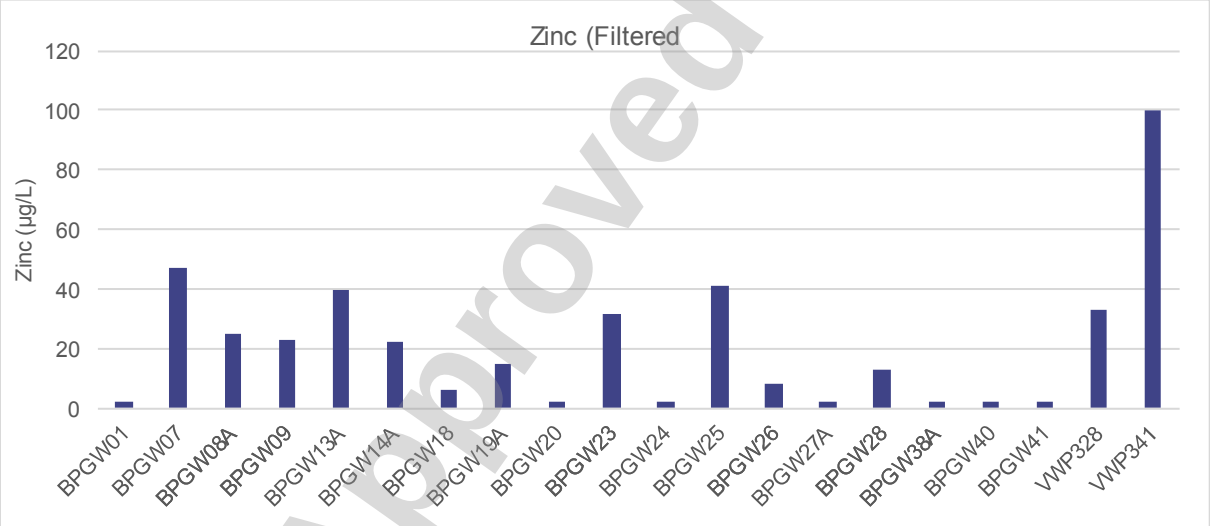


Figure 4-8: Groundwater survey 3 zinc concentrations

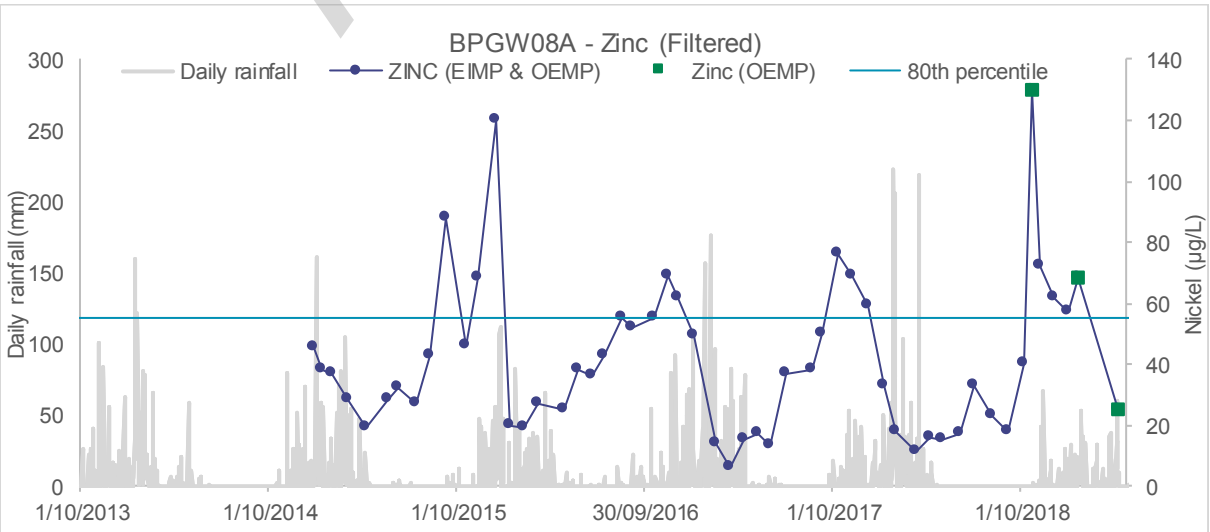


Figure 4-9: Groundwater well BPGW08A zinc (filtered) concentrations with daily rainfall

Hydrocarbons

No hydrocarbons (benzene, ethylbenzene, toluene, xylenes or TRH) were observed in any of the samples from any of the wells during the reporting period.

Microbiological

Faecal coliforms (total) and BOD have been recorded at both groundwater wells closest to the Ichthys LNG wastewater treatment facility (Table 4-3). However, no *E. coli* has been detected indicating the observed levels of faecal coliforms (total) and BOD are not attributable to Ichthys LNG activities.

Table 4-3: Microbiological results for the reporting period

Well	Date	*E. coli* (mpn/100mL)	Faecal coliform (total) (mpn/100mL)	BOD (mg/L)
BPGW19A	Survey 1	<1	20	5
	Survey 2	<1	4	<1
	Survey 3	<1	>2400	40
BPGW27A	Survey 1	<1	<1	<1
	Survey 2	<1	125	<2
	Survey 3	<1	47	36

4.1.3 Trigger assessment outcomes

In accordance with the receiving environment adaptive management process outlined in Section 7.5 of the OEMP, groundwater trigger exceedances were investigated. A summary of the number of trigger exceedances by survey is provided in Table 4-4 with corresponding investigation reports listed below:

- Groundwater Survey 1 – Trigger Investigation Report (L060-AH-REP-60019)
- Groundwater Survey 2 – Trigger Investigation Report (L060-AH-REP-60024)
- Groundwater Survey 3 – Trigger Investigation Report (L060-AH-REP-60028)

Investigation for all trigger exceedances using multiple lines of evidence concluded that the reported trigger exceedances were likely natural (e.g. represent seasonal trends and natural variability) and no further evaluation or management response was required.

Table 4-4: Summary of groundwater trigger exceedances

Date	Month	Physio-chemical	Nutrients	Metals	Total
Survey 1	October	10	32	49	91
Survey 2	January	3	34	12	49
Survey 3	April	4	16	12	32

4.1.4 Program rationalisation

Given that no change in groundwater quality attributable to Ichthys LNG activities has been detected to date (i.e. Elizabeth-Howard Rivers Region Groundwater declared beneficial uses or objective have not been adversely affected), and if no changes are detected for the fourth quarterly survey, groundwater sampling will revert to six-monthly (i.e. biannual) as described in Section 7.3.1 of the OEMP and mention in Section 4.1.

5 FLORA, FAUNA AND HERITAGE

5.1 Mangrove health, intertidal sediment and bio-indicators

Mangrove health, intertidal sediments and bio-indicators were monitored to detect potential adverse changes in mangrove community health as an indirect result of Ichthys LNG operations. The objectives of annual mangrove health, intertidal sediment and bio-indicator surveys are to:

- informatively monitor mangroves adjacent to the Ichthys LNG plant
- detect changes in intertidal sediment quality attributable to Ichthys LNG operations
- determine through bio-indicator monitoring if changes in seafood quality is occurring and if so determine if it is attributable to Ichthys LNG operations.

As per the OEMP, mangrove health, intertidal sediments and bio-indicators are required to be monitored annually for the first 36 months of operations (i.e. EPL activation) with longer term requirements assessed based on a review of these results. Table 5-1 provides a summary of the mangrove health, intertidal sediments and bio-indicators survey completed during the reporting period.

Table 5-1: Mangrove health, intertidal sediment and bio-indicator monitoring survey details

Survey	Date	Report	INPEX Doc #
1	19-27 March 2019	Mangrove Health, Intertidal Sediment and Bio-indicator Monitoring – Trigger Assessment Report No. 1	F280-AH-REP-60088
		Mangrove Health, Intertidal Sediment and Bio-indicator Monitoring – Interpretative Report No. 1	F280-AH-REP-60091

5.1.1 Method overview

The mangrove health, intertidal sediment and bio-indicator monitoring was undertaken in accordance with the INPEX approved Mangrove Health, Intertidal Sediment and Bio-indicator Monitoring Plan (F280-AH-PLN-60009). This included monitoring at 11 sites; three control and eight impact. At each site, a transect from the landward margin of the Hinterland assemblage to the seaward margin of the Tidal Creek assemblage was established during construction phase monitoring. The transects traverse each of the three main Darwin Harbour mangrove assemblages, where present; Hinterland Margin (HM), Tidal Flat (TF) and Tidal Creek (TC). The location of each transect is shown in Figure 5-1.

Monitoring at each site is undertaken at fixed quadrats (10 m × 10 m) established along each transect. At impact sites, monitoring is undertaken at the fixed quadrat within the most landward assemblage present. The location of impact transects were selected based on their proximity to groundwater sampling locations and their location downstream of potential contamination sources, such as condensate storage tanks. For each control site monitoring is undertaken at three fixed quadrats along transects that were also established during construction phase monitoring, with each quadrat representing a different community assemblage. As such, 17 quadrats (i.e. eight impact and nine control quadrats) are monitored during each annual survey. Each of the 17 monitoring quadrats is divided into four 5 m × 5 m subplots formed by the fixed quadrat, four corner posts and a centre post (resulting in a total of 68 subplots).

An overview of the monitoring parameters is presented in Table 5-2.

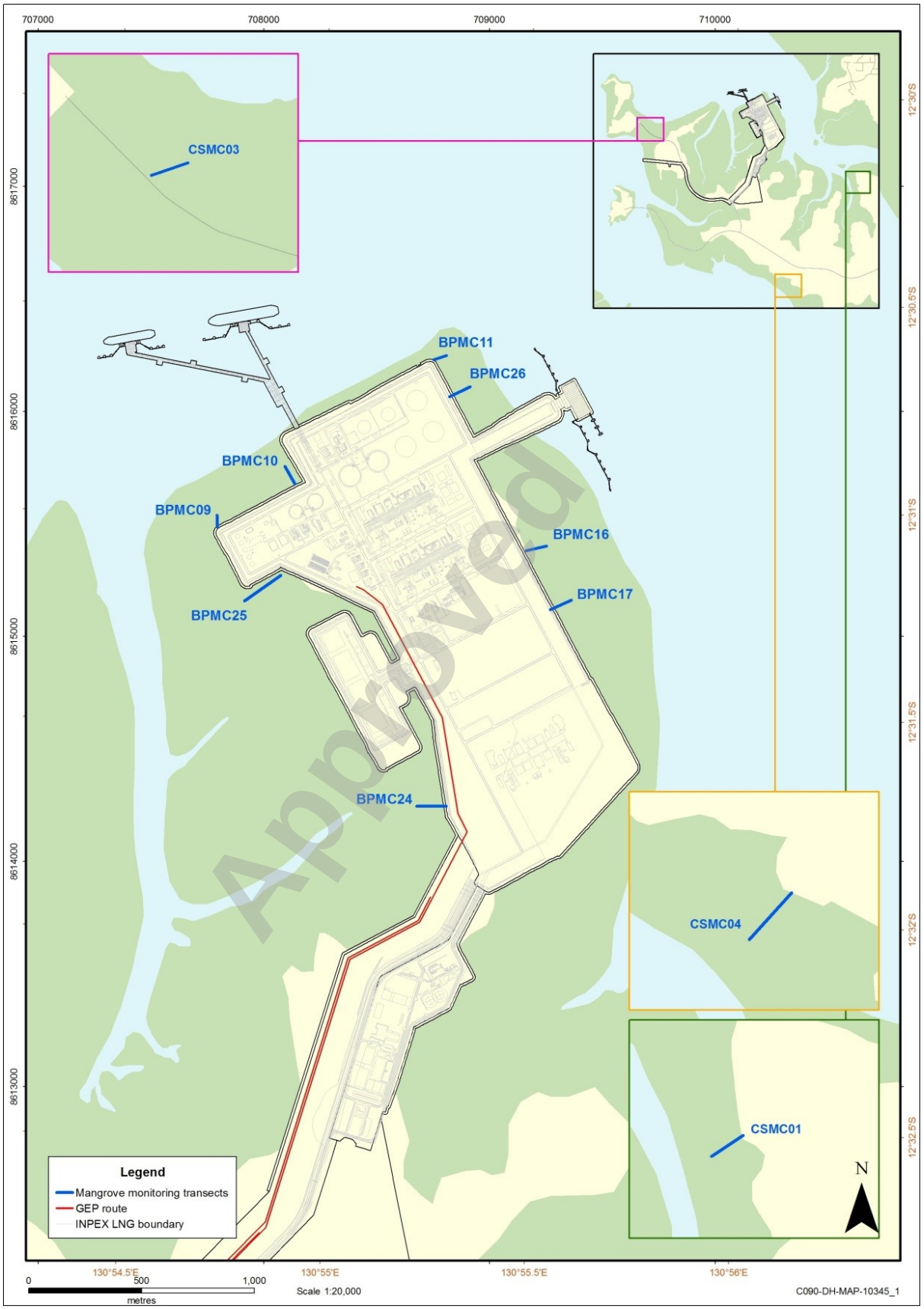


Figure 5-1: Mangrove health, intertidal sediment and bio-indicator monitoring locations

Table 5-2: Monitoring parameters, methodologies and associated metrics

Parameter	Methodology	Monitoring Metrics
Mangrove health	• Mangrove canopy cover assessment • Surveillance photo-monitoring	• Percentage canopy cover • Observations on mangrove health (e.g. leaf colour).
Sediment quality	• Sediment sampling and laboratory analysis • In situ sediment measurements for pH and redox.	• Metal and metalloids (Al, Sb, As, Cd, Cr, Cu, Pb, Hg, Ni, Zn) • Total Recoverable Hydrocarbons (TRH) • PSD (laser diffraction) • pH (measured in field) • Redox (measured in field) • TOC (for normalisation of TRH)
Biota	• Collection of mud whelks and laboratory analysis.	• Metal and metalloids (Al, Sb, As, Cd, Cr, Cu, Pb, Hg, Ni, Zn) • TRH* • Poly Aromatic Hydrocarbons (PAH)*

* Following year one, mud whelk hydrocarbon analysis is not required unless an incident has occurred (e.g. discharge of significant hydrocarbon volume to the mangroves).

Mangrove health monitoring

At each of the 17 quadrats, mangrove canopy cover was measured within each sub-plot (total 68 subplots) using a Stickler's modified spherical densiometer (Stickler 1959). Three replicated measurements consisting each of four directional cover estimates (i.e. turning 90° to take four measurements from each replicate location) were taken within each sub-plot to provide an estimate of foliage cover.

Repeatable mangrove surveillance photo-monitoring was also undertaken at each site to provide a visual record of the communities' appearance and condition (e.g. leaf colour). General observations with respect to the condition of the mangroves and surrounding areas were also noted (i.e. presence of litter, erosion, general indications of mangrove health, flowering, presence of propagules or seedlings).

Sediment monitoring

To test for potential changes in sediment composition and sediment quality, two replicate surficial sediment samples were taken (top 2-5 cm) from within each of the 17 monitoring quadrats. Collected sediments were sent to NATA accredited laboratories for analysis. Laboratory results were then compared to benchmark levels to ascertain whether a trigger exceedance had occurred. Exceedance of a benchmark level is defined as a measured analyte exceeding its relevant recommended sediment quality guideline value (SQGV; also referred to guideline value) as per Simpson et al (2013) and the same analyte also exceeding the background level for Darwin Harbour sediment. Background levels (i.e. average concentration) were calculated based on intertidal results presented in Darwin Harbour Baseline Sediment Survey 2012 (Munksgaard et al. 2013). Note, where measured metal or metalloids exceeded SQGVs, results where possible will be normalised for aluminium concentrations based on the methods described in Munksgaard (2013) and Munksgaard et al. (2013) and compared to background levels (i.e. baseline or reference levels)

Sediments were also tested in-situ for pH, temperature and redox potential within two subplots of each quadrat.

Bio-indicator monitoring

Ten mud whelk (*Telescopium telescopium*) samples were collected during the survey from a combination of impact and control sites (six impact and four control sites) for testing of levels of hydrocarbon and metal contamination. Each mud whelk sample consisted of two mud whelks (total 20 individuals). Collected mud whelks were sent to NATA accredited laboratories for analysis. Laboratory results were then compared to benchmark levels to ascertain whether a trigger exceedance had occurred. Exceedance of a benchmark level is defined as a measured analyte exceeding the national food standards contaminant levels for molluscs (FSANZ 2013) and the same analyte also exceeding the background level for Darwin Harbour sediment. Background levels (i.e. average concentration) were calculated based on reference site results presented in French (2013).

5.1.2 Results and discussion

Mangrove Health Monitoring

Canopy Cover

Canopy cover across all assemblages has remained relatively stable over time (Figure 5-2). The one notable change between March 2014 and March 2015 for control site tidal flat is due to the inclusion of two new control sites (CSMC03 and CSMC04) rather than an actual increase in canopy cover.

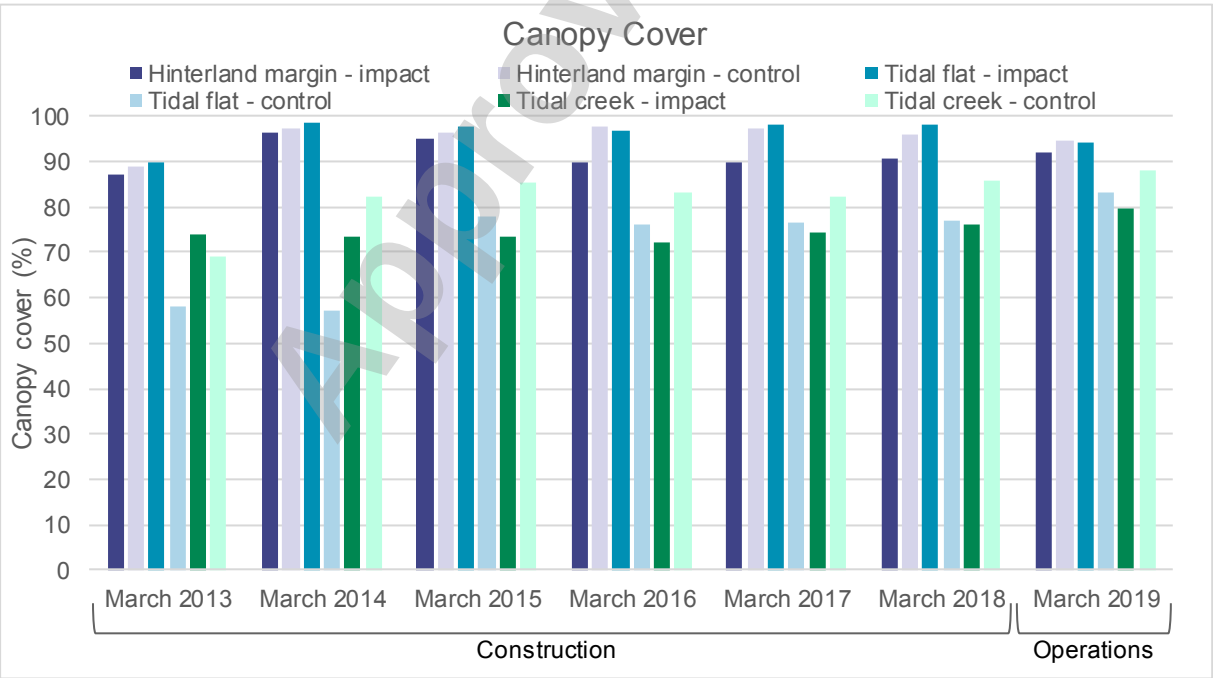


Figure 5-2: Mangrove canopy cover by assemblage

Community Health

All sites were classified as healthy in 2019 with visible recruitment (including the presence of flowering, seedlings, and saplings) and benthic fauna with signs of bioturbation (Figure 5-3). Leaf litter, insect damage and physical damage varied across sites but was generally classified as low to medium and within what would be considered normal for healthy mangrove forest stands.

Figure 5-3: Photo examples of mangrove health, recruitment and benthic fauna (mud whelks) observed during the 2019 survey

Sediment Monitoring

In-situ Sediment Measurements

In situ sediment measurements indicated that sediment at all sites is slightly acidic and highly reducing (Table 5-3), which is typical and characteristic of mangrove environments (Bomfim et al. 2018; Huang et al. 2018; Hossain and Nuruddin, 2016; Matthijs et al. 1999). Measurements were relatively consistent across impact and control sites (without significant differences or obvious trends) and do not indicate contamination or disturbance.

Table 5-3: Mangrove sediment in situ monitoring results

Assemblage	pH		Temperature		Redox potential	
	Impact	Control	Impact	Control	Impact	Control
Hinterland margin	6.21	6.52	29.1	29.5	-158.76	-137.85
Tidal flat	6.37	6.29	29.7	31.6	-66.56	-182.73
Tidal creek	6.37	6.15	28.9	32.1	-189.37	-173.45

Sediment Chemistry

A summary of the mangrove sediment chemistry results is provided in Table 5-4. Exceedances of the benchmark levels were recorded at both the impact and control sites for arsenic and hydrocarbons A single elevated level of chromium (exceeding the trigger level) was also found at one control site but was not investigated further as no exceedances were found at impacts sites.

For arsenic, given the exceedance was limited to only one impact site and an exceedance was also recorded at one control site, the high levels of arsenic at BMPC24 are unlikely to be attributable to Ichthys LNG activities. High levels of arsenic are known to naturally occur in Darwin Harbour and are considered a reflection of local geology rather than anthropogenic activities (Padovan 2003).

For hydrocarbons, a TPH exceedance was limited to one impact site while all three control sites (five of nine quadrats) also recorded exceedances. Positive results for TPH were reported throughout construction monitoring, including elevated concentrations above guideline values. However, following silica gel clean-up no exceedances were recorded indicating the presence of naturally occurring hydrocarbons (e.g. lipids, plant oils, tannins, animal fats, proteins, humic acids, fatty acids). Although silica gel clean-up wasn't undertaken as part of this (operations) survey, it is a method which can be performed during TPH/TRH analysis during future surveys to exclude bionic organics from results (Muijs and Jonker 2009, BCMELP 2004).

Levels of TPH at impact and control sites were found to be correlated with high levels of organics in the sediment (i.e. TOC). The Sediment Quality Guidelines note that hydrocarbons partition strongly to organic carbon; however, there is currently insufficient information to accurately normalise TPH for high levels of TOC (Simpson et al., 2013).

Based on the available information it was concluded, that no significant detectable impact from elevated sediment hydrocarbon levels has occurred and high levels of hydrocarbons are likely related to natural sources.

Bio-indicator Monitoring

A summary of the trigger assessment for sediment chemistry is provided in Table 5-5. All parameters were below benchmark levels. Interestingly all mud whelk samples recorded arsenic concentrations greater than FSANZ (2013). However, samples were below background levels, and as such did exceed benchmark levels. High levels of arsenic in mud whelks is likely a reflection of the naturally occurring high levels of arsenic in Darwin Harbour sediments which is a reflection of local geology rather than anthropogenic activities (Padovan 2003).

Table 5-4: Summary of mangrove sediment chemistry.

Site[1]	Aluminium (Al)	Antimony (Sb)	Arsenic (As)*	Cadmium (Cd)	Chromium (Cr)*	Copper (Cu)	Lead (Pb)	Nickel (Ni)	Zinc (Zn)	Mercury (Hg)	TOC	TPH
Guideline value	n/a	2	20	1.5	80	65	50	21	200	0.15	n/a	280
Background	n/a	n/a	16.0	0.071	17.5	4.7	8.8	8.7	21.4	n/a	n/a	n/a
BPMC09	5,380	<0.5	6.1	<0.1	12.8	3.0	4.4	<0.01	3.2	11.8	1.17	185
BPMC10	3,970	<0.5	4.3	<0.1	9.2	2.4	3.0	<0.01	2.6	10.2	1.22	190
BPMC11	2,135	<0.5	4.2	<0.1	5.5	<1	1.6	<0.01	<1	2.8	0.54	78
BPMC16	1,440	<0.5	3.2	<0.1	6.6	<1	<1	<0.01	<1	2.6	0.52	107
BPMC17	5,780	0.76	15.0	<0.1	72.5	4.6	5.0	0.02	2.2	16.4	4.08	**768**
BPMC24	5,495	0.86	**26.7 (48.5)**	<0.1	59.8	5.9	6.9	<0.01	3.4	24.2	0.53	140
BPMC25	6,020	<0.5	11.6	<0.1	18.8	3.7	7.0	<0.01	4.5	20.9	0.96	159
BPMC26	5,350	<0.5	6.7	<0.1	15.6	3.3	4.6	<0.01	3.4	10.6	1.76	269
CSMC01-HM	2,460	<0.5	<1	<0.1	5.0	1.1	<1	<0.01	<1	1.8	1.62	258
CSMC01-TF	3,110	<0.5	5.1	<0.1	10..	<1	2.2	<0.01	1.2	6.2	0.65	98
CSMC01-TC	12,500	<0.5	16.2	<0.1	34.1	6.7	10.6	0.02	8.8	23.8	5.70	**358**
CSMC03-HM	8,615	0.76	18.4	<0.1	**99.4 (115.4)**	12.5	31.2	0.02	9.0	34.7	0.90	124
CSMC03-TF	12,100	<0.5	18.8	<0.1	33.9	6.6	10.8	0.02	7.6	23.8	5.20	**1213**
CSMC03-TC	9,620	<0.5	**20.6 (22.0)**	<0.1	32.4	4.7	9.6	0.01	7.4	20.0	1.86	166
CSMC04-HM	4,590	<0.5	8.2	<0.1	18.8	10.4	8.2	0.02	3.8	15.0	2.26	**408**
CSMC04-TF	17,650	<0.5	17.6	<0.1	43.8	6.4	13.7	0.02	10.8	27.0	4.47	**514**
CSMC04-TC	16,700	<0.5	1900	<0.1	42.4	7.5	13.2	0.02	12.3	32.9	3.94	**358**

* Bold value indicates trigger exceedance and results in brackets have been normalised for aluminium concentrations as per Munksgaard (2013)[4].

Table 5-5: Summary of mangrove bio-indicator chemistry results.

Site	Aluminium (Al)	Antimony (Sb)	Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Lead (Pb)	Nickel (Ni)	Zinc (Zn)	Mercury (Hg)	TPH	Total PAH
Guideline value	n/a	n/a	1	2	n/a	n/a	2	n/a	n/a	Mean of >0.5	n/a	n/a
Background	n/a	n/a	3.8	0.31	n/a	n/a	0.54	n/a	n/a	n/a	n/a	n/a
BPMC09	3	<0.01	3.0	0.015	<0.05	17	<0.01	0.056	9	0.039	<100	<0.02
BPMC10	12	0.012	1.8	0.380	0.12	40	0.171	1.552	132	0.365	<100	<0.02
BPMC11	7	<0.01	1.9	0.035	0.04	24	<0.01	0.093	9	0.008	<100	<0.02
BPMC17	7	<0.01	1.8	0.014	0.09	19	0.014	0.160	12	0.011	<100	<0.02
BPMC24	117	<0.01	2.8	0.016	0.30	16	0.069	0.133	9	0.015	<100	<0.02
BPMC25	21	<0.01	2.4	0.013	0.07	20	0.016	0.110	9	0.066	<100	<0.02
CSMC01-HM	32	<0.01	2.5	0.025	0.11	10	0.015	0.246	12	0.103	<100	<0.02
CSMC03-TF	173	<0.01	2.6	0.064	0.60	12	0.124	0.420	26	0.107	<100	<0.02
CSMC04-TF	11	<0.01	1.6	0.025	0.06	37	0.011	1.045	10	0.075	<100	<0.02
CSMC04-TC	70	<0.01	2.5	0.025	0.17	10	0.034	0.130	6	0.020	<100	<0.02

5.1.3 Trigger assessment outcomes

In accordance with the receiving environment adaptive management process outlined in Section 7.5 of the OEMP, a trigger investigation report (L060-AH-REP-60025) was completed to evaluate multiple lines of evidence for:

- arsenic in sediment
- hydrocarbons in sediment.

The Trigger Investigation Report (L060-AH-REP-60025) concluded that the two potential sediment trigger exceedances are not attributable to Ichthys LNG activities. This investigation report also identified one recommendation to reduce the number of false-positive trigger exceedances in future surveys:

1. Potential impact site mangrove sediment samples that exceed the TPH 280 mg/kg trigger value are reanalysed following silica gel clean-up to remove non-petrogenic hydrocarbons

5.1.4 Program rationalisation

Minor changes to the mangrove health, intertidal sediment and bio-indicator monitoring program as per the recommendations from the trigger investigation (see Section 5.1.3).

5.2 Nearshore marine pests

5.2.1 Method overview

Nearshore marine pests were monitored to assess the presence/absence of invasive marine species at the Ichthys LNG and LPG/condensate product loading jetties (Figure 5-4) using artificial settlement units (ASUs; Figure 5-5). Each ASU consists of four settlement plates (back to back) and two rope mops. The ASUs are provided by NT Aquatic Biosecurity Unit, within the Fisheries Division of the Northern Territory Department of Primary Industry and Resources (NT DPIR).

Photo-monitoring of ASUs is undertaken monthly with ASUs collected and replaced every fourth month. Collected ASUs were sent to NT DPIR for identification. The ASUs were installed in September 2018 with monthly monitoring commencing in October 2018, with ASUs collection and replacement in January and May 2019.

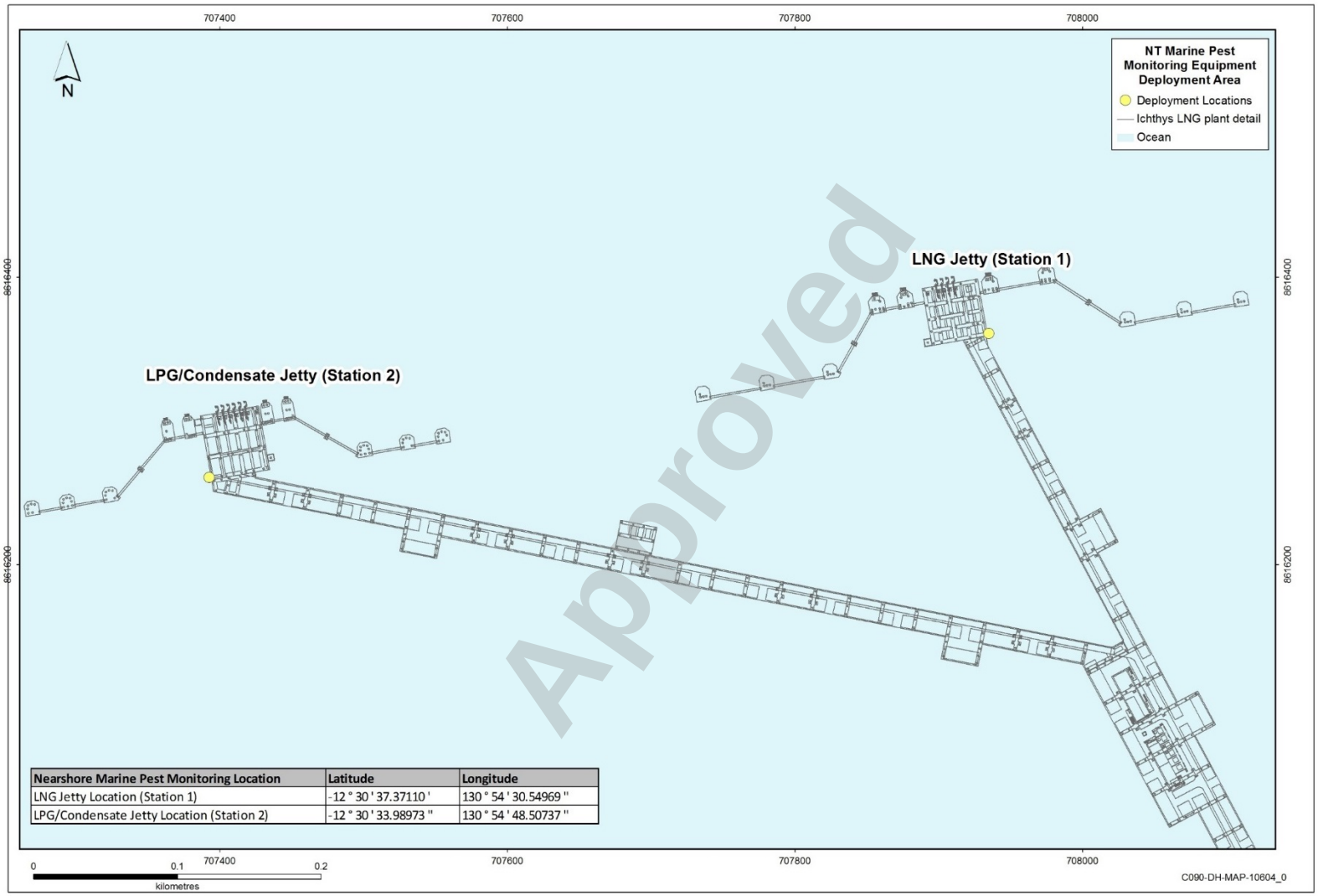


Figure 5-4: Nearshore marine pest monitoring locations

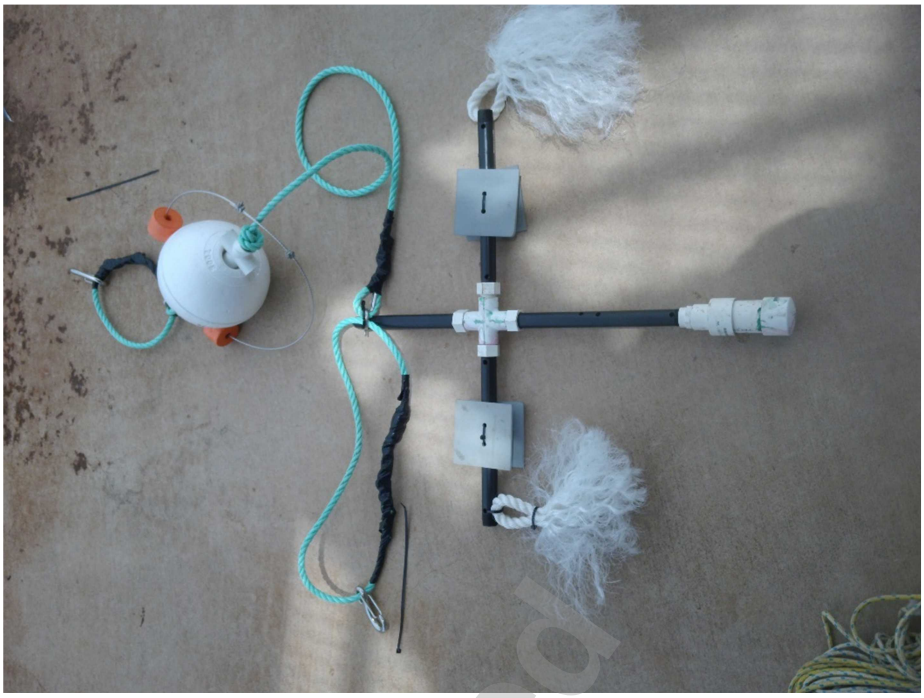


Figure 5-5: Nearshore marine pest ASU

5.2.2 Results and discussion

No invasive marine species have been identified during this reporting period. Table 5-6 provides a summary of organisms identified on LNG and LPG/condensate jetties.

Table 5-6: Organisms identified on ASUs during reporting period by NT DPIR

LNG jetty	LPG/condensate jetty
• Sabellidae • Barnacle • Colonial Ascidian • Solitary Ascidian • Hydroid • Serpulidae • Serpulid • Oysters • Amphipod tubes • Algae • Polychaete • Silt • Encrusting Bryozoan • Branching Byrozoan • Sponge	• Sabellidae • Barnacle • Colonial Ascidian • Solitary Ascidian • Hydroid • Serpulidae • Oyster • Amphipod tubes • Algae • Polychaete • Silt • Encrusting Bryozoan • Branching Bryozoan

5.2.3 Program rationalisation

No change proposed to the marine pest monitoring. Monitoring on each of jetties will be completed for the first three years of operations. Following this, the program will be reviewed to assess adequacy and determine whether or not future monitoring is warranted.

5.3 Introduced terrestrial fauna

Introduced terrestrial fauna may be monitored to determine the presence, location and methods used to control nuisance species.

5.3.1 Method overview

In the event introduced terrestrial fauna are deemed to be a nuisance at Ichthys LNG, INPEX will undertake an annual survey using a third-party licenced pest management contractor.

5.3.2 Results and discussion

During the reporting period there was no reports of introduced terrestrial fauna being deemed a nuisance, as such, no annual survey was undertaken. The routine and ad-hoc pest management programs including baiting and trapping adequately managed introduced terrestrial fauna at Ichthys LNG.

5.3.3 Program rationalisation

No change to the current program is proposed

5.4 Weed mapping

The key objectives of the weed mapping program are to:

- identify the abundance and spatial distribution of known and new emergent weed populations; and
- inform weed management and control activities.

Weed surveys were undertaken biannually (twice yearly) during distinct 'wet' and 'dry' seasons. Table 5-7 provide a summary of surveys completed during the reporting period.

Table 5-7: Weed survey details

Survey	Date	Report	INPEX Doc #
Survey 1	November 2018	Weed Management Report No. 1	F280-AH-REP-60100
Survey 2	May 2019	Weed Management Report No. 2	F280-AH-REP-60101

5.4.1 Method overview

Weed surveys were performed in accordance with INPEX's approved Weed Mapping Plan (F280-AH-PLN-60010). The area surveyed is shown in Figure 5-6.

Figure 5-6: Weed survey area

Parameters monitored during the weed surveys are listed in Table 5-8. Where identification of a species was not possible in the field, a voucher sample, together with photographs were taken to facilitate post survey identification.

Table 5-8: Weed survey parameters

Key Parameter	Descriptor
Weed names	Scientific and common names
Physical locations	GPS coordinates of localised outbreaks, polygons for larger occurrences
Abundance	Individual numbers and/or percentage cover, enabling comparison with previous and historic monitoring events
Date	Date of data collection for future and historic comparison

5.4.2 Results and discussion

No new declared or non-declared weed species were recorded at Ichthys LNG during the reporting period, with all species previously recorded during the construction phase. Declared weed species previously identified during construction phase weed surveys were:

- perennial mission grass
- neem tree
- flannel weed
- annual mission grass
- gamba grass
- horehound

Annual mission grass infestations and single plants were the most widespread and abundant within the site with the species recorded across the site. Larger infestations were recorded in the GEP corridor and adjacent to Bladin Point Road while single plants and thin strips were observed in the production and operations areas.

These findings are generally consistent with Construction phase weed monitoring surveys in 2018, which recorded gamba grass, annual mission grass, perennial mission grass and horehound as the weeds with the highest abundance. These weeds were also recorded in the highest abundance during the 2014 weeds monitoring which indicates no significant change in weeds species present on the site.

Weeds identified during the weed mapping surveys were communicated to the Weed Contractor and managed according (see Section 5.5).

5.4.3 Program rationalisation

No changes proposed to the weed mapping surveys.

5.5 Weed management

5.5.1 Method overview

Vegetation control at the site was undertaken and managed by Territory Weed Management Pty Ltd during the reporting period. Vegetation control at the site occurred along the fence lines, drains, inside the facility and along the GEP corridor. Weed control was conducted predominately in the wet season through spray application of herbicides.

Grasses and smaller broadleaf weeds are controlled through the application of Roundup Biactive (glyphosate 360 g/L) and Ken-Met (metsulfuron-methyl 600g/kg). Woody weeds are controlled through the use of Grazon Extra (300 g/L triclopyr, 100 g/L picloram, 8 g/L aminopyralid).

5.5.2 Results and discussion

Territory Weed Management visited the site on four occasion to undertaken vegetation control on the following dates:

- 8 to 10 August 2018 – treatment between the perimeter drain and inner security fence, and along the GEP corridor. Vegetation control of grasses and woody weeds.
- 18 to 23 February 2019 –concentrated on GEP, and random spot treatments around the operations complex area. Vegetation control of grasses.
- 11 to 13 April 2019 –treatment to known problem areas throughout operational areas (i.e. muster points, contractor B, local electrical rooms/local instrument rooms). Vegetation control of grasses, and woody weeds
- 27 to 31 May 2019 - treatment to perimeter fencing. Vegetation control of grasses, and woody weeds.

5.5.3 Program rationalisation

No changes proposed to weed management.

5.6 Vegetation rehabilitation monitoring

The key objectives of the vegetation rehabilitation monitoring were to:

- map the distribution of vegetation communities immediately adjacent to the GEP corridor
- map the pre-clearing vegetation community within the GEP corridor
- classify areas within the GEP corridor according to their rehabilitation progress.

A summary of the vegetation rehabilitation monitoring (also known as vegetation surveillance) for the reporting period is detailed in Table 5-9.

Table 5-9: Vegetation surveillance survey completed

Survey	Date	Report	INPEX Doc #
Survey 1	May 2019	Vegetation Surveillance Report No. 1	F280-AH-REP-60112

5.6.1 Method overview

An annual vegetation re-habitation surveillance survey was performed in accordance with INPEX's approved Vegetation Surveillance Plan (F280-AH-PLN-60011). The areas surveyed are shown in Figure 5-7. Key parameters assessed the surveillance survey are shown in Table 5-10.

Table 5-10: Vegetation surveillance parameters

Key Parameter	Descriptor
Flora species identifier	Scientific and common names
Vegetation community description	Description of vegetative communities' composition, including species present and life-stages
Vegetation community condition	Description of condition of vegetation communities present, including percentages of vegetative cover, evidence of erosion, bare earth or scalds, weed presence, litter cover, evidence of recruitment, organic crust
Physical locations	GPS coordinates and polygons of communities
Reference photographs	Photograph point locations were established within the first survey for future reference. Point photographs were taken within each key vegetation community identified for future comparison
Date	Date of data collection for future and historic comparison

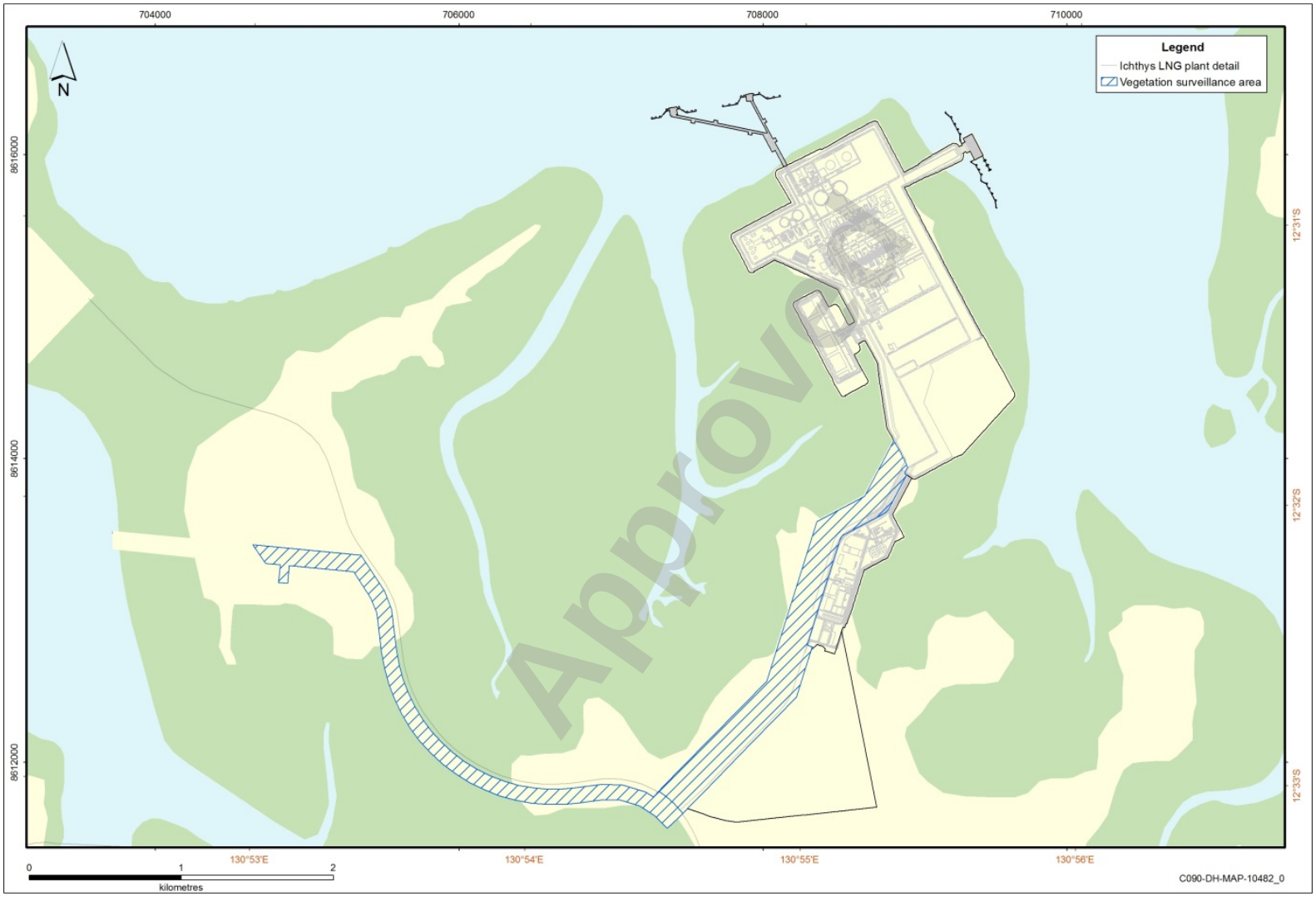


Figure 5-7: Vegetation surveillance survey area

5.6.2 Results and discussion

The results of the survey indicate that the rate and nature of natural regeneration of vegetation within the GEP corridor differs for each of the vegetation communities:

- *Mixed eucalypt woodland* – recruitment of primarily pioneering Acacia species, was evident throughout most areas of this community. However only a small number of Eucalypt seedlings were recorded. It is anticipated that with suitable seasonal conditions recruitment events of these and other overstorey species will occur given the prevailing stable soil surfaces and seed source provided by adjacent remnant vegetation. Soil surfaces were observed to be stable in most eucalypt woodland areas however isolated patches of low to moderate gully erosion were recorded at two locations associated with slightly sloping ground where elevated woodland areas transition into tidal communities.
- *Mangrove low closed forest* - Natural regeneration of mangroves was evident in all areas of this community surveyed with scattered seedlings and juveniles of both dominant mangrove species recorded with evidence of several recruitment events and mixed age-class mangroves noted. Surface soils were observed to be stable through the community. These observations indicate that the rehabilitating mangrove communities are trending towards a self-sustaining state.
- *Melaleuca open woodland/sedgeland* - Natural regeneration was recorded throughout all areas of this community within the GEP corridor with extensive recruitment of a range of sedge species forming moderately dense stands. Scattered melaleuca juveniles and seedlings were also recorded on elevated areas. Surface soils were observed to be stable through the community. These observations indicate that this community is trending towards a self-sustaining state.

The results of the survey indicate that the current minimal intervention approach is achieving good progress in the rehabilitation of vegetation within the GEP corridor. Natural regeneration has taken place in approximately two thirds of the rehabilitation area, indicating significant progress towards achieving a self-sustaining state whereby perennial vegetation dominates and soil surfaces are stable. Over time it is anticipated that the rehabilitating vegetation communities will approach the structure and species richness of the adjacent remnant vegetation and transition towards the ultimate rehabilitation outcome of self-sustaining vegetation communities resembling the species composition and structure of surrounding remnant vegetation.

Earthen embankments have been constructed primarily along the access track (particularly in areas of sloping ground) and these appear to have largely been successful in arresting surface water flows and preventing accelerated erosion and promoting vegetation regrowth. In addition, branches have also been placed on the rehabilitation strips either side of the access track on some sections and these have also contributed to stabilising soil surfaces and capturing plant litter and seed, thereby enhancing regeneration of native vegetation.

5.6.3 Program rationalisation

No changes proposed to the vegetation surveillance monitoring surveys.

5.7 Cultural heritage

The objective of cultural heritage surveys is to determine if there has been any interference to cultural heritage sites.

5.7.1 Method overview

Visually inspections of cultural heritage sites will be undertaken annual.

5.7.2 Results and discussion

INPEX, in conjunction with the Larrakia Advisory Board conducted a tour of Heritage Hill on 27 September 2018. During the reporting period there were no reports of any damage to, or interference with heritage sites.

INPEX has engaged the Larrakia Development Corporation to undertake weed management within the heritage site and to install a new protection fence around the Heritage Hill site.

6 WASTE REDUCTION MEASURES

For the first year of Ichthys LNG operations, the intent is to establish waste volumes to benchmark future years against (with the exceptions of specific start up waste streams). Following the establishment of a baseline for Ichthys LNG, subsequent years waste volumes will be tracked and compared.

Following the execution of EPL228 in September 2018, the OEMP and supporting waste management documentation were implemented. This involved management of waste in accordance with the INPEX waste management processes and the waste control hierarchy (Figure 6-1).

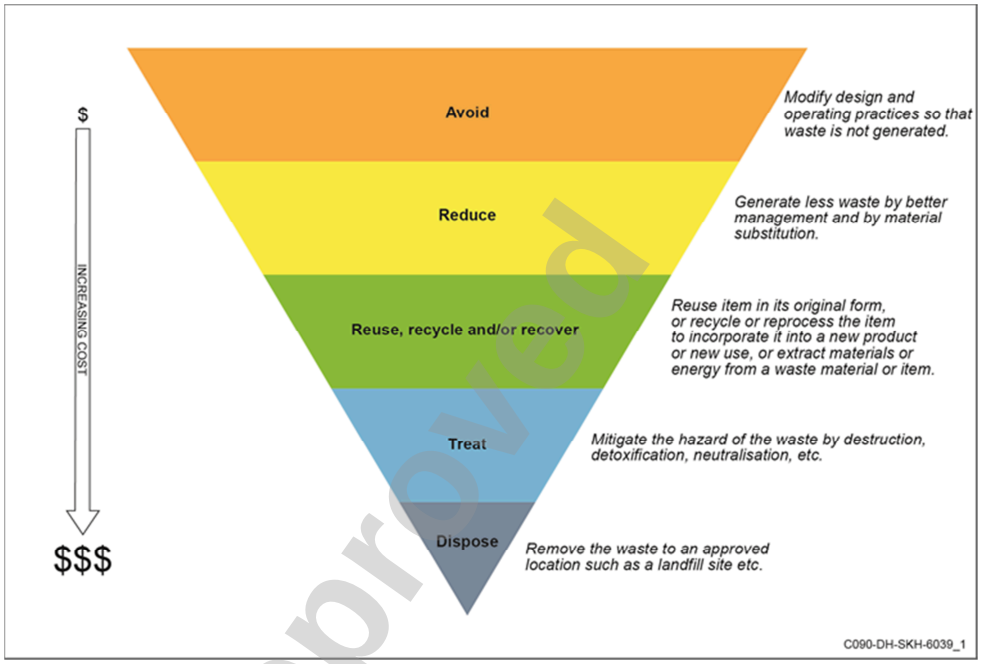


Figure 6-1: INPEX waste control hierarchy

Waste streams at the site were categorised into four broad classes:

- Recyclable (non-hazardous) waste
- Non-recyclable (non-hazardous) waste
- Recyclable (hazardous) waste
- Non-recyclable (hazardous) waste.

Waste segregation measures involved the placement of various recyclable and non-recyclable waste receptacles around Ichthys LNG, while liquid wastes were segregated into recyclable and non-recyclable streams and then disposed of offsite to suitable treatment and disposal facilities.

The main waste reduction measure implemented during the reporting period (i.e. reduce waste being disposed offsite) was through the use of the onsite evaporation basin. The evaporation basin is designed to handle low level chemical and hydrocarbon contaminated water generated at Ichthys LNG, and inter-site transfers to the wastewater treatment plants. Approximately 5,500 tonnes of liquid waste was transferred to the evaporation basin and wastewater treatment plants during the reporting period, which resulted in this liquid waste not being taken offsite for treatment and disposal.

INPEX will continue to work with its main waste contractor to identify waste reduction measures for Ichthys LNG.

7 PROGRAM RATIONALISATION SUMMARY

7.1 Discharges to water

Following commencement of steady state operations for LNG Train 1 and 2 on 19 June 2019, the frequency of sampling reduced from weekly to monthly in accordance with EPL228. The sampling frequency will be increased to weekly when the CCPP discharge stream is introduced to 750-SC-003 and will revert back to monthly once the CCPP reaches steady state[2].

There are no changes proposed to the jetty outfall or harbour sediment quality monitoring programs. Section 2.2.4 details a number of operational limitations that may impact the ability to execute the jetty outfall monitoring program as described in EPL228.

7.2 Emissions to air

As described in Section 3, three of the four emissions to air monitoring programs were not triggered during the reporting period or were trigged with monitoring commencing outside the reporting period in accordance with the relevant EPL228 conditions. Results for these programs will be included in the 2019/2020 AEMR.

No dark-smoke event program rationalisation is proposed.

7.3 Unplanned discharges to land

No changes in groundwater quality attributable to Ichthys LNG activities have been detected to date. If no changes are detected for the fourth quarterly survey, groundwater sampling will revert to six-monthly as described in Section 7.3.1 of the OEMP.

7.4 Flora, fauna and heritage

There are no changes proposed to any of the flora, fauna and heritage programs with the exception of including silica gel clean-up as part of the mangrove intertidal sediment analysis. This change is proposed to reduce the number of false-positive TPH trigger exceedances (see Section 5.1.3).

8 REFERENCES

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APPENDIX A: NT GUIDELINE FOR ENVIRONMENTAL REPORTING

NT Guideline for Environmental Reporting	NT Guideline Information	AEMR Reference
Title page	The title page should include: • report name • reporting period (e.g. October 2014–October 2015) • date of submission • version number • where relevant, licence/approval number, or reference to other document the report is being submitted in relation to (e.g. environmental impact statement, pollution abatement notice) • details of report author, including company details.	Title page and Section 1
Executive summary	The executive summary should succinctly summarise each section of the report, and in particular, the findings of the report.	Executive summary
Monitoring objective	The monitoring objective(s) should be clearly stated in order to enable the results of monitoring to be assessed in the context of the objectives. Note, where monitoring is linked to a licence or approval, the objectives of monitoring: • may already be specified in an approved monitoring plan, or • may simply be the specific conditions on monitoring included in the • licence/approval that state monitoring point locations, analytes, analysis type, frequency and limits/trigger values.	Each section includes a subsection with monitoring objectives for each monitoring program
Monitoring method	*Where there is an approved monitoring plan* Provide details of the approved plan (title, version number, date of submission). *Where there is not an approved monitoring plan* Provide details including: • current map showing sampling locations (including control/reference sites), discharge/emission points, major infrastructure, sensitive environmental receptors, key, scale bar and north arrow • a description of the receiving environment, including environmentally sensitive receptors and significant features	Each section includes a subsection with monitoring methods for each monitoring program

NT Guideline for Environmental Reporting	NT Guideline Information	AEMR Reference
	• a description of sampling and analysis methods, including detail on reasons for selection of sampling locations (e.g. random stratified), assumptions and deviations from standard sampling/analysis methods1 • factors that may affect variability in monitoring results (e.g. tidal movement, climate, fauna migration, peak production months).	
Monitoring results–presentation	The clear and concise presentation of monitoring results is a critical component of a monitoring report. When presenting results it is important to ensure that: • current results are presented in a table and graph • results are presented along with: o units o assessment criteria (e.g. limits/trigger values specified in o licences/approvals, or in relevant standards or guidelines2) o analysis type (e.g. for filtered/unfiltered with filter pore size, five-day or o three-day biological oxygen demand, wet or dry weights) o analytical methods o limit of reporting (LOR), or level of precision for results obtained from o field instruments o measures of uncertainty • necessary calculations have been made, to compare data with assessment • criteria (e.g. calculation of medians, means, running averages and loads) • modification calculations (such as for hardness) have been made using the modifying parameter recorded at the time of sampling • all results that exceed the assessment criteria are clearly highlighted • summary of previous results (sufficient to highlight trends – usually a minimum of 2–5 years data) is included.	Each section includes a subsection with monitoring results and discussion for each monitoring program
Monitoring results–quality assurance/ quality control (QA/QC) evaluation	Results presented in the monitoring report should be reviewed for data completeness, accuracy and precision. Some typical QA/QC questions include: • for completeness – were all samples taken at the correct location and frequency? • for quality control – _ were all samples collected, preserved in accordance with the	Monitoring plans (referenced in the method overview section) include

NT Guideline for Environmental Reporting	NT Guideline Information	AEMR Reference
	specified sampling method or standard sampling methods? • were calibration checks made and were results within an acceptable range? • was analysis undertaken in accordance with relevant national standards (such as accredited under the National Association of Testing Authorities)?	QA/QC processes.
Discussion and interpretation of results	This section should include: • discussion of results in context with the monitoring objective(s) • discussion of results where assessment criteria were exceeded, including likely cause of exceedances and likelihood of further exceedances • discussion of trends (consideration of spatial and temporal trends in comparison to previous monitoring data) • discussion of anomalous results, including likely cause • statistical analysis where appropriate • a table of non-conformances with monitoring method.	Each section includes a subsection with monitoring results and discussion for each monitoring program
Conclusion and proposed actions	This section should include conclusions on: • whether the monitoring objective(s) was achieved • compliance with assessment criteria • if, and to what extent, environmental harm may have been caused (such as by emissions/discharges and/or exceedances of assessment criteria –when considering both acute and chronic affects) • major assumptions or uncertainties • conclusions about effectiveness of the monitoring method/plan and overview of any proposed changes (if any) • proposed actions to address exceedances or non-conformances.	Each section includes a subsection for program rationalisation
Certification	In this section the submitter of an environmental monitoring report must confirm that the report is true and accurate. Where the report relates to a licence/approval, confirmation must be provided by a person(s) authorised to legally represent the holder of the licence/approval. The wording for this section should be: *I [NAME AND POSITION], have reviewed this report and I confirm that to the best of my knowledge and ability all the information provided in the report is true and accurate.*	Appendix B

NT Guideline for Environmental Reporting	NT Guideline Information	AEMR Reference
	Note: significant penalties may apply where it is demonstrated that false or misleading information has been supplied to the NT EPA.	
Abbreviations	Use of abbreviation should be minimised. However, if they are used to improve readability, this section should specify all abbreviations used in the report.	Throughout AEMR
References	If information (facts, findings etc.) from external documents is to be included in the report, the information must be referenced. If references are from documents that are not freely available (e.g. internal reports, mine management plans) then such documents will need to be provided to the NT EPA on request.	Throughout AEMR
Appendices	Appendices should be used for information that is too detailed or distracting to be included in the main body of the report (such as raw data tables, laboratory reports, QA/QC data). Note: raw data should be submitted electronically in a spreadsheet format (such as Microsoft Excel).	Appendices included

APPENDIX B: EPL228 AEMR 2018-2019 CERTIFICATION

B.1 Qualified Professional

ERM

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INPEX Corporation
Jamie Carle
Team Lead – Environmental Services
Level 22, 100 St Georges Terrace
Perth, WA, 6000

ERM

19 September 2019

Reference: ERM 0520839

Dear Jamie

Subject: AEMR Review and certification report

Environmental Resources Management Australia Pty. Ltd (ERM) was engaged by INPEX Corporation (INPEX) to undertake an independent review of the Ichthys LNG Plant's Annual Environmental Monitoring Report (AEMR) by Qualified Professionals[1]. This report documents the review process, identifies the issues raised and their resolution, resulting in a statement of verification and Statutory Declaration as required by the Northern Territory EPA (NT EPA).

The scope of the review is pursuant to Condition 91 of the Environmental Protection Licence (EPL) 228-01, stated as follows:

91 The Annual Environmental Monitoring Report must:

91.1 report on monitoring required under this licence;

91.2 summarise performance of the authorised discharge to water, compared to the discharge limits and trigger values specified in Table 3 in Appendix 2;

91.3 summarise performance of the authorised emissions to air, compared to the emission limits and targets specified in Table 5 in Appendix 3, when the fuel burning or combustion facilities for the Scheduled Activity have operated under normal and maximum operating conditions for the annual period;

91.4 summarise operating conditions of each emission source and the resulting air emission quality;

91.5 provide total emissions to air in tonnes per year for the air quality parameters listed in Table 6 in Appendix 3;

91.6 assess the contribution of the authorised emissions on the Darwin region ambient air quality during periods not affected by bushfire smoke for Wet and Dry seasons;

91.7 report on outcomes of the REMP monitoring and assessment;

91.8 summarise measures taken to reduce waste;

[1] A *'qualified professional'* as described by the EPL228-01 is a person who has professional qualifications, training or skills or experience relevant to the nominated subject matters and can give authoritative assessment, advice and analysis about performance relevant to the subject matters using relevant protocols, standards, methods or literature.

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91.9 consider the NT EPA Guideline for Reporting on Environmental Monitoring

91.10 be reviewed by Qualified Professional(s); and

91.11 be provided to the NT EPA with the Qualified Professional(s) written, certified review(s) of the Annual Environmental Monitoring Report.

The purpose of the qualified professional review of the AEMR is to provide an independent assessment verifying that the AEMR is compliant with the conditions of EPL228-01. The review was undertaken by a number of qualified professionals as deemed appropriate for the content of the AEMR. The qualified professionals are listed in Table 1.

Area of expertise	Qualified professional
Discharges to Water	Ken Kiefer
Waste	Nicole Bradley
Air Quality	Christopher Thomson

Each of the qualified professionals individually reviewed the AEMR with respect to the EPL228-01 condition 91 and the relevant corresponding area of expertise. The comments raised were recorded in a comments register which is appended to this report in **Annex A**. The register was provided to INPEX seeking comment on how the identified issues will be closed out. INPEX resubmitted the revised AEMR to ERM for review, which incorporated the agreed changes and the comments register cross-referenced with the revised sections of the AEMR.

A total of 26 items were queried during the review. ERM is satisfied that each of these have been appropriately closed out, enabling the following statement of verification to be made and signed by each of the qualified professionals who undertook the review.

Statement of verification: Based on the review as outlined in this report, ERM confirms that INPEX responded to all comments raised. ERM has reviewed INPEX responses to the comments provided and is satisfied that the content of the AEMR comply with Condition 91 of the EPL228-01 for the 2018-2019 period.

Area of expertise	**Qualified professional**	**Qualified profession Signatures**
Discharges to Water	Ken Kiefer	
Waste	Nicole Bradley	
Air Quality	Christopher Thomson	

Yours sincerely,

For Environmental Resources Management Australia Pty. Ltd.

Christopher Thomson
Principal Environmental Scientist

Paul Fridell
Partner

Annex A: Comments Register
Annex B: Statutory Declarations
Annex C: Qualified Professionals – profile and CVs

ERM

19 September 2019
Reference: ERM 0520839

ANNEX A: - COMMENTS REGISTER

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2018/2019

Contract Number	INPEX PO 4500054249 (ERM proposal 0515674)
Reviewer	ERM
Document Name	EPL228 Annual Environmental Monitoring Report 2018-2019
Company Document No#	L060-AH-REP-60029
Document Revision No# / Date	Revision B / 3 September 2019

No.	Context	Reviewer Comment/Recommendation (6/09/2019)	INPEX Response (10/09/2019)	Reviewer Response (13/09/2019)	INPEX Response (13/09/2019)
General Compliance Matters (Paul Fridell)					
1	Defining AEMR monitoring period – Section 1.1	Licence condition 90 states: *"The licensee must submit an Annual Environmental Monitoring Report to the NT EPA by 30 September for each year of this licence unless otherwise agreed, for the Scheduled Activity conducted during the preceding 12 month period."* The nominal monitoring period of the AEMR is 14 September 2018 – 30 June 2019 (a nominal 9 month period). Taking a literal interpretation of this condition implies monitoring report including at least 12 months. It is suggested that if an alternative interpretation has been agreed with EPA that this be discussed in the report, or if INPEX has unilaterally made a determination of monitoring period to financial years that this decision is also discussed. Given the number of versions of the EPL it should also be clear that EPL228-01 was the version current for the duration of the nominal reporting period.	Footnote has been added to Section 1.1 clarifying reporting period for AEMR. Footnote text is provided below: *"AEMR reporting period was agreed with NT EPA via email on 10 August 2019 to cover a 12-month period from 1 July to 30 June. However, as EPL228 was only activated part way through the reporting period on 14 September 2018, the reporting period for this AEMR only covers the nine and a half month period from EPL228 activation until 30 June 2019."*	Closed	Closed
2	Sec 1.2 Table 1-1 defining Condition 91 requirements.	Condition 91.1 requires the AEMR to *"report on monitoring required under this licence"*. It would therefore be logical to assume that the monitoring required under the licence is all conditions under the "Monitoring" sub heading (Conditions 59-78). A compliance table at the start of each section (like Table 1-1) would therefore be a useful and transparent way to demonstrate compliance. Table rows include the monitoring licence condition, brief detail on applicability and cross reference to AEMR section that demonstrates compliance.	INPEX has considered including a table but the evidence/level of detail required to demonstrate compliance with a number of conditions is more suited to audit evidence (e.g. Condition 64 relates to field data sheets, CoCs and lab assays including QAQC) and as such is not included in the AEMR (this level of detail is included in technical reports, with outcomes summarised in the AEMR). INPEX therefore doesn't propose any change. INPEX does acknowledge that it could be assumed that monitoring required under the licence is all conditions under the "Monitoring" sub heading (Conditions 59-78). As such, monitoring that wasn't previously included in the AEMR has been included/referenced. such as the wastewater commissioning monitoring plan.	Closed	Closed
3	Certification / Appendix B	According to the NT guidelines, the certification is to be provided by the *"submitter"*. The qualified professionals also need to provide certification under 91.11 but the AEMR itself is to be certified by INPEX according to the guidelines (91.9).	INPEX is seeking internal legal clarification regarding whether certification has to be provided by INPEX as Condition 91.9 states the guideline only has to be considered: *"**consider** the NT EPA Guideline for Reporting on Environmental Monitoring"*. Regardless, the finalised report will include a document control page that has the endorsement and approval of the General Manager Onshore Operations and Environmental Manager respectively.	Closed	Closed
Air Quality (Qualified Professional - Chris Thomson)					

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COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2018/2019

No.	Context	Reviewer Comment/Recommendation (6/09/2019)	INPEX Response (10/09/2019)	Reviewer Response (13/09/2019)	INPEX Response (13/09/2019)
1	Section 3 – incomplete sentence reword for clarity	Reword sentence for clarity "As per the requirements of EPL228 Condition 57, ambient air quality and air toxic monitoring is triggered to commence once both LNG trains and the CCPP (in combined cycle) have reached steady-state."	Paragraph has been reworded to read: *"Point source emission monitoring is triggered to commence within two months of steady-state following completion of first start-up of the first LNG (Condition 67 of EPL228). As this occurred on 19 June 2019, no monitoring occurred during the reporting period. Monitoring of point source emissions is scheduled to commence in August 2019 and outcomes of this will be reported on in the 2019/2020 AEMR."*	Closed	Closed
2	First para section 3 in relation to Condition 91.4.	It is acknowledged that much of the plant has not been operating at steady state and therefore does not trigger the reporting period for the 2018/2019 AEMR. This is described in general within the document (first para of Section 3). In order to comply with condition 91.4, it is suggested that a table be prepared and included within Section 3, which articulates the status of the emission source, and include a column stating air quality. The air quality column is expected to have n/a due to being outside of the reporting requirements for this AEMR. This table will then be consistent for the 2019-2020 AEMR. This could take a similar form to Table 7-2 of the OEMP.	A new table (Table 3-1) has been added as suggested based on OEMP Table 7-2 with columns for status and air quality. Air quality for all is n/a while status is start-up/intermittent.	Closed	Closed
3	Section 3 – incomplete line, reword for clarity	Reword for clarity "As mentioned above, point source emission, ambient air quality and air toxic monitoring was not triggered during the reporting period. Regardless, INPEX is required (Condition 91.5 of EPL228) to provide total emissions of air quality parameters listed in Table 6, Appendix 3 of EPL228, as per. "	Paragraph has been reworded: *"As mentioned above, no point source emission, ambient air quality and air toxic monitoring was undertaken during the reporting period as it was not triggered. Although no monitoring was undertaken, INPEX is required (Condition 91.5 of EPL228) to provide total emissions of air quality parameters listed in Table 6, Appendix 3 of EPL228. Estimated total emissions to air for the reporting period are provided in Table 3-2, which are based on INPEX's Commonwealth emission reporting requirements (National Pollutant Inventory (NPI) and National Greenhouse and Energy Reporting Scheme (NGERS)."*	Closed	Closed
4	Table 3-1	While the content of the table satisfies condition 91.5, there is no reference to the source of the data provided. It is understood that the parameters of temperature, efflux velocity and volumetric flow rate although are within table 6 of appendix 3, they are not provided because they do not constitute emissions.	The values presented in Table 3-1 (now Table 3-2) are based on INPEX Commonwealth reporting requirements (National Pollutant Inventory and National Greenhouse and Energy Reporting). This context has been added for clarity (see above cell for changes to text).	Closed	Closed
5	Section 3.1 – first line	The first line cross-reference to Section 2. This section reports on discharges to Water. Amend cross reference and check cross-referencing throughout.	Amended, unclear why this cross reference didn't update.	Closed	Closed
6	Section 3.1.1	Reference "NEPM" to include Schedule 3 and the year 2015 for accuracy.	Updated to include Schedule 3 and the year 2015	Closed	Closed
7	Section 3.2.1	be sure to include reference that the sampling ports for point source emissions to air are specified. With relation to EPL condition 91.1 and 65.1-65.2.	Section updated to reference Table 4, Appendix 3 of EPL228.	Closed	Closed
8	Section 3.2.1	Ensure reference to *NSW Protection of the Environment Operations (Clean Air) Regulation, Schedule 5 Test methods, averaging periods and reference conditions for scheduled premises.* is included in method overview as per EPL condition 91.1 (67.4)	Reference included in Section 3.2.1.	Closed	Closed

2

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2018/2019

No.	Context	Reviewer Comment/Recommendation (6/09/2019)	INPEX Response (10/09/2019)	Reviewer Response (13/09/2019)	INPEX Response (13/09/2019)
9	Section 3.3.1	Along with the flare system results recording dark smoke events, it would be good to provide a reference as to where data on flow, volume and source of hydrocarbons that are flared is stored and also the quality and quantity of VOCs being flared as per EPL condition 91.1 (72).	Section 3.3.1 updated to include the following text: *"Flaring and other data is stored in the sites Process Control System (PCS). The PCS serves as the primary means to control and monitor the plant and automatically maintains operating pressures, temperatures, liquid levels and flow rates within the normal operating envelope with minimal intervention from operator consoles in the central control room (CCR). The system has built in redundancy in communication, control and human interface. Information from the PCS is displayed on visual display units in the CCR. During process upset conditions, the system has detailed alarm handling and interrogation functions to minimise operator overload. The PCS is also equipped with a database function that permits operations personnel to investigate a historical sequence of events. In addition, VOC emission are estimated by use of the NPI and NGERS reporting tools."*	Closed	Closed
10	Section 3.2	Reference to the first start-up emissions test plan should be provided as this has been undertaken during the reporting period. This links to EPL condition 91.1 (73).	First start-up emissions test plan reference has been included in Section 3.2	Closed	Closed
Discharges to Water (Qualified Professional – Ken Kiefer)					
1	Table 2-1	Monitoring was only completed three times in February 2019, which doesn't represent weekly monitoring frequency as specified in Table 3, Appendix 2 of EPL228. Provide justification/ reasoning for not monitoring.	Sampling was undertaken on 13 February but left out of Table 2-1 by accident. This has been updated. Data for this sampling event was already included in Appendix C.	Closed	Closed
2	Table 2-2	Provide a description of the discharge sampling point (e.g. 750-SC-003)	Section 2.1.1 updated to include brief description of sampling point: *"The commingled treated effluent sampling point (750-SC-003) is located downstream of treated effluent observation basin (750-SU-404) and upstream of the jetty outfall. Samples collect from 750-SC-003 represent liquid effluent that is discharged to Darwin Harbour via the jetty outfall. The sampling point consists of two values, an isolation valve and a sample needle valve, with the latter used to regulate flow for sample collection."*	Closed	Closed
3	Table 2-2	The list if parameters in table 2-2 are not consistent with the Water Quality Parameters listed in Table 3, Appendix 2 of EPL228. For consistency, list the parameters in Table 2-2 consistent with the EPL and provide clarification on the need for the additional analytical parameters, include for aMDEA and Glycols.	Table updated to reflect Table 3, Appendix 2 of EPL228 with footnote added for glycol and aMDEA. For glycol, Meg and TEG are measured as the two glycols that may be in the system. No laboratories are accredited for aMDEA analysis, as such MDEA using an accredited lab was measured as a proxy for aMDEA.	Noted. Please confirm that the LOR for glycols is 2 mg/L. If both MEG and TEG are present and have a LOR of 2 mg/L then the combined LOR of 4 mg/L.	Glycol LOR updated to 4 mg/L as LOR for MEG and TEG is 2 mg/L each.
4	Section 2.1.2	It is noted that the flow cell for rate of discharge was not functioning during the period from September 2018 to May 2019. A monthly discharge volume was calculated based on pump run times and pit/tank volumes and presented in Table 2-3. A reporting of monthly is not consistent with the Table 3, Appendix 2 of EPL228 frequency of "continuous" for volumetric flow rate at 750-SC-003. While continuous data is not available, the reporting of monthly averages does not capture variability. If data are available for pump run times and pit/tank volumes at a frequency higher than monthly during this period, use of that would provide better understanding of the potential variability for peak periods of flow.	There is a significant amount of data which can be provided if required. INPEX however proposes to include the following text regarding pump rates for clarity rather than include this data: *"The maximum flow rate during this period is dependent on the two pumps which discharge out the jetty outfall. The two pumps are 750-P-550 (treated sewage from the irrigation tank to the jetty outfall) rated at 25 m^3/hr and 750-P-402-A/B (observation basin to jetty outfall) rated at 70 m^3/hr. Note reject brine was directed into the accidently oil contaminated (AOC) system and not directly discharged to the jetty. Therefore, the combined rated flow was 95 m^3/hr, noting that periods of increased flow/surge (i.e. greater than rated pump capacity) can be experienced."*	Noted. For clarity, the following edit is suggested to reference the post 14 May data. Therefore, the combined maximum rated flow was 95 m3/hr. *It is noted ~~noting~~ that periods of increased flow/surge (i.e. greater than rated pump capacity) can be experienced, as maximum measured flow after 14 May 2019 was #### [insert max hourly flow reading](see Figure 2-1).*	Text updated as suggested.

3

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2018/2019

No.	Context	Reviewer Comment/Recommendation (6/09/2019)	INPEX Response (10/09/2019)	Reviewer Response (13/09/2019)	INPEX Response (13/09/2019)
5	Section 2.2.4	The discussion regarding the frequency of monitoring is not referenced in the EPL, however the current frequencies are compliant with the EPL of Quarterly. While the constraints of the sampling windows are noted, the report does not present a program change. Further consideration is warranted for pre-planning of quarterly monitoring activities to identify the specific windows of sampling availability every quarter. Documentation of these pre-planning attempts and constraints would provide support for further AEMR reporting.	Planning for sampling and identifying sampling windows is done months in advance with field trip plans done closer (weeks) to the sampling window. However, shipping schedules are not known until weeks in advance and can change at short notice due to a number of factors outside of our control. It is these last-minute (e.g. with 48 hours) changes to shipping that cannot be accounted for in planning and it cannot be expected that INPEX delay LPG/condensate tankers to collect water samples. The intention is to highlight some of the operational constraints that may be faced with this program and in the event there are delays, these will be well documented for auditing to justify why sampling frequency wasn't met. Sentence has been updated to provide more context: *"This is because there is only a small sampling window (i.e. slack water on a neap high tide) and if this coincides with an LPG or condensate offtake due to a late change in the shipping schedule, sampling cannot occur due to safety"*	Closed	Closed
6	EPL Clause 91.1	The sampling details/methods for sampling are not provided in the AEMR as required by the EPL (Clause 64).	There is no requirement to include these in the AEMR, this information just has to be recorded and retained. This information is detailed in the technical reports (e.g. Table 2-6) and would be made available on request through audits etc. and is a level of detail that is not suited to an AEMR.	Closed	Closed
7	EPL Clause 91.1	It is noted that the requirements of the EPL Clause 61 are not discussed within the AEMR. If addressed already in a separate document it should be referenced. Or state when the Clause would be addressed	A commissioning monitoring plan has been developed but is dependent on all discharge streams being online and discharged via the jetty outfall. The CCPP steam blowdown stream isn't anticipated to come online until Q4 2019, as such results will be presented in the 2019/202 AEMR. The following text has been added to Section 2.1 as sampling results from the commingled treated effluent sampling will inform this plan: *"Data collected as part of commingled treated effluent sampling will also be used to inform the Ichthys Onshore LNG Facilities Jetty Outfall Commissioning Monitoring Plan (L750-AH-PLN-60001), which has been developed to meet Condition 61 of EPL228. The final component of this plan will be implemented once the last discharge stream to the jetty outfall comes online. It is anticipated that discharge of the steam blowdown from the CCPP (in combine cycle) will commence in Q4 2019. As such, the outcomes of the commissioning jetty outfall monitoring plan will be reported on in the 2019/2020 AEMR."*	Closed	Closed
8	EPL Clause 91.1	With the exception of odours, The AEMR does not document observations or lack thereof the monitoring requirements in EPL Clause 46	No change proposed. By implementing commingled treated effluent sampling and jetty outfall sampling and ensuring the respective discharge criteria and trigger values are met ensures the discharges do not cause any of the events specified in Condition 46. This is because the criteria and triggers are designed to ensure 95% species protection (or greater) is achieved at the edge of the mixing zone. Further, such events (e.g. algal blooms, fish deaths) would only be reported by exception.	Closed	Closed
9	Appendix D	The Jetty Outfall monitoring data LORs for mercury are greater than the EPL limits. While the monitoring was prior to steady-state operation and not part of compliance, consideration of achieving lower LORs is warranted.	The mercury trigger value (0.05 µg/L) is half the ANZECC 99% species protection level and is a mistake that has been highlighted to NT EPA. INPEX has requested this be changed in an EPL228 amended currently under consideration by NT EPA. Further, to ensure compliance while waiting this change to be approved, were lab analysis reports samples to have a concentration as below LOR, half the LOR is being used for comparison to the trigger values. This is one of the commonly used approaches mentioned in Australian Guidelines for Water Quality Monitoring and Reporting (ANZECC and ARMCANZ 2000).	Closed	Closed

4

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2018/2019

No.	Context	Reviewer Comment/Recommendation (6/09/2019)	INPEX Response (10/09/2019)	Reviewer Response (13/09/2019)	INPEX Response (13/09/2019)
10	Executive Summary	Typo – "Norther Territorry" should be "Northern Territory"	Amended	Closed	Closed
Waste (Nicole Bradley –Qualified Professional)					
1	Section 6, second paragraph	The EPL228-01 was executed in June 2018, rather than September 2019	Amended	Closed	Closed
2	Section 6, third paragraph	Should this be waste streams rather than waste stream?	Amended	Closed	Closed
3	Section 6 (in relation to Condition 91.8)	Only one waste reduction measure was detailed. Please identify if others were identified. Were these documented in the waste management plan?	Only one was implemented during the reporting period. The focus of waste management is about reducing the overall volume disposed offsite and not creating new streams.	Closed. Note: The comment was to ascertain if there were other waste reduction measures that had been implemented over the period.	Closed

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ERM

19 September 2019
Reference: ERM 0520839

ANNEX B: - STATUTORY DECLARATIONS

THE NORTHERN TERRITORY OF AUSTRALIA

STATUTORY DECLARATION

(1) Insert full name and address of person making declaration

I, Christopher James Thomson of Environmental Resources Management Australia Pty Ltd located at Level 18, 140 St Georges Terrace, Perth, Western Australia 6000.

(2) Here insert the matter declared to, either directly following the word "declare" or, if the matter is lengthy, insert the words "as follows" and thereafter set out the matter in numbered paragraphs

solemnly and sincerely declare that the results are accurate to the best of my knowledge or belief and that I have not included in the results information that I know or suspect to be false or misleading or failed to include in the report information that I know to be relevant.

This declaration is true and I know it is an offence to make a statutory declaration knowing it is false in a material particular.

Declared at Perth the 19th day of September 2019

(3) Signature of the person making the declaration

(4) Signature of the person before whom the declaration is made

Witnessed by:

(5) Here insert full name of person before whom the declaration is made, legibly written, typed or stamped

Bethwyn Lewis

(6) Here insert contact address or telephone number of person before whom the declaration is made

Environmental Resources Management Australia Pty Ltd located at Level 18, 140 St Georges Terrace, Perth, Western Australia. Phone: (08) 6467 1600.

NOTE: This declaration may be witnessed by any person who is at least 18 (eighteen) years of age.

NOTE: This written statutory declaration must comply with Part 4 of the *Oaths Affidavits and Declarations Act.*

NOTE: Making a declaration knowing it is false in a material particular is an offence for which you may be fined or imprisoned.

THE NORTHERN TERRITORY OF AUSTRALIA

STATUTORY DECLARATION

(1) Insert full name and address of person making declaration

I, Kenneth Leo Kiefer of Environmental Resources Management Australia Pty Ltd located at Level 15, 309 Kent Street, Sydney, NSW 2000.

(2) Here insert the matter declared to, either directly following the word "declare" or, if the matter is lengthy, insert the words "as follows" and thereafter set out the matter in numbered paragraphs

solemnly and sincerely declare that the results are accurate to the best of my knowledge or belief and that I have not included in the results information that I know or suspect to be false or misleading or failed to include in the report information that I know to be relevant.

This declaration is true and I know it is an offence to make a statutory declaration knowing it is false in a material particular.

Declared at Sydney the 19th day of September 2019

(3) Signature of the person making the declaration

(4) Signature of the person before whom the declaration is made

(5) Here insert full name of person before whom the declaration is made, legibly written, typed or stamped

(6) Here insert contact address or telephone number of person before whom the declaration is made

Witnessed by:

Melissa Gooch

Environmental Resources Management Australia Pty Ltd located at Level 15, 309 Kent Street, Sydney, NSW 2000. Phone: (02) 8584 8888

NOTE: This declaration may be witnessed by any person who is at least 18 (eighteen) years of age.

NOTE: This written statutory declaration must comply with Part 4 of the *Oaths Affidavits and Declarations Act.*

NOTE: Making a declaration knowing it is false in a material particular is an offence for which you may be fined or imprisoned.

THE NORTHERN TERRITORY OF AUSTRALIA

STATUTORY DECLARATION

(1) Insert full name and address of person making declaration

I, Nicole Jane Bradley of Environmental Resources Management Australia Pty Ltd located at Level 6, 99 King Street, Melbourne, Victoria 3000.

(2) Here insert the matter declared to, either directly following the word "declare" or, if the matter is lengthy, insert the words "as follows" and thereafter set out the matter in numbered paragraphs

solemnly and sincerely declare that the results are accurate to the best of my knowledge or belief and that I have not included in the results information that I know or suspect to be false or misleading or failed to include in the report information that I know to be relevant.

This declaration is true and I know it is an offence to make a statutory declaration knowing it is false in a material particular.

Declared at Melbourne the 19th day of September 2019

(3) Signature of the person making the declaration

.....

(4) Signature of the person before whom the declaration is made

Witnessed by:

.....

(5) Here insert full name of person before whom the declaration is made, legibly written, typed or stamped

Paul Steven Fridell

(6) Here insert contact address or telephone number of person before whom the declaration is made

.....

Environmental Resources Management Australia Pty Ltd located at Level 6, 99 King Street, Melbourne, Victoria. Phone: (03) 9696 8011

NOTE: This declaration may be witnessed by any person who is at least 18 (eighteen) years of age.

NOTE: This written statutory declaration must comply with Part 4 of the *Oaths Affidavits and Declarations Act.*

NOTE: Making a declaration knowing it is false in a material particular is an offence for which you may be fined or imprisoned.

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ANNEX C: - QUALIFIED PROFESSIONAL PROFILE AND CV

ERM

19 September 2019
Reference: ERM 0520839

Air Quality

Christopher Thomson (Air Quality Qualified Professional)

Chris is a Principal Environmental Scientist and has gained his 18 years' experience in Australia and internationally. His oil and gas experience is highlighted by being seconded as the environment advisor to the Chevron's Central Environment team for Wheatstone, with a focus on streamlining the air quality monitoring scope for the project, whilst maintaining compliance. He was also the air quality lead for the baseline component of the INPEX Masela Project in rural Indonesia. A role that included the planning, development and execution of the air quality monitoring programme, including reporting in accordance with IFC requirements and coordinating the efforts of an international team.

Chris led the preparation of the Ichthys LNG Plant's air quality monitoring plan, published and accepted by the NT EPA earlier this year, which built on his involvement with executing the air quality and noise monitoring program for the INPEX Ichthys project's first year of construction. These projects have provided Chris with a deeper understanding of the operations at the plant and an appreciation of the project-specific constraints involved in setting up and securing offsite monitoring locations.

Water

Ken Kiefer (Water Quality Qualified Professional)

Ken has over 20 years of experience in the risk assessment and environmental toxicology. He is currently the ERM global risk assessment technical community leader. Ken has experience quantitative health risk assessments for the management of water discharges to the environment to meet a range of client and regulatory objectives in line with environmental policy frameworks within all Australian states, U.S., New Zealand, India, and other international jurisdictions.

Ken has provided human health and ecological risk assessment support for Oil and Gas clients of operational use chemicals in drilling or enhanced production of gas and oil. Ken has also recently provided the aquatic toxicology advice to INPEX supporting the INPEX submission to NT EPA seeking regulatory approval of modified licensed discharge limits of key chemicals likely to be found in discharge water from Ichthys project into Darwin Harbour.

Waste

Nicole Bradley (Waste Qualified Professional)

Nicole is a principal environmental consultant based in Melbourne with approximately 18 years of experience in the environmental industry, fourteen of which have been in consulting and four years with a metropolitan water authority.

As an Environmental Consultant, Nicole has worked on and project managed a variety of broad environmental projects, including development of waste management and minimisation plans and strategies; assisting in the auditing of waste management systems, landfills and other contaminated sites; co-ordination and delivery of regulatory approvals and associated environmental management plans.

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Nicole Bradley has also been an auditor support person for Paul Fridell (Qualified Person) on a number of the Ichthys dredging (EPA8) and onshore construction (EPA7) compliance audits, including the most recent May 2019 audit which included an audit of INPEX operations waste records and waste reduction measures.

Christopher Thomson

Principal Environmental Scientist

Chris has gained his 18 years' international experience in executing air quality monitoring programmes and assessments and coordinating environmental approvals for a range of oil and gas, mining and infrastructure projects.
This broad exposure to different industries has given him an equally broad understanding of the risks that are characteristic to different projects in different geographies. During his 11 years working in WA, his air quality experience is highlighted by being seconded as the environment advisor to the Chevron's Central Environment team for Wheatstone, with a focus on streamlining the air quality monitoring scope for the project, whilst maintaining compliance. He was also the air quality lead for an LNG project in rural Indonesia. A role that included the planning, development and execution of the air quality monitoring programme, including reporting in accordance with IFC requirements and coordinating the efforts of an international team.

Chris' air quality expertise is coupled well with his detailed understanding of the WA, NT, NSW environmental approvals processes and how they interplay with the requirement of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*) allowing him to enjoy the advisory aspect to his project management and client facing role, for a range of different projects.

Experience: 18 years in air quality and EIA

LinkedIn: https://www.linkedin.com/in/christopher-thomson-6977988a/
Email: Christopher.thomson@erm.com

Fields of Competence

- Air quality impact assessment
- Air quality monitoring and environmental management
- Certified Project Manager
- Environmental impact assessment and approvals preparation / coordination

Education

- Master of Science (Environmental Impact Assessment, Environmental Management Systems and Environmental Auditing), University of East Anglia (UK), 2003
- Bachelor of Science (Chemistry and Environmental Science – double major), Murdoch University W.A, 1997

Languages

- English, native speaker
- Spanish, fluent

The business of sustainability

ERM

Christopher Thomson

Air Quality Monitoring and Environmental Management

GEMCO: Groote Eylandt Air quality management plan, best practice gap analysis 2019
Chris provided technical input to GEMCO's air quality management plan in identifying international best practice management measures ahead of the proposed mine expansion.

Woodside LCA comparative assessment - 2019
Project manager for the development of a gas reserve specific LCA and energy intensity study. Chris sustained momentum on the project and coordinated the information flow between the client and ERM project team, to ensure timely delivery of the project within budget.

INPEX air toxics and ambient air quality monitoring plan – 2019
Project manager and air quality lead for the development of the Ichthys LNG Plant air quality monitoring plan.

Roy Hill dust deposition study on mangroves, Port Hedland 2015-2018
Project manager and air quality lead for the execution and management of the study. Data management and report preparation, trouble shooting and programme refinement. Study executed to determine extent of dust deposition and the subsequent effects on mangrove communities near RHI operations.

Buru Energy Fugitive Emissions Assessment 2015-2016
Project manager and local air quality lead. This project involved monitoring fugitive emissions during well completion for onshore gas wells in the Kimberly region of WA. Chris' role included, designing the monitoring program, coordinating field work and drafting final report. The project was supported by technical skills in Brisbane and Texas (USA). The design was an innovative approach which matched technical requirements and project economic constraints.

INPEX Masela LNG Project 2013-2015
Air quality lead for an LNG project in Indonesia. This role included the planning and execution of the air quality component of the impact assessment and monitoring programme, including development of the programme and reporting in accordance with IFC and World Bank best practice requirements.
This also involved management of logistical challenges with monitoring in such environments.

Chevron Wheatstone LNG Project 2014
Environmental Advisor on air quality to the Central Environment Team. This involved deploying air quality monitoring station to Onslow, reviewing technical sub-consultant reports and troubleshooting air quality queries raised by the Central Environment Team. My return to the Wheatstone project was because of my previous experience allowing for historical knowledge gained during the original ERMP 2009 assessment, allowing for delivery of a more streamlined monitoring program entailing cost efficiencies to be incorporated.

Colorado Secondment 2014
As part of URS president's initiative, he was seconded to the US to gain experience in onshore oil and gas industry in Colorado. I was instrumental in multiple aspects of URS Durango office projects as well as attended client forums and regulator meetings in aid of gaining more understanding of the industry. The project work involved air quality permitting of existing producing oil and gas wells and preparation of site audits, the early stages of pipeline projects and delineating impacts and rehabilitation of wetlands.

JKC – Ichthys LNG Project 2012-2013
Team lead of the air quality (dust) monitoring programme for the construction phase of the project in Darwin. This role included coordinating technical personnel and troubleshooting challenges that result in a smooth delivery of the client's data and reporting requirements. Innovative inclusion of real time data was linked to sms alerts for the site team to implement site dust management activities. This approach proved useful to limit extent of dust emissions from the construction site.

Rio Tinto Nammuldi Below Water Table Project 2012
Project manager for the execution of the project's construction phase dust and noise monitoring programme. This programme focussed on dust and noise emissions from construction on the accommodation village. This involved directional analysis of dust and management of noise sub consultant.

Environmental Impact Assessment

Teck Australia: Teena Resource, Environmental Approvals strategy and Scoping Study 2019
This study outlined the NT and federal environmental approvals strategy for the development of the Teena Resource. This comprehensive approach included identification of risks and environmental sensitivities related to the development and provision of costings and schedules for execution of the preferred development option. Chris co-authored and reviewed the project for submission.

Alcoa Australia: ICMM review and gap analysis 2019
Chris was part of the interview team whose objective was to gain a full understanding of the environmental obligations/performance and status of Alcoa's Bauxite and refinery operations as they prepare to re-gain membership onto the International Council on Mining and Metals.

RES Australia: Koojan/Coorow Wind Farm 2018
Project manager and study coordinator for the constraints and site selection study. This involves coordinating preliminary site studies and review of deliverables prior to release to the client.
Describe project details and overview with main points of interest.

Strandline Resources: Coburn Zircon Project 2018
Project manager, and lead approvals advisor for this current project, which is based on his and his team's previous experience at the site. The scope of this project involves the execution of EMP's regulator liaison, site team coordinator, preparation of approvals / obligations register to facilitate execution of the project.

Telstra: Indigo project - Singapore Perth fibre optic cable approvals 2018
Engaged to deliver approvals for the beach-landing directional drilling component of this project. This involved preparation of a Development Application to the City of Cambridge, liaison with the DoEE related to potential EPBC referrals and coordination of the delivery of approvals and consultation with the public, though the planning process.

Holcim Australia: Baldivis Quarry Stage 2 expansion 2018
Project manager and approvals lead. Project included preparation of Mining proposal, Mine closure plan, clearing permit, licence amendment for two project options. Project was delivered adhering to budget and time constraints.

Cassini Resources: West Musgraves Environmental Approvals Scoping Study 2017
Project manager and author providing an update to the 2015 study encompassing not only changes to the project but the 2016 changes to the impact assessment process, EPA guidance and preparation of mining proposals under the *Mining Act 1978*. This scoping document outlined an approvals strategy roadmap for successful delivery of the project, covering environmental risks, budget and schedule.

BC Iron: Iron Valley Above / Below Water Table 2011-2012/2015-2017
Project manager, EIA coordinator and lead environmental approvals author for the BCI Iron Valley Below Water Table mining project, this included Part IV and Part V environmental approvals (API level of assessment) and requirements under the Mining Act. The PM role also involved providing ongoing approvals advice to the client throughout the project.

Water Corporation: Neerabup Sewer District Upgrade Project 2016
Preparation of construction environmental management plan, preliminary environmental impact assessment for the placement of sewer pipelines and infrastructure through urban areas north of Perth WA. Involved provision of advice and assessment against clearing principals constrained by environmental sensitive areas and black cockatoo habitat.

Australian Department of Defence: J0091 Replacement Aviation Fire Truck Facilities Project, 2015
This project applied to bases nation-wide, it required effective and coordinated approach. This work involved the technical review of environmental assessments and the preparation of a comprehensive Construction Environmental Management Plan.

Cassini Resources: West Musgraves Environmental Approvals Scoping Study 2015
This study outlined the WA and federal environmental approvals strategy for the development of the Nebo Babel deposit. This provided a comprehensive approach, costings and schedules for execution of the preferred development option. Chris co-authored and reviewed the project for submission.

Chevron Wheatstone LNG Project 2009-2012
Project team lead for the pollution studies which included, air quality, greenhouse gases and noise impact assessments. Authored impact assessments chapters for inclusion to the ERMP approval document. The role also included coordinating sub-consultants for execution of the various technical monitoring studies. Time and schedules were kept on delivering this aspect of the broader project.

BHP Billiton/ Nickel West NDS1 Project 2010-2011
EIA co-ordinator, project manager and lead environmental approvals author for a Nickel expansion mining project (NDS1) in the Northern Goldfields, WA. This involved preparation of all approvals documentation, but also development of the EIA strategy with the client team that was most suitable for its particular circumstances.

BHP Billiton Yeelirrie Project 2010-2011
AECOM (Formerly URS) project manager for the development of the project's formal environmental approvals. This role involved providing approvals advice to the client as well as being a contributing author to the approvals documentation. (ERMP).

Aviva – Coolimba Power Station project 2008-2009
EIA co-ordinator and project manager and lead approvals author for the Public Environmental Review. This involved power plant and linear infrastructure approvals for the project near Eneabba in Mid-West Region of WA.

UK Experience

Environmental Impact Assessment
EIA coordinator for the West Wight Wind Farm for Your Energy ltd. 2007
EIA coordinator and author for Bournemouth airport redevelopment, Manchester Airport Group 2007 EIA coordinator and author for the Crowthorne mixed use / business park scheme, Legal & General, 2007
EIA coordinator and author for the West Wight Wind Farm for Your Energy ltd. 2007
EIA coordinator and author for Crewkerne mixed use development, Wimpey homes, 2003
EIA coordinator and author for Newbury Racecourse redevelopment, Newbury Racecourse 2006. Chris also undertook the air quality impact assessment and baseline monitoring for this project.

Air quality monitoring and Environmental management

Carbon balance and dust impact assessment for inclusion into environmental statement for Six Penny Wood Wind Farm, Your Energy Ltd, 2006.
Carbon balance and dust impact assessment for inclusion into environmental statement for North Rhins Wind farm, Wind Energy Ltd. 2006.
Carbon balance and dust impact assessment for inclusion into environmental statement for A'Chruach Wind Farm, Novera Energy. 2007.

Carbon balance and dust impact assessment for inclusion into environmental statement for Lissett Wind Farm, Wind Energy. 2006.
Drafting of environmental statement air quality chapter of environmental statement from technical report. Newhaven Energy Recovery Facility, Onyx 2004.
Drafting of environmental statement air quality chapter of environmental statement from technical report Hollingdean Materials Recovery Facility, Onyx, 2004.
Traffic emissions monitoring and dust impact assessment for Warren Way Materials Recovery Facility, Onyx, 2004.
Traffic emissions monitoring and dust impact assessment for Leavesden Studio development, MEPC group, 2007.
Traffic emissions monitoring and dust impact assessment South Kilburn Redevelopment, London, 2007.
Traffic emissions monitoring and dust impact assessment, Hollands Wood, campsite extension, New Forest, Forest Enterprises, 2004.

Environmental Management

Drafted environmental management plans for Lissett Wind Farm, Wind Energy, 2006. Drafted dust management plans for Kingston housing project Isle of Wight, 2005.
Drafted dust management plans for Hollands Wood, campsite extension, New Forest, Forest Enterprises, 2004.
Key member of EMS team responsible for implementing and co-ordinating the company EMS (to the ISO14001 standard), which was accredited June 2006. This role included internal audits, communicating initiatives and environmental awareness and monitoring of all key indicators for the firm to achieve carbon neutrality.

BAA Terminal 5, Heathrow Airport, Environmental Management

Using the Terminal 5 project as a case study, Chris carried out a series of internal environmental audits across several of the sub-projects within the wider project. This was done in accordance with the ISO14001 EMS standard, and the information gathered fed into his Masters dissertation, titled *The influence of EIA in developing EMS's and potential for their further integration.*

Casella – Stanger Group West Midlands, UK 1998 to 2002

Chris led small teams to carry out isokinetic industrial emissions air quality compliance monitoring surveys at a variety of processes around the UK. Specific projects included atmospheric emission surveys from automotive and aviation paint spray booths incinerator emission optimisations for commissioning new plant equipment as well as noise and ambient and indoor air quality surveys (environmental and occupational exposure) and COSHH assessments were also included in this work. The client base comprised predominantly multinational automotive manufacturing companies and their suppliers, some clients include Toyota UK - Bernaston Plant, Honda Motors - Swindon, Jaguar Cars - Castle Bromwich, Ford - Southampton, Peugeot - Coventry, Vauxhall Motors – Luton, British Airways – Heathrow Airport.

Other environment professional experience

Universidad de Chile, Santiago, Chile (short term placement) Jan – March 1998

Employed to commission a BAS100B Voltametry and Polarography apparatus for the University's metallurgy faculty. This included research on the suitability of the apparatus for trace analysis of industrial wastewaters and development of operating procedures designed for the laboratory's routine analysis.

Mining and Environmental Department of SERGEOMIN Oruro, Bolivia, Environmental Chemist (short term) Nov 1997/Jan 1998

Conducted the environmental department's water quality monitoring and treatment programme for the Santa Rita Tin, Lead, Copper and Zinc mine, operated by COMIBOL. Specific duties included onsite monitoring, sampling and lab analysis of surface and subsurface acidic waters.

Yorke Environmental Consultants – Perth, WA. Environmental Assistant, May 1997/Sept 1997

Christopher Thomson

Carried out air emissions monitoring and inline sampling for particulates, sulphurous and nitrous oxides from mining operations and industrial sites around WA. The work required the use of an Andersen GS 80 Stack sampler, ambient sampling and laboratory preparation.

Tiwest Joint Venture Chandala Site, Muchea, Western Australia, Under Graduate Environmental Officer Student Placement, Dec 1995 to Feb 1996
Required to design and implement an ambient dust monitoring programme for the mineral sands separation plant at Muchea in order to determine the quantity, composition and radioactivity of dust in the immediate environment of Chandala. Further duties included groundwater monitoring from onsite bores. Vegetation Health Assessment of dieback contaminated areas and its management.

Ken Kiefer

Technical Director –
Global Human Health and Ecological Risk Assessment Technical Community Director

Mr. Kiefer has over 20 years of experience in the risk assessment and environmental toxicology. He is currently the ERM global risk assessment technical community leader. Mr. Kiefer has experience quantitative health risk assessments for the management of contaminated sites to meet a range of client objectives in line with environmental policy frameworks within all Australian states, U.S., New Zealand, India, and other international jurisdictions.

Mr. Kiefer has provided human health and ecological risk assessment support for Oil and Gas clients of operational use chemicals in drilling or enhanced production of gas and oil. Mr. Kiefer has also provided aquatic toxicology support for regulatory approval of discharge of chemicals.

Experience: 20 years' experience in environmental consultancy, project management and research

LinkedIn: https://www.linkedin.com/in/ken-kiefer-79b07940/

Email: ken.kiefer@erm.com

Education

- M.S., Agricultural and Environmental Chemistry, University of California, Davis (1998)
- B.S., Environmental Toxicology, University of California, Davis (1993)

Professional Affiliations & Registrations

- Australasian College of Toxicology and Risk Assessment
- Australian Contaminated Land Consultants Association
- Australian Land and Groundwater Association (ALGA)

Key Industry Sectors

- Government
- Mining
- Oil and Gas
- Chemical
- Manufacturing
- Power

Languages

- English, native speaker

Fields of Competence

- PFAS
  - Design of investigations of PFAS impact in soil, groundwater, surface water, sediment and biota
  - Environmental fate and transport
  - Quantitative health and ecological risk assessment
  - Toxicological evaluations
- Quantitative health and ecological risk assessment
- Vapour intrusion evaluations
- Environmental fate and transport
- Probabilistic risk assessment
- Toxicological evaluations

Key Recent PFAS Conference Presentations

- Vida Maulina, Lisa Thomson, and **Ken Kiefer**. *(Abstract Accepted)* September 2019. *Derivation Of Water Quality Guideline Value For Marine Discharge Of Monoethylene Glycol*. CleanUp Conference, Adelaide, SA.
- Ron Arcuri, **Ken Kiefer**, Belinda Goldsworthy. October 2013. *Developing Surface Water Screening Levels For Compounds Associated With Aqueous Film Forming Foams*. CleanUp Conference, Melbourne, VIC.

The business of sustainability

ERM

Ken Kiefer

Key Projects

- Aquatic toxicity assessment and derivation EPL discharge limits. The assessment provided a review of specific products that maybe discharged. The derivation of EPL limits also provided a review of the on-site laboratory analytical methodologies to meet the derived EPL criteria.
- Ecological risk assessment for Water Treatment Plant effluent as part of remediation of former gas works. Risk assessment successfully led to increases in discharge limits.
- Human health and ecological risk assessment for residual coal tar impacts to remain post-remediation due to the practical limits of the remediation. Successfully demonstrated isolated residual coal tar impacts do not pose a risk.
- Provided senior technical review and oversight over the delivery of over 30 quantitative human health and ecological risk assessments as part of the management of a large portfolio (>100 sites) of petroleum hydrocarbon sites. The completion of risk assessments include wide ranging complex sites including: site with impact groundwater seeping into car parks of multi-story residential buildings; shallow groundwater plumes affecting multiple residential properties; and emerging contaminants (e.g. PFAS and MTBE).
- PFAS human health and ecological risk assessment for Refinery Senior Technical Lead. Development of surface water Site-Specific Screening Levels (SSSL) for PFOS and PFOA for human health and ecological receptors. The methodology used to derive the ecological screening criteria was based on the NEPM (1999) and the ANZECC (2000) methods used to derive trigger values. The result was a set of surface water SSSLs for PFOS and PFOA protective of aquatic species present in the site area. Human health SSSLs were also developed to be protective of humans consuming fish caught within the site area. The outcomes of the risk assessment process were used to eliminate the need for remediation to mitigate potential risks and highlight areas of the site where management of LNAPL was warranted to meet regulatory requirements. The risk assessment was accepted by the EPA-appointed site Auditor
- PFAS human health and ecological risk assessment. Airport JUHI Facility. Senior Technical Lead. An off-site sediment and surface water sampling program was also undertaken to determine the extent of PFOS and PFOA impacts. Human health and ecological screening criteria were selected for PFOA and PFOS. PFOS and PFOA were not measured above Tier 1 criteria in media relevant to potential fish or ecologically sensitive benthic assemblages. No risks posed by PFOS and PFOA were identified on-site and off-site human or ecological receptors. ERM employed a proactive communication and consultation strategy throughout the life of the project, to assist in the acceptance of the risk assessment outcomes by the Federal Assessor.

PFAS Projects

- **Legacy AFFF and Non-AFFF Product Sampling for PFAS – Multiple Sites, Australia (Department of Defence).** ERM was commissioned to conduct product sampling of both Aqueous Film Forming Foam (AFFF) and non-AFFF (such as aviation hydraulic oils) in order to build an understanding of the type and variability of PFAS compounds in products used across the Defence estate. One of the key objectives was to provide inputs to ongoing investigations, and support management and remediation actions. Ken is providing technical expert support for this work developing sampling strategies and data interpretation.
- **Auditor Technical Expert Support – RAAF Edinburgh and RAAF Wagga, Australia (Department of Defence)** Ken is providing technical expert support to State accredited auditors of the site investigations and risk assessment of legacy PFAS impacts.
- **AFFF Loss of Containment– Brisbane International Airport, Australia (Qantas).** PFAS human health and ecological risk assessment Senior Technical Lead for an AFFF loss of containment to adjacent river and estuary. A multi-media sampling program of sediment, soil, groundwater, surface water, and biota was developed to support the site-specific

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risk assessment. The risk assessment used multiple lines of evidence to separate the risks related to the loss of containment with residual baseline pre-existing PFAS impacts; included mass balance assessment; and detailed laboratory analysis as a method to differentiate the PFAS fingerprint of the loss of containment from other PFAS sources. The Federal Assessor accepted the risk assessment. Successfully working with Commonwealth and state (QLD) regulators to demonstrate residual impact post initial water containment treatment efforts did not pose further risk to human health and the environment including indirect exposures associated with bioaccumulation of PFAS in biota. The outcomes of the risk assessment process were used to eliminate the need for further remediation to mitigate potential risks.

- **PFAS human health and ecological risk assessment for a Refinery (Confidential Client).** PFAS human health and ecological risk assessment for a Refinery. Senior Technical Lead. Development of surface water Site-Specific Screening Levels (SSSL) for PFOS and PFOA for human health and ecological receptors. The methodology used to derive the ecological screening criteria was based on the NEPM (1999) and the ANZECC (2000) methods used to derive trigger values. The result was a set of surface water SSSLs for PFOS and PFOA protective of aquatic species present in the site area. Human health SSSLs were also developed to be protective of humans consuming fish caught within the site area. The outcomes of the risk assessment process were used to eliminate the need for remediation to mitigate potential risks and highlight areas of the site where management of LNAPL was warranted to meet regulatory requirements. The risk assessment was accepted by the EPA-appointed site Auditor
- **PFAS human health and ecological risk assessment for a Refinery (Confidential Client).** PFAS human health and ecological risk assessment. Airport JUHI Facility. Senior Technical Lead. An off-site sediment and surface water sampling program was also undertaken to determine the extent of PFOS and PFOA impacts. Human health and ecological screening criteria were selected for PFOA and PFOS. PFOS and PFOA were not measured above Tier 1 criteria in media relevant to potential fish or ecologically sensitive benthic assemblages. No risks posed by PFOS and PFOA were identified on-site and off-site human or ecological receptors. ERM employed a proactive communication and consultation strategy throughout the life of the project, to assist in the acceptance of the risk assessment outcomes by the Federal Assessor.
- **PFAS human health assessment. RAAF Amberley (Department of Defence).** PFAS human health assessment. RAAF Amberley. Senior Technical Lead. Reviewed the consolidation of over six years of soil and groundwater data (for both hydrocarbons and Perfluorinated Compounds (PFCs) to refine the site Conceptual Site Model and understand the risks of undertaking the redevelopment works. Developed Site Specific Target Levels (SSTLs) to inform the remedial requirements and ensure construction works and future use of the site do not have an adverse impact upon human health or the environment.

Risk Assessment Projects

- Mr. Kiefer has provided health and ecological risk assessments as well as senior technical and quality programmes management as part of the management of a large portfolio (>100 sites) of petroleum hydrocarbon sites (including complex major hazard facilities such as refineries and terminals) across Australia, New Zealand and southeast Asia.
- Indoor Air Risk Assessment. Carson, California. Completed a human health risk assessment for exposure to VOCs including TCE and PCE to current on-site commercial workers and off-site residents due vapor intrusion from groundwater plume. Developed site-specific soil vapor attenuation factors and soil vapor target levels. Delineated indoor air concentrations of VOCs related to ambient air from the sub-surface sources.

Ken Kiefer

- Prepared a risk assessment for off-site receptors to supplement an existing on-site risk assessment for a Superfund site. Off-site exposures included indoor air impacts to homes above the chlorinated VOC ground water plume. A number of different approaches were used to evaluate indoor air risks including vapour intrusion modelling from ground water, measured indoor and crawlspace air concentrations. Incorporated the use of GIS to present and communicate the complex environmental and risk information to regulators and the public.
- Human Health Risk Assessment of Rocket Testing Facility - Ventura, CA. Development of site-specific vapour migration model and vapour migration model validation field study focused on vapour transport through fractured bedrock.
- Determination of Ambient Chloroform Indoor Air Concentrations. Hill Air Force Base, UT. Established chloroform indoor air screening concentrations due to chlorinated drinking water.
- Vapour Intrusion Modelling, Mather Air Force Base, CA. Conducted vapour intrusion modelling in support of closure at Castle Air Force Base. Human health risk assessments for potential future receptors at multiple sites. COPCs include TCE and PCE.
- Prospective, Deterministic Baseline Human Health Risk Assessment (Vapour Intrusion) at a Sacramento Brownfield Site. Chico, CA. Industrial Site Redeveloped to Multi-family Land-use. Vapour intrusion assessment for BTEX and 1,2-DCA.
- Area–Specific Risk Assessment. Industrial Complex, South Bend, Indiana. Performed an area-specific risk assessment and developed of risk-based cleanup levels (RBCLs) for COPCs including PCE. The assessment included modelling to evaluate the potential of site constituents in soil to migrate to on-site indoor air and off-site groundwater.
- Soil Vapor Characterization and Risk Assessment, Los Angeles, CA. Developed strategy to address concerns regarding potential risks due to exposure in on-site and off-site indoor air to site related VOCs, including TCE and PCE. Performed risk assessment for current and future indoor receptors.
- Human Health Risk Assessment, Superfund, Olathe, KS. Multi-media human health risk assessment at a former industrial chemical storage and recycling centre. Qualitative and quantitative risk assessment conducted on measured and modelled VOCs in indoor air.
- Focused Human Health Risk Assessment at a former chemical facility, West Sacramento, CA. Conducted exposure and human health risk assessment to volatized CVOCs in indoor and outdoor air under the future land use conditions of a professional sports stadium.
- Performed Human health risk assessment evaluated risks to receptors due to dermal contact or ingestion exposures related to the beneficial use of red and brown mud and phosphogypsum as levee construction materials. This evaluation used the results material specific physiochemistry and aquatic toxicology studies. The evaluation included metals and radionuclides. Radionuclides were evaluated using USEPA RESRAD risk assessment model.
- Development of surface water discharge target levels for groundwater remediation system for a former coal fired power plant. Evaluation considered short-term and long term ecological effects.
- Post-release assessments of material harm to harbour water of high ecological and tourist value. Included innovated multiple-lines of evidence including understanding the nature of the release, the short-lived nature of the contaminants and understand of the complex mixing processes between the release and harbour.
- Human Health Risk Assessment for Complex Industrial Site. Human Health Risk Assessment for the redevelopment of waste-water ponds of former industrial complex of over 2,000 acres. Conducted human health risk assessments for multiple sites. Evaluation includes radionuclide, asbestos, dioxins/furans, PCBs, TPH, metals, SVOCs, and VOCs.
- Conducted human health risk assessment on two proposed >30-acre rural residential development

that was a former orchard. Soils contained arsenic, lead, and organochlorine pesticides. Assessment included probabilistic exposure assessment methodologies; site-specific in-vitro bioaccessability assessment; and background assessment. California regulatory agency approved the risk assessment.

- Provided senior technical review and oversight over the delivery of over 30 quantitative human health and ecological risk assessments as part of the management of a large portfolio (>100 sites) of petroleum hydrocarbon sites.
- Development of surface water Site-Specific Screening Levels (SSSL) for aqueous film forming foam (AFFFs) chemicals perfluorooctane sulphonate (PFOS) and perfluorooctanoic acid (PFOA) for human health and ecological receptors.
- Developed risk-based cleanup levels for arsenic, copper, and hexavalent chromium at wood treating facility. Cleanup levels were developed for protection of current and future workers as well as ground water quality.
- Completed a prospective human health risk assessment for future hypothetical beneficial uses for impacted ground water beneath a former Naval facility slated for commercial redevelopment. Chemicals of concern included chlorinated hydrocarbons, and BTEX. The assessment included a qualitative screening of many future potential ground water uses to focus the quantitative portion of the risk assessment to the two or three scenarios of greatest concern. Measured ground water concentrations were kriged to estimate areal average concentrations of each constituent, and subsequently three scenarios were quantitatively assessed: two worker scenarios and a school scenario. All scenarios were shown to be below acceptable hazard indices and EPA's risk range.
- Developed site-specific site-specific vapour migration modelling to evaluate potential migration from soil, shallow ground water, and deep ground water, which accounted for potential transport through fractured bedrock.
- Developed site-wide risk assessment methodologies risk from soil, shallow ground water, and deep ground water at a complex rocket testing facility.
- Baseline human health and ecological risk assessment for nitroammonia plant in Mexico to aid in divestment for on-going use. Primarily focused on assessment of off-site risks to current water users and ecological receptors potentially impacted by site groundwater. Included fate and transport modelling for migration of nitrate and ammonia in groundwater.
- Human health and ecological risk assessment related to the sub-surface fraccing and development of coal seam gas wells. Included evaluation of chemical and radiological tracer composition of frac fluids and return; pathway assessment of the potential release scenarios of frac fluids to the environment; and modelling of potential exposures frac fluid due potential surface and sub-surface release scenarios.
- Human health risk assessment related to the sub-surface fraccing and development of shale gas wells. Included evaluation of chemical and naturally occurring radioactive material (NORM) composition of frac fluids and return; pathway assessment of the potential release scenarios of frac fluids to the environment; and modelling of frac fluid into ground water aquifers.
- Human Health and Ecological Risk Assessment of Superfund Site - Former Radionuclide Research Facility and University Landfills. Risk assessment for a former radionuclide research facility and university landfills. Evaluation included tiered ecological and human health evaluation. Evaluation includes metals, VOCs, and radionuclides.
- Ecological Screening Risk Assessment. Performed screening ecological risk assessment for abandoned petroleum storage facility. Evaluated risks terrestrial and aquatic receptors. Developed site-specific surface water and sediment benchmarks.
- Performed screening ecological risk assessment for chemical manufacturing facility including

development of surface water and sediment benchmarks for site-specific constituents.

- Performed screening ecological risk assessment for abandoned petroleum storage facility. Evaluated risks terrestrial and aquatic receptors. Developed site-specific surface water and sediment benchmarks.
- Performed supplemental cumulative ecological risk assessment for U.S. Air Force. Evaluated risks of far-ranging species due to cumulative exposure to multiple individual sites that is not accounted for in individual site assessments.
- Performed baseline human health and ecological risk assessment and development of risk-based corrective action levels at a solvent recycling centre as part of RCRA facility investigations. Implemented a fractionation risk assessment approach for TPH. Performed environmental fate assessment of chemical constituents from soil into ground water using the SESOIL and Summers environmental fate and transport models. Performed environmental fate assessment of chemical constituents from soil into indoor air using the Johnson and Ettinger environmental fate and transport models. Provided statistical characterization and distribution analysis of soil and ground water concentrations.
- Performed screening ecological risk assessment for chemical manufacturing facility including development of surface water and sediment benchmarks for site-specific constituents.
- Developed strategy address concerns regarding potential risks due to exposure in on-site and off-site indoor air to site related VOCs. Assisted in developing site characterization work plan to support future risk assessment.
- Performed an area-specific risk assessment and developed of risk-based cleanup levels (RBCLs). The assessment included modelling to evaluate the potential of site constituents in soil to migrate to on-site indoor air and off-site ground water. The evaluation included VOCs and PCBs.
- Prepared risk assessment in support of RCRA facility investigations. Developed site-wide risk assessment methodologies including site-specific vapour migration modelling to evaluate potential migration from soil, shallow ground water, and deep ground water, which accounted for potential transport through fractured bedrock.
- Conducted risk assessment for a former radionuclide research facility and university landfill. A tiered ecological and human health evaluation included metals, VOCs, and radionuclides.
- Conducted health risk assessment on estimated emissions from a proposed waste to energy facility in Hong Kong. Evaluation included metals, VOCs, and dioxins.
- Performed a preliminary endangerment assessment human health risk assessment for a proposed new school on former agricultural property.
- Performed human health risk assessment and geostatistical evaluation using GIS (ArcView) as part of an analysis of historically released DDT at a manufacturing facility.
- Assisted with exposure and human health risk assessment of volatile organic chemicals in ground water. Performed modelling to assess exposure and risk to volatized chemicals under the future land use conditions of a sports stadium.
- Assisted with exposure and human health risk assessment of inorganic and organic chemicals in soil and sediments. Developed sediment target concentrations for chemicals based on recreational fish ingestion. Modelled transfer from sediments to fish for bioconcentrating chemicals including PCBs, Dioxins, Furans, PARs, and chlorinated pesticides.
- Assisted with exposure and toxicity assessment of over 20 chemicals in soil and ground water. Performed environmental fate assessment in soil and ground water using the SESOIL and VHS environmental fate and transport models. Provided statistical characterization and distribution analysis of soil and ground water concentrations.
- Performed environmental fate assessment of chemical constituents from soil and ground water into indoor and outdoor air using the Johnson and Ettinger and Hannah environmental fate and transport models in support of multiple site-specific risk assessments and development of risk based clean-up levels.

Ken Kiefer

- Performed environmental fate assessment of chemical constituents from domestic water use into indoor air using published air stripping methodologies in support of multiple site-specific risk assessments as well as litigation support.
- Performed air dispersion modelling based on the accidental release scenario using EPA's ALOHA model. Used model outputs to estimate probable exposure levels for comparison with toxicity information.
- Provided litigation support for testifying toxicology and risk assessment expert for plaintiff on a case involving alleged illegal disposal of hazardous waste by a furniture stripping company. Evaluated available data for ability to determine amounts material illegally disposed.
- Provided litigation support for testifying toxicology and risk assessment expert for the defense on a case involving environmental damages resulting from an accidental release of Cl-containing gases. Researched information and performed air dispersion modelling for expert report in support of a lawsuit regarding phytotoxic effects from an accidental release of chlorine gas. Reviewed phytoxicity studies of chlorine gas to develop toxicity threshold for pine trees and determine the long term effects from an acute exposure event. Performed air dispersion modelling based on the accidental release scenario using EPA's ALOHA model. Used model outputs to estimate probable exposure levels for comparison with toxicity information.
- Provided litigation support for testifying toxicology and risk assessment expert for the defense on a case involving migration of VOCs and methane from an adjacent landfill into a commercial building.
- Provided litigation support for testifying toxicology and risk assessment expert for the defense on a case involving alleged health effects in inmates in California's Tehachapi Prison associated with hazardous substances in ground water at the prison. Lawsuit regarding potential health effects from exposure to PCE, TCE and nitrate impacted ground water. Reviewed database of ground water analytical results for completeness and reliability. Evaluated exposure levels for toxicological significance, comparing water levels, length of exposure to known toxicology of substances.
- Prepared GIS for a property development at a former orchard site. The GIS was used to geographically integrate risk assessment results with sample locations, and future property planning. Risk-based cleanup decisions were based on the results of GIS geostatistical analyses. Subsequent remediation alternative decisions were also based on the GIS developed for the site.
- Assisted in development of a GIS to support air modelling conducted for several commercial facilities for Proposition 65 warning requirements. The GIS was used to develop a mailing list database for properties within the air emissions plume using GIS geocoding.
- Developed database of surface water and soil concentrations for cadmium, copper, lead, and zinc from available data. Database was designed for use in a GIS for the purpose of evaluating spatial relationships in metal background concentrations. Access and Arc View were used in the development of the GIS.
- Developed GIS database of soils characteristics for use in the exposure and risk assessment model CalTOX. Data from the USDA STATSGO database was used for the development of GIS database of CalTOX soil inputs. ArcINFO was used in the development of the GIS.

Publications

- Kenneth L. Kiefer, Chuck E. Schmidt, Mark K. Jones, Ranajit (Ron) Sahu. 2013. *Assessing Vapour Intrusion - How do assessment technologies compare?* Remediation Australasia. Issue 12. 2013
- Norbeck et al. 1998. *Evaluating Factors That Affect Diesel Exhaust Toxicity*. Center for Environmental Research and Technology, College of Engineering, University of California, Riverside. Final Report Contract No. 94-312.
- Hsieh D.P.H., McKone, T.E., Geng, S., Schwalen, E.T. and Kiefer, K.L., 1995. *The Distribution of Landscape Variables for CalTOX within California*,

Department of Toxic Substances Control, California Environmental Protection Agency, Sacramento, California.

- T.E. McKone, Kiefer, K.L., Currie, R.C., Geng, S. and Hsieh, D.P.H., 1995. *Representing Uncertainty in Risk Assessments; Task I a: Constructing Distributions*, Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Berkeley, California.
- T.E. McKone, Currie, R.C., Chiao, F.F., Kiefer, K.L. and Hsieh, D.P.H., 1995. *Representing Uncertainty in Risk Assessments; Task I b: Representing Uncertainty in Intermedia Transfer Factors: Case Studies*, Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Berkeley, California.

Invited Speaker

Presenter at the ALGA 2-Day Risk Assessment 101 training course. Auckland and Christchurch, NZ (2017) and Hobart (2018).

Presentations

- **Ken Kiefer** and Darren Reedy. *PFAS Health Risk Assessment*. EcoForum 2018 Conference, Sydney, NSW.
- **Ken Kiefer** Kylie Dodd and Darren Reedy. *The Distribution of PFAS Compounds in the Marine Environment and Implications for Ecological Risk*. EcoForum 2018 Conference, Sydney, NSW.
- Lisa Thomson, **Ken Kiefer**, Kylie Dodd and Darren Reedy *Bioaccumulation of PFAS Within Aquatic Trophic Levels in an Australian Estuarine Environment*. EcoForum 2018 Conference, Sydney, NSW.
- Gavin Powell, Rob MacIntosh, **Ken Kiefer**, Wijnand Gemson, and Peter Madden. *PFAS and Urban Stormwater: Use of Mass Discharge Assessment in the Interpretation of the Conceptual Site Model*. EcoForum 2018 Conference, Sydney, NSW.
- **Ken Kiefer**, Kylie Dodd, and Darren Reedy. *Using TOPA in Risk Assessment*. EcoForum 2018 Conference, Sydney, NSW.
- **Ken Kiefer**, Wijnand Germs, Nathan Seaver, Kylie Dodd, and Ed Dennis. *Differentiating Groundwater Sources Using Mass Flux*. CleanUp 2017 Conference, Melbourne, NSW.
- **Ken Kiefer**. Re-Assessing Remedial Targets Based on Changes in Total Recoverable Hydrocarbons Mixtures During Remediation. CleanUp 2017 Conference, Melbourne, NSW.
- **Ken Kiefer**. Reducing Uncertainty in Vapour Intrusion Risks and Conservatism in Chlorinated Hydrocarbon Site Decision Making. CleanUp 2017 Conference, Melbourne, NSW.
- Kathryn East, **Ken Kiefer**. Extended **PFAS** Suite: Future-Proofing, or Creating More *Uncertainty?* EcoForum 2016 Conference, Freemantle, WA.
- W. Germs, **K. Kiefer**, and A. Kohlrusch. You Can't Manage What You Don't Measure: 1,4–Dioxane as Co-Contaminant at Chlorinated Solvent Sites. EcoForum 2016 Conference, Freemantle, WA.
- Sophie Wood, Phillippa Biswell, **Ken Kiefer** and Warren Pump. *The Trouble with Environmental Management Plans….* EcoForum 2016 Conference, Freemantle, WA.
- **Ken Kiefer** and Thavone List. What Are Total Recoverable Hydrocarbons? Implications for Contaminated Site Management. EcoForum 2016 Conference, Freemantle, WA.
- **Ken Kiefer** and Kathleen Prohasky. Evaluation of Primary Industry Beneficial Water Use and Consideration of Non-Health and –Environmental Risk Endpoints. EcoForum 2016 Conference, Freemantle, WA.
- Joseph Ferring and **Ken Kiefer**. *Using D Data Analysis and Visualisation to Reduce Uncertainty.* EcoForum 2016 Conference, Freemantle, WA.
- **Kenneth Kiefer**, Kathleen Prohasky, Wijnand Germs, Neil Gray and Tamie Weaver. September 2015. A Comparison Of Passive Sampling And Low-Flow Or Bailed Sampling Results Across A Range Of Australian Hydrogeological Settings. Cleanup 2015, Melbourne, Vic.
- **Kenneth Kiefer** and Thavone Shaw. September 2015. *Using Mass Balance In Risk Assessment.* Cleanup 2015, Melbourne, Vic.
- Kathleen Prohasky and Kenneth Kiefer. September 2015. *Complications Of Ambient*

Sources In Assessing Vapour Intrusion Risks. Cleanup 2015, Melbourne, Vic.

- Kathleen Prohasky and Kenneth Kiefer. September 2015. Developing Groundwater Tier 1 Screening Criteria For Chronic And Acute Vapour Risks For Chlorinated Hydrocarbons. Cleanup 2015, Melbourne, Vic.
- **Ken Kiefer,** Joseph Ferring, & Will Ellis. October 2014. *Differentiating Between Soil and Groundwater Solvent Sources in Soil Vapour Risk Assessment.* EcoForum 2014 Conference, Gold Coast, QLD.
- Christine Lussier, Kathryn East & Ken Kiefer. October 2014. *Screening Levels for Polychlorinated Biphenyls in Water.* EcoForum 2014 Conference, Gold Coast, QLD.
- Jeremy Hogben, Steven Morrison & Kenneth Kiefer. October 2014. *Assessing Polar Compounds as Degradation Metabolites of Hydrocarbon Sources – The Need for Change.* EcoForum 2014 Conference, Gold Coast, QLD.
- Kathleen V. Prohasky and Kenneth L. Kiefer. October 2014. *Tier 1 Screening of Vapour Risks from Groundwater Data for Chlorinated Hydrocarbons.* ACTRA Conference. Coogee, NSW.
- **Kenneth L. Kiefer,** Alyson N. Macdonald, Kathleen Prohasky & Sophie Wood. October 2013. *Tier 1.5 Soil Vapour Screening For Non-Petroleum Volatile Organic Compounds.* CleanUp Conference, Melbourne, VIC.
- Kathleen V. Prohasky and Kenneth L. Kiefer. October 2013. Assessing Degradation Processes of Subsurface Vapours from a Petroleum Source in Fractured Basalt Using a Carbon Filter. CleanUp Conference, Melbourne, VIC.
- Ron Arcuri, Ken Kiefer, Belinda Goldsworthy. October 2013. Developing Surface Water Screening Levels For Compounds Associated With **Aqueous Film Forming Foams**. CleanUp Conference, Melbourne, VIC.
- **Kenneth Kiefer,** Alyson Macdonald, and Sophie Wood. October 2012. *Why do we need two different methods for screening vapour intrusion risks?* ACTRA. Adelaide SA.
- Dr. Sophie Wood, Ken Kiefer and Olivia Patterson. October 2012. *Health and Ecological Risk Assessment of Hydraulic Fracturing Fluids.* ACTRA. Adelaide SA.
- **Kenneth L. Kiefer**, Jonathan Lekawski, Valerie Phipps, Harrison Swift, and Sophie Wood. March 2012. *Case Studies of Implementing HSLs in Petroleum Hydrocarbon Sites.* EcoForum. Sydney. NSW.
- **Kenneth L. Kiefer**, Chuck E. Schmidt, Mark K. Jones, Ranajit (Ron) Sahu. September 2011. Comparison of Technologies for Assessing Vapour Intrusion In Future Structures from Subsurface Sources - Case Study with Side-by-Side Measured Flux and J&E Modelling. CleanUp Conference, Adelaide, SA.
- Kiefer, K.L., Jones, M., Shibata, M., Olsen, H., Steinmacher, S., and Case, J. April, 2005. *Dealing with Confounding Background Indoor Air Concentrations.* Air & Waste Management Association. Symposium on Air Quality Measurement Methods and Technology, San Francisco, CA
- Shull, L. and Kiefer, K. March 2005. *Those Pesky Emerging Contaminants: Will We Ever Be Done With Them?* Association for Environmental Health and Sciences: The 15th Annual AEHS Meeting & West Coast Conference on Soils, Sediments and Water, San Diego, CA.
- Kiefer, K.L., Shull, L., Bowland, M., and Jones, M. October 2003. Risk Based Decision Making Tools: Property Redevelopment and Arsenic Case Study, Brownfields 2003, Portland, Oregon.

Nicole Bradley

Principal Consultant / Project Manager
Auditor Assistant

Nicole is a principal environmental consultant based in Melbourne with approximately 18 years of experience in the environmental industry, fourteen of which have been in consulting and four years with a metropolitan water authority.

As an Environmental Consultant, Nicole has worked on and project managed a variety of broad environmental projects, including development of waste management and minimisation plans and strategies; assisting in the auditing of waste management systems, landfills and other contaminated sites; co-ordination and delivery of Victorian EPA Works Approvals and associated environmental management plans.

Experience: 18 years' experience in the environmental sector.

Email: Nicole.bradley@erm.com

Education

- Bachelor of Applied Science (Natural Resource Management), Australia
- Bachelor of Business (Accounting), Australia

Languages

- English, native speaker

Fields of Competence

- Waste Management
- Contaminated Site Assessment
- Works Approvals
- Environmental Management Plans

Key Industry Sectors

- Government
- Oil and Gas
- Mining
- Power
- Development

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Key Projects

Waste Management Projects

Environmental Impact Assessment – Waste Management Strategy, Surat Basin, Australia - Queensland Gas Company (QGC) (2012). As a component of an overall EIA prepared by ERM, ERM Waste team in Melbourne Australia prepared the waste management and resource minimisation sections of EIA documentation in collaboration addressing potential wastes generated from drilling operations, construction and demolition wastes and putrescible wastes generated by on-site workers.

Thevenard Island Facility, WA – Waste Management Plans for Cessation and Retirement, Chevron Australia (2013). Technical specialist responsible for waste minimisation inputs of the waste management plans for cessation (systematic shut down) and retirement (decontaminate, decommission and demolition) of Chevron's Thevenard Island Facility. Waste Management Plans were prepared in accordance with Chevron standards and with state and federal legislation.

Confidential O&G Client, Strategic Waste Advice for Decommissioning of LNG Off-shore Platforms (2015). Nicole was the project manager of an initial, high-level desk top assessment of established waste/ decommissioning facilities in Australia and the Asia Pacific Region. The objective of the study was to assess the current or potential waste management capacity of facilities to receive, decommission, recycle, reuse and dispose of materials and associated wastes (both hazardous and non-hazardous) relating to retirement of the client's offshore platforms. ERM prioritised preferred facilities for further consideration/ investigation considered adequate to support the client's requirements.

Mercury and Naturally Occurring Radioactive Material (NORM) Waste Management Review, Ichthys LNG Project, INPEX Australia (2016). ERM was engaged to undertake a legislative and national/international market review of the management and disposal of mercury and NORMs waste streams that will be generated during the operational phase of the INPEX Ichthys LNG project at various locations. Nicole was a technical support to the project manager and partner in charge of reviewing the legislative related to NORM waste.

Waste Management Strategy, Bass Coast Shire Council, (2015). ERM prepared a waste management strategy to provide a sustainable framework for managing the waste of the Bass Coast municipality over the ensuing 10 years, i.e. 2015 – 2025. The strategy was developed collaboratively with council and in line with local, regional, state and federal policies and strategies. It included comprehensive public consultation, including public consultation sessions and directed surveys to identified key stakeholders.

Undertaken at another consultancy):

- **Waste Management Strategy, Mildura Rural City Council (2011)**
- **Council Waste Management Strategy template, Metropolitan Waste Management Group (2011)**

Construction and Operational Environmental Management Plan Audits

Onshore Construction Environmental Management Plan, Ichthys Gas Field Development Project Australia, INPEX Operations Australia Pty Ltd (2012-2019). ERM has provided INPEX Operations Australia Pty Ltd with regular environmental audits of the Onshore Construction Environmental Management Plan as part of the Ichthys Gas Field Development Project (the Ichthys Project). The scope of these audits was an assessment of compliance with the project NT EPA Environmental Approval and the Construction Environmental Management Plans Nicole has supported Paul Fridell (Lead Auditor) on a number of these audits.

NT EPA Qualified Person Review of the Onshore Construction Environmental Management Plan (Revisions 7 and 11), Ichthys Gas Field Development Project Australia, JKC Australia Pty Ltd (2013 - 2018). ERM provided JKC Australia Pty Ltd with Environmental Auditor (Qualified Person) review of the Onshore Construction Environmental Management Plan as part of the Ichthys Gas Field Development Project. Nicole provided audit support to the auditor. The scope of the review undertaken was an assessment the environmental management measures proposed in the Construction Environmental Management Plan for a variety of work packages including underwater piling, sewage outfall impacts, concrete batching plant, quarantine, hazardous materials, waste, dredging, pre-commissioning works, hydrotesting, surface water discharges and general civil earthworks.

NT EPA Qualified Person Review of the Annual Environmental Monitoring Report, Ichthys Gas Field Development Project Australia, JKC Australia (2015 – 2016). ERM provided JKC Australia LNG Pty Ltd with environmental Auditor (Qualified Person) review of the Annual Environmental Monitoring Report 2014 – 2015 and 2015-2016. The scope of the review was an assessment of monitoring data as presented in the report and any observations/explanation of trends, conclusions and recommendations made are technically sound based on the various ERM subject matter expert/s knowledge. Nicole project managed the review to support the auditor.

S53V Landfill Operations Audits

S53V Audit of Mildura Landfill Operations, Mildura City Council (2018). Assist auditor with the audit of an operational landfill in Victoria to identify and where possible quantify the risk of any possible harm or detriment to a segment of the environment caused by operation of a landfill.

Other Projects

Works Approval application for the extension of landfilling space, Australia, Wyndham City Council (2013-2014). Nicole project managed the preparation of a works approval application in support of the extension of the landfilling operations at the facility, including development of Master Plan, Needs Analysis, co-ordination of technical inputs including, odour and air emissions, visual impact assessments, environmental monitoring and management plans, concept designs, and liaison with Victorian Environment Protection Authority (regulator).

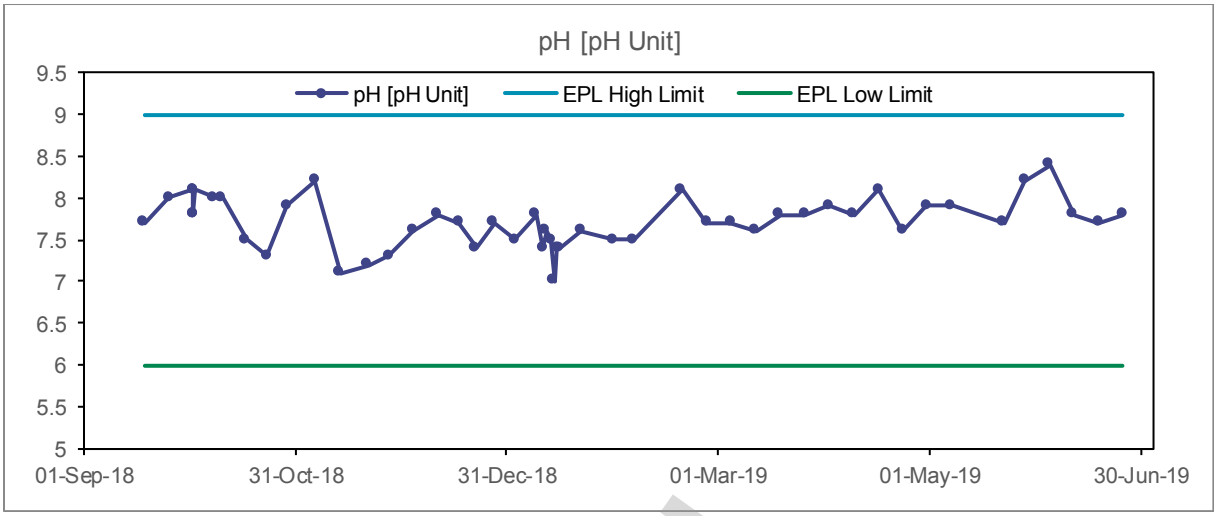
APPENDIX C: COMMINGLED TREATED EFFLUENT (750-SC-003) LABORATORY RESULTS

C.1 Weekly sampling results for 750-SC-003

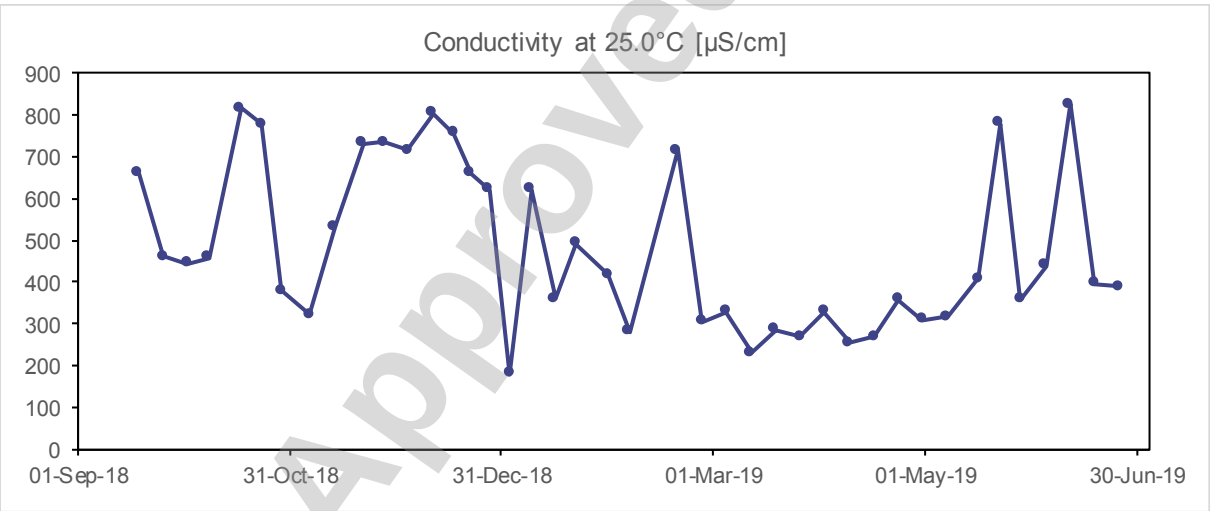
Shaded cells indicate trigger exceedances described in Table 2-5.

Date	LIMS Sample ID	pH	Conductivity	Temperature	Turbidity	DO	TPH as oil and grease	TRH (C10-C40)	TSS	BOD	COD	Ammonia	Total nitrogen	Total phosphorus	FRP	Total cadmium	Total chromium	Total copper	Total lead	Total mercury	Total nickel	Total silver	Total zinc	Enterococci	*E. coli*	Faecal coliforms	Anionic surfactants	aMDEA	MDEA	MEG	TEG
		pH units	µS/cm	°C	NTU	%	mg/L	mg/L	mg/L	mg/L	mg/L	mg N/L	mg N/L	mg P/L	mg P/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	cfu/100 mL	cfu/100 mL	cfu/100 mL	mg/L	mg/L	µg/L	mg/L	mg/L
		6 to 9	n/a	35	n/a	n/a	6	n/a	10	20	125	n/a	10	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	100	400	n/a	n/a	n/a	n/a	n/a
18-Sep-18	L1803234001	7.7	659	31.6	<0.5	94	< 1	<100	< 5	<2	11	< 2	2	0.3	< 0.2	<0.1	2	5	<1	<0.1	8	<1	<5	<1	<1	<1	<0.1	<15	-	<15	< 15
25-Sep-18	L1803377001	8	461	30.5	<0.5	87	< 1	<100	< 5	<2	-	0.07	0.7	**2.7**	-	<0.1	<1	<1	<1	<0.1	<1	<1	<5	<1	<1	<1	<0.1	-	-	-	-
02-Oct-18	L1803589001	8.1	444	31.6	<0.5	79	< 1	<100	< 5	<2	19	< 2	< 2	**2.3**	0.3	<0.1	<1	2	<1	<0.1	<1	<1	<5	<1	<1	<1	<0.1	<15	-	<15	< 15
08-Oct-18	L1803672001	8	458	30.9	<0.5	80	< 1	<100	< 5	<2	18	< 2	< 2	**2.2**	< 0.2	<0.1	<1	1	<1	<0.1	<1	<1	<5	<1	<1	<1	<0.1	<15	-	<15	< 15
17-Oct-18	L1803827001	7.5	816	31.8	1.0	94	< 1	<100	< 5	<2	17	3.00	8	< 0.2	< 0.2	<0.1	<1	4	<1	<0.1	8	<1	25	<1	<1	<1	<0.1	-	<1	<2	<2
23-Oct-18	L1804000001	7.3	778	33.5	0.5	76	< 1	<100	< 5	2	15	< 2	6	< 0.2	< 0.2	<0.1	<1	5	<1	<0.1	10	<1	35	<1	<1	<1	<0.1	-	<1	<2	<2
29-Oct-18	L1804098001	7.9	380	31.7	1.0	91	2	<100	< 5	<2	13	< 2	2	0.3	< 0.2	<0.1	<1	4	<1	<0.1	4	<1	65	18	1	1	<0.1	-	<1	<2	<2
06-Nov-18	L1804319001	8.2	323	31.2	1.5	95	< 1	<100	< 5	<2	-	< 2	< 2	1	0.6	<0.1	2	<1	<1	<0.1	1	<1	50	16	1	3	<0.1	-	<1	<2	<2
13-Nov-18	L1804445001	7.1	534	33.0	0.5	105	< 1	<100	< 5	<2	9	< 2	2	< 0.2	< 0.2	<0.1	<1	6	<1	<0.1	5	<1	72	<1	<1	<1	<0.1	-	<1	<2	<2
21-Nov-18	L1804629001	7.2	733	32.1	<0.5	84	< 1	<100	< 5	<2	14	< 2	5	< 0.2	< 0.2	<0.1	5	4	<1	<0.1	7	<1	145	<1	<1	<1	<0.1	-	<1	<2	<2
27-Nov-18	L1804843001	7.3	734	33.0	<0.5	55	< 1	<100	< 5	<2	18	< 2	4	< 0.2	< 0.2	<0.1	<1	3	<1	<0.1	7	<1	34	<1	<1	<1	<0.1	-	<1	<2	<2
04-Dec-18	L1805075001	7.6	716	32.4	1.0	78	1	<100	< 5	2	23	< 2	5	< 0.2	< 0.2	<0.1	1	4	<1	<0.1	9	<1	70	<1	<1	<1	<0.1	< 5	<1	<2	<2
11-Dec-18	L1805282001	7.8	803	32.2	1.0	68	< 1	<100	< 5	<2	19	< 2	4	< 0.2	< 0.2	<0.1	<1	2	<1	<0.1	8	<1	39	<1	<1	<1	<0.1	-	<1	<2	<2
17-Dec-18	L1805461001	7.7	756	34.6	1.5	85	1	<100	< 5	8	18	< 2	3	< 0.2	< 0.2	<0.1	<1	1	<1	<0.1	8	<1	26	<1	<1	<1	<0.1	-	<100	<2	<2
22-Dec-18	L1805542001	7.4	659	32.4	0.5	94	< 1	<100	< 5	-	17	< 2	5	< 0.2	< 0.2	<0.1	<1	2	<1	<0.1	6	<1	34	-	-	-	-	< 5	<1	<2	<2
27-Dec-18	L1805648001	7.7	622	30.0	1.5	95	< 1	<100	< 5	3	14	0.04	3.3	< 0.2	< 0.2	<0.1	<1	2	<1	<0.1	7	<1	26	<1	<1	<1	<0.1	-	<1	<2	<2
02-Jan-19	L1900004001	7.5	181	30.3	2.0	73	< 1	<100	< 5	<2	13	0.04	0.9	< 0.2	< 0.2	<0.1	<1	2	<1	<0.1	2	<1	263	10	<1	<1	<0.1	-	<1	<2	<2
08-Jan-19	L1900171001	7.8	621	31.5	1.5	97	-	<100	< 5	<2	12	< 2	4	< 0.2	< 0.2	<0.1	1	3	<1	<0.1	3	<1	20	<1	<1	<1	<0.1	-	<1	<2	<2
15-Jan-19	L1900342001	7.4	360	29.6	1.0	57	< 1	<100	< 5	3	12	< 2	4	< 0.2	< 0.2	<0.1	<1	2	<1	<0.1	3	<1	121	16	18	18	<0.1	-	<1	<2	<2
21-Jan-19	L1900499001	7.6	493	30.2	1.5	72	< 1	<100	< 5	15	27	< 2	7	< 0.2	< 0.2	<0.1	<1	5	<1	<0.1	5	<1	103	<1	<10	36	<0.1	-	<1	<2	<2
30-Jan-19	L1900677001	7.5	418	30.9	1.5	84	< 1	<100	< 5	6	22	0.37	7	< 0.2	< 0.2	<0.1	<1	6	<1	<0.1	3	<1	231	7	44	66	<0.1	-	<1	<2	<2
05-Feb-19	L1900846001	7.5	280	29.4	1.5	82	< 1	<100	< 5	7	12	0.05	2	< 0.2	< 0.2	<0.1	<1	4	<1	<0.1	3	<1	206	46	3	14	<0.1	-	<1	<2	<2
13-Feb-19	L1900963001	7.8	270	31.2	2.0	81	< 1	<100	< 5	<2	17	< 2	1	< 0.2	< 0.2	<0.1	<1	3	<1	<0.1	2	<1	113	<1	10	10	<0.1	-	<1	<2	<2
19-Feb-19	L1901110001	8.1	715	32.1	<0.5	102	< 1	<100	< 5	<2	12	0.03	3	< 0.2	< 0.2	<0.1	<1	8	<1	<0.1	4	<1	19	<1	<1	1	<0.1	-	<1	<2	<2
26-Feb-19	L1901286001	7.7	305	30.8	0.5	89	< 1	<100	< 5	<2	10	<0.01	< 2	0.3	< 0.2	<0.1	<1	3	<1	<0.1	2	<1	135	5	2	2	<0.1	-	<1	<2	<2
05-Mar-19	L1901437001	7.7	329	30.6	1.0	87	< 1	3130	< 5	<2	12	0.20	6	0.4	< 0.2	<0.1	<1	4	<1	<0.1	2	<1	143	<1	<1	<1	<0.1	-	<1	<2	<2
12-Mar-19	L1901580001	7.6	230	30.5	2.0	80	< 1	<100	< 5	2	14	0.22	< 2	0.6	< 0.2	<0.1	<1	2	<1	<0.1	2	<1	205	5	**160**	160	<0.1	-	<1	<2	<2
19-Mar-19	L1901719001	7.8	285	31.6	2.5	86	< 1	<100	< 5	<2	14	0.49	< 2	0.2	< 0.2	<0.1	<1	5	<1	<0.1	2	<1	121	8	<2	<2	<0.1	-	<1	<2	<2
26-Mar-19	L1901875001	7.8	270	30.5	1.0	88	< 1	<100	< 5	<2	12	0.02	< 2	0.3	< 0.2	<0.1	<1	3	<1	<0.1	3	<1	313	4	42	42	<0.1	-	<1	<2	<2
02-Apr-19	L1902039001	7.9	330	30.8	1.0	81	< 1	<100	< 5	3	23	0.84	5	0.2	< 0.2	<0.1	<1	<1	<1	<0.1	2	<1	290	17	<1	<1	0.1	-	3	<2	<2
09-Apr-19	L1902205001	7.8	255	27.9	<0.5	93	< 1	<100	< 5	<2	6	<0.01	< 2	< 0.2	< 0.2	<0.1	<1	4	<1	<0.1	1	<1	228	80	49	49	0.1	-	<1	<2	<2
16-Apr-19	L1902331001	8.1	268	31.1	2.0	92	< 1	<100	< 5	<2	7	0.10	< 2	< 0.2	< 0.2	<0.1	<1	6	<1	<0.1	1	<1	153	19	<1	20	<0.1	-	<1	<2	<2
23-Apr-19	L1902469001	7.6	359	31.7	1.5	88	< 1	<100	< 5	5	28	1.97	5	< 0.2	< 0.2	<0.1	<1	6	<1	<0.1	4	<1	324	480	<1	<1	<0.1	-	<1	<2	<2
30-Apr-19	L1902646001	7.9	311	30.6	0.5	91	< 1	<100	< 5	<2	6	0.09	2	0.2	< 0.2	<0.1	<1	8	<1	<0.1	1	<1	130	76	**300**	300	<0.1	-	<1	<2	<2
07-May-19	L1902833001	7.9	318	29.1	1.0	83	< 1	<100	< 5	<2	11	0.07	4	0.3	< 0.2	<0.1	<1	9	<1	<0.1	2	<1	126	73	8	11	<0.1	-	<1	<2	<2
16-May-19	L1903005001	7.5	408	29.1	0.8	83	3	<100	<5	2	<10	2.45	**11**	0.34	0.16	<0.1	<1	10	<1	<0.1	7	<1	335	45	50	250	<0.1	-	<1	<2	<2
22-May-19	L1903139001	7.7	779	30.8	1.5	66	< 1	<100	< 5	4	22	6.10	**14**	0.5	0.2	<0.1	<1	6	<1	<0.1	9	<1	314	13	8	9	<0.1	-	<1	<2	<2
28-May-19	L1903301001	8.2	359	27.2	2.0	74	< 1	<100	< 5	2	23	0.12	2	0.5	0.3	<0.1	<1	3	<1	<0.1	8	<1	522	12	10	10	<0.1	-	<1	<2	<2
04-Jun-19	L1903402001	8.4	439	25.4	2.0	82	< 1	<100	< 5	3	20	0.08	3	0.3	< 0.2	<0.1	<1	4	<1	<0.1	4	<1	104	36	18	22	<0.1	-	<1	<2	<2
11-Jun-19	L1903531001	7.8	825	28.1	<0.5	66	< 1	<100	< 5	<2	17	0.83	7	0.3	< 0.2	<0.1	<1	6	<1	<0.1	6	<1	34	1	<1	<1	<0.1	-	<1	<2	<2
18-Jun-19	L1903696001	7.7	396	27.1	2.0	76	< 1	<100	8	2	10	0.30	4	0.8	< 0.2	<0.1	<1	4	<1	<0.1	3	<1	188	22	<1	<1	<0.1	-	<1	<2	<2
25-Jun-19	L1903839001	7.8	388	24.0	1.5	87	2	<100	< 5	<2	14	0.07	5	0.7	0.2	<0.1	<1	6	<1	<0.1	5	<1	157	9	<1	1	<0.1	-	<1	<2	<2

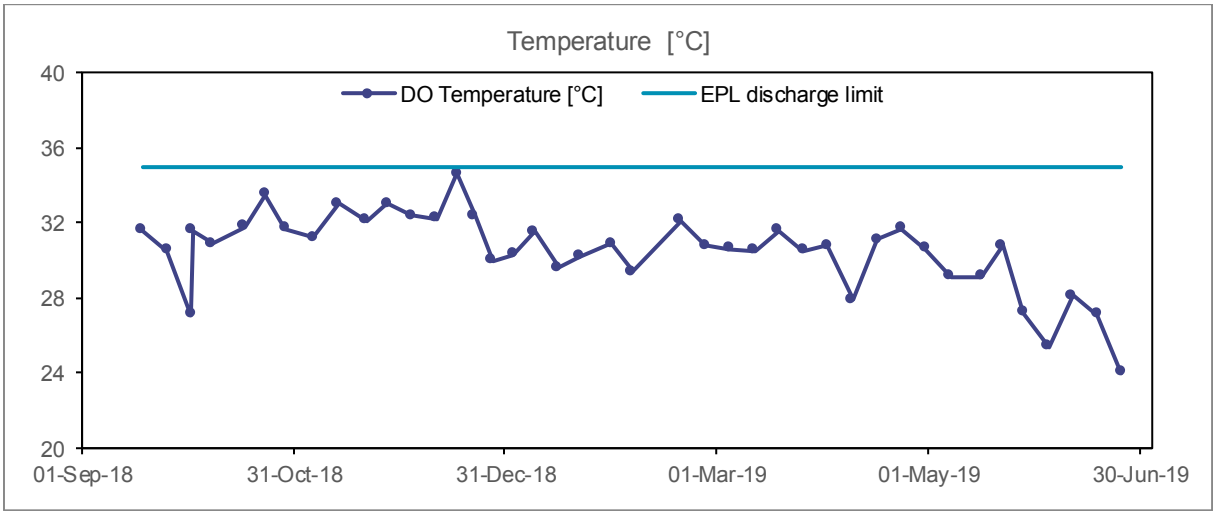
C.2 pH



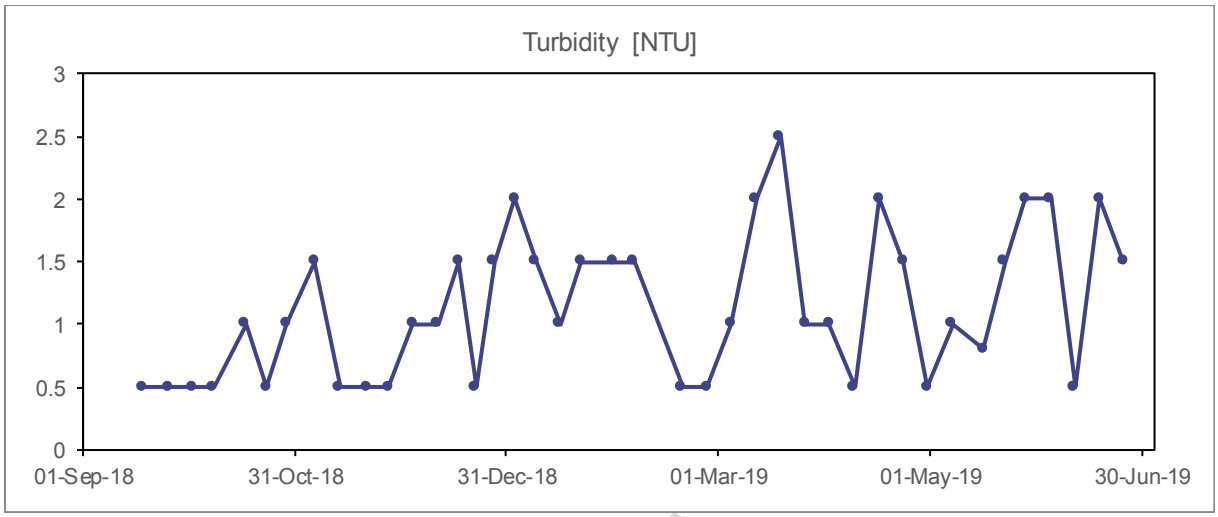
C.3 Conductivity



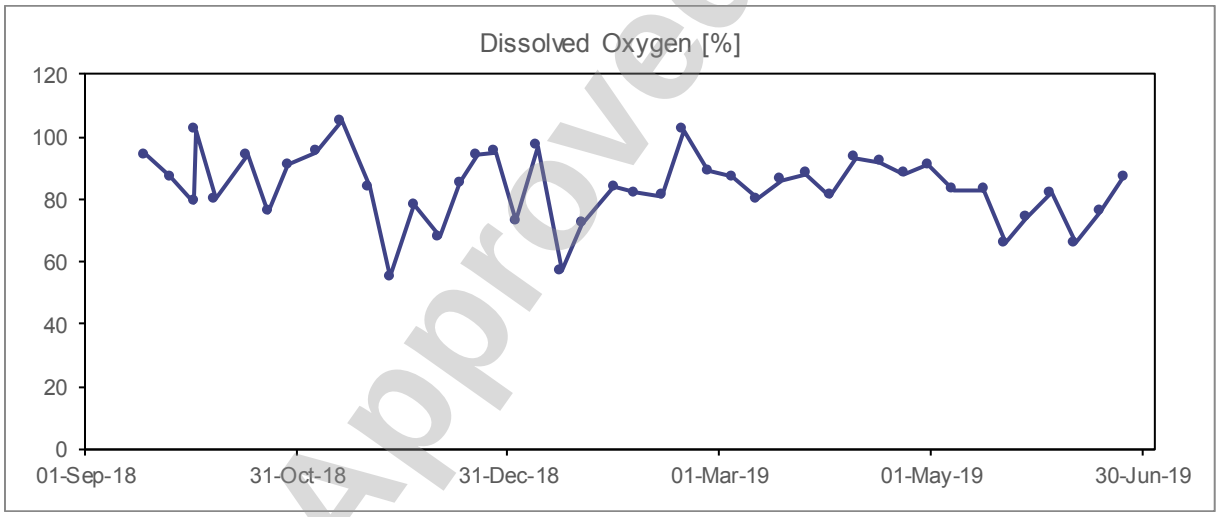
C.4 Temperature



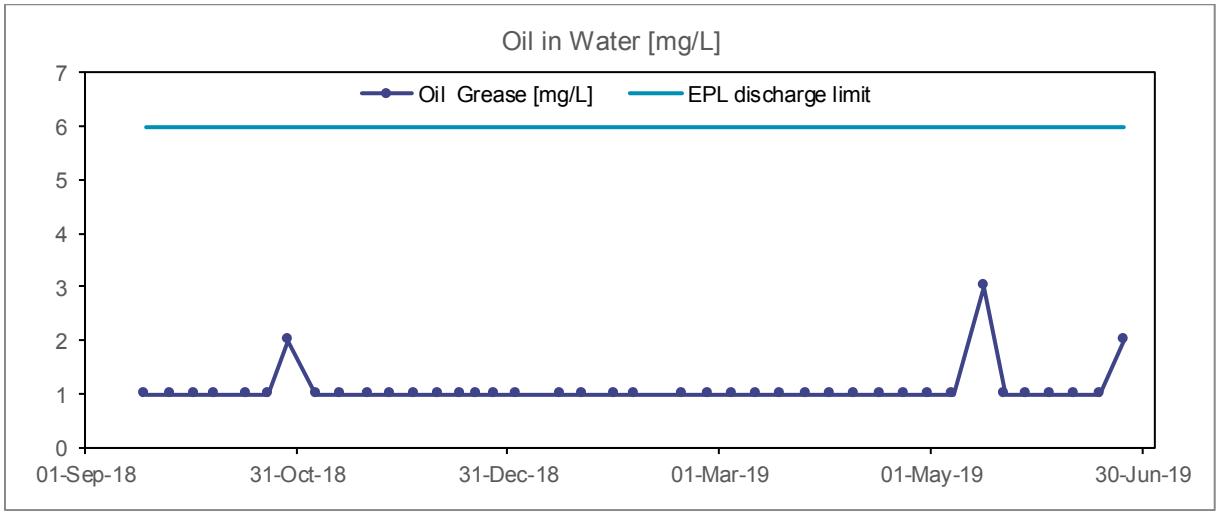
C.5 Turbidity



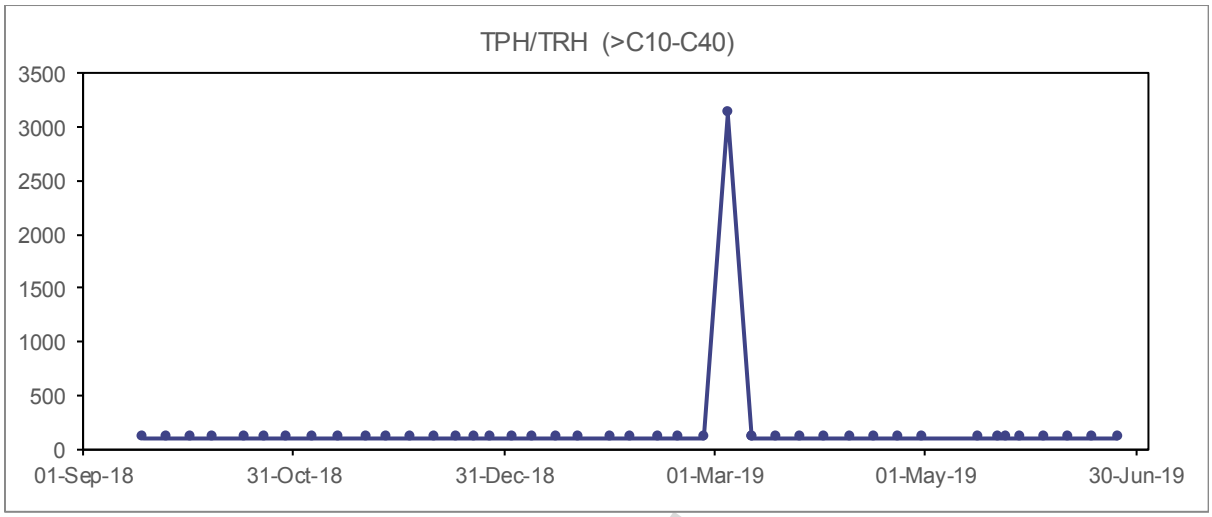
C.6 Dissolved Oxygen (%)



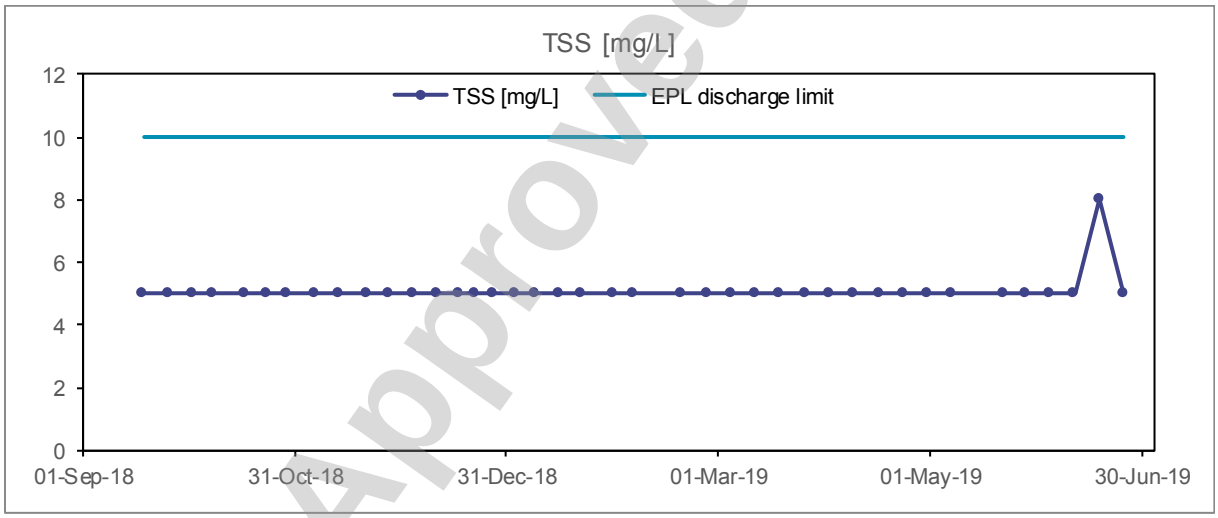
C.7 Oil in Water



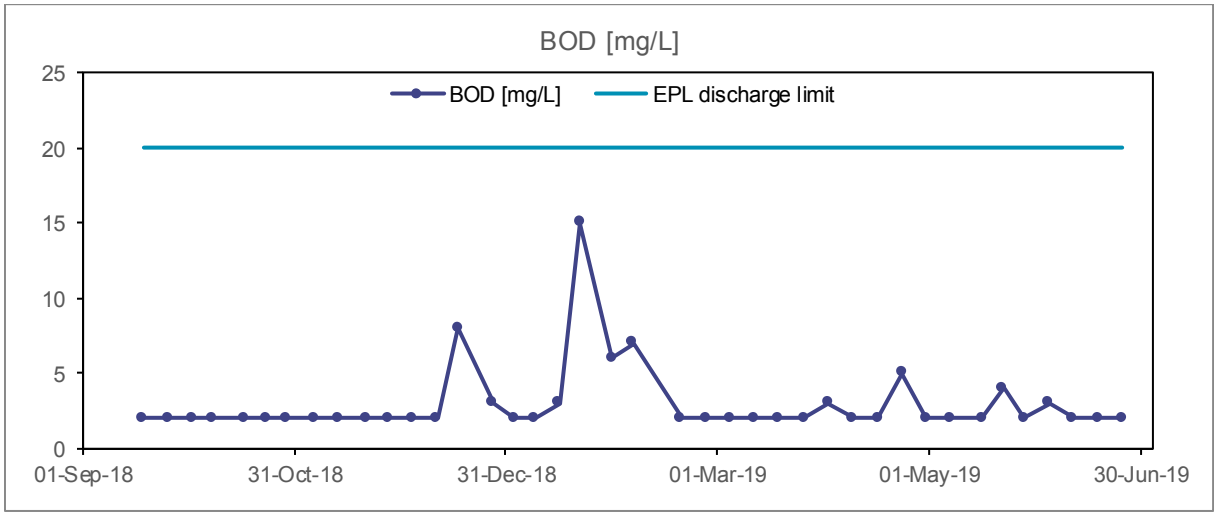
C.8 Total Recoverable Hydrocarbons (C10-C40)



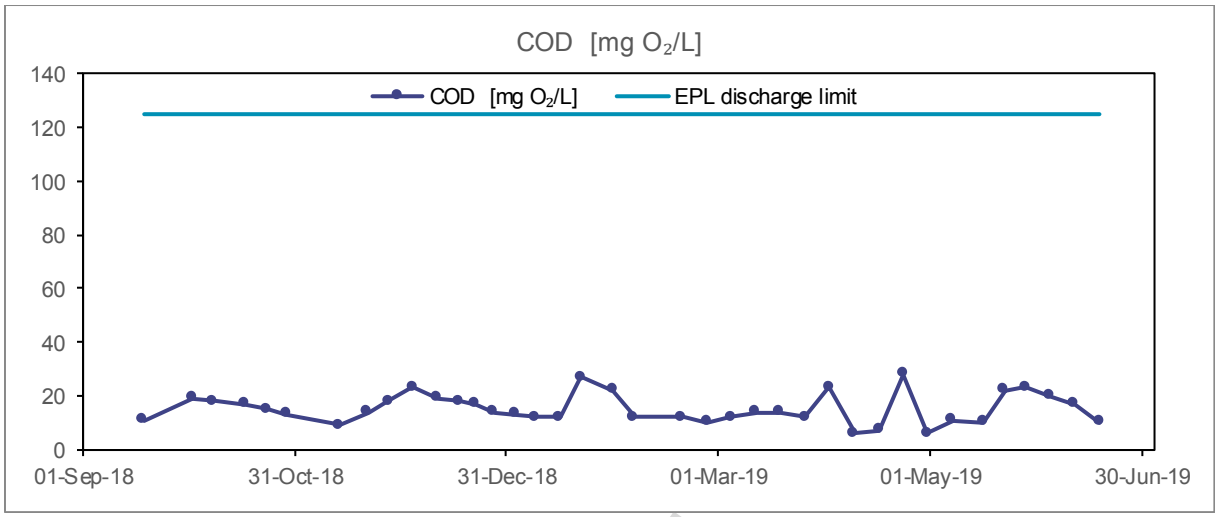
C.9 Total Suspended Solids



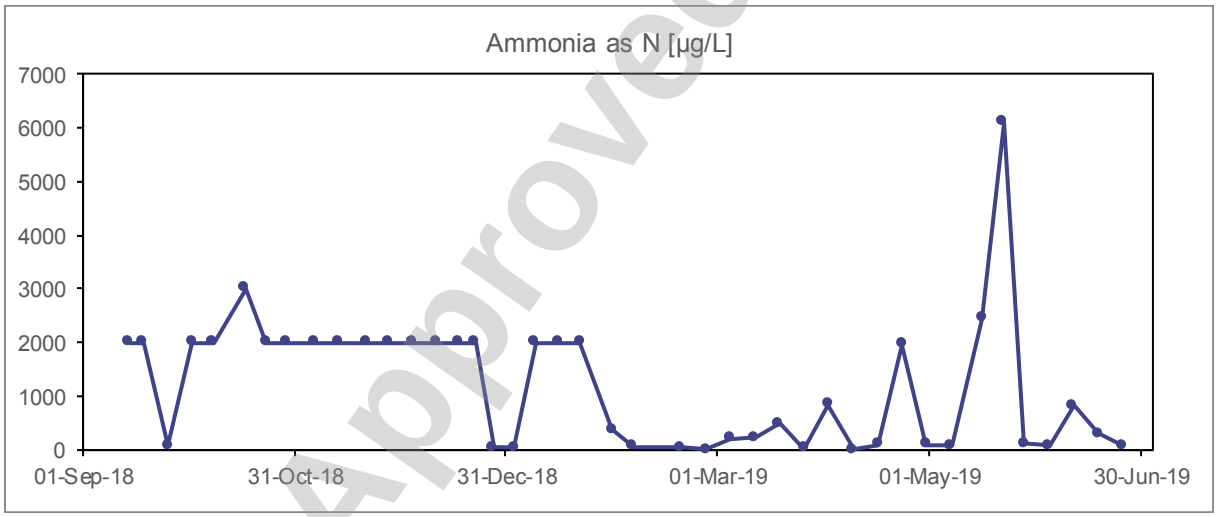
C.10 Biochemical Oxygen Demand



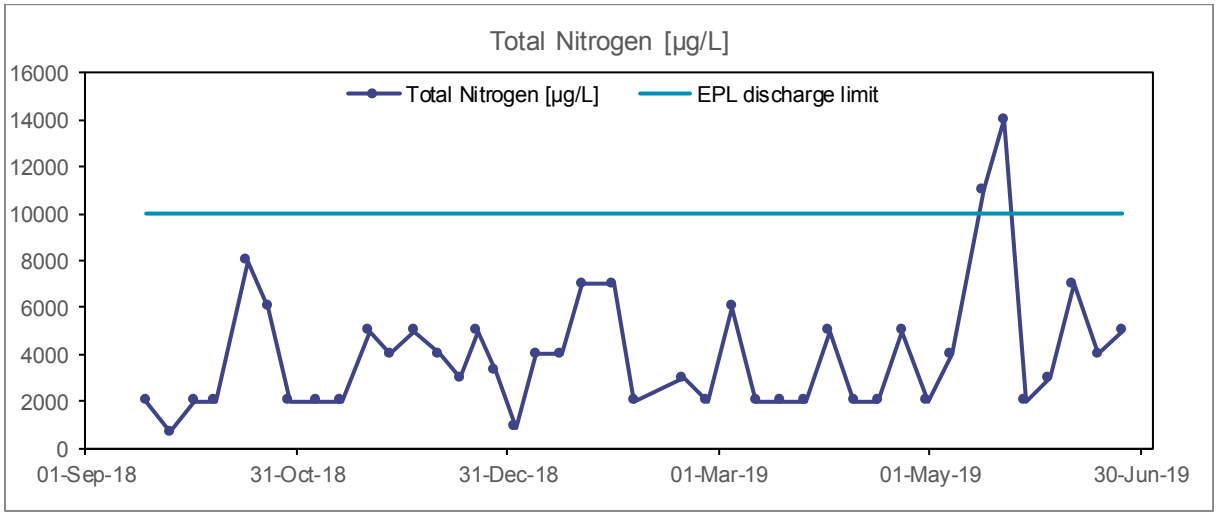
C.11 Chemical Oxygen Demand



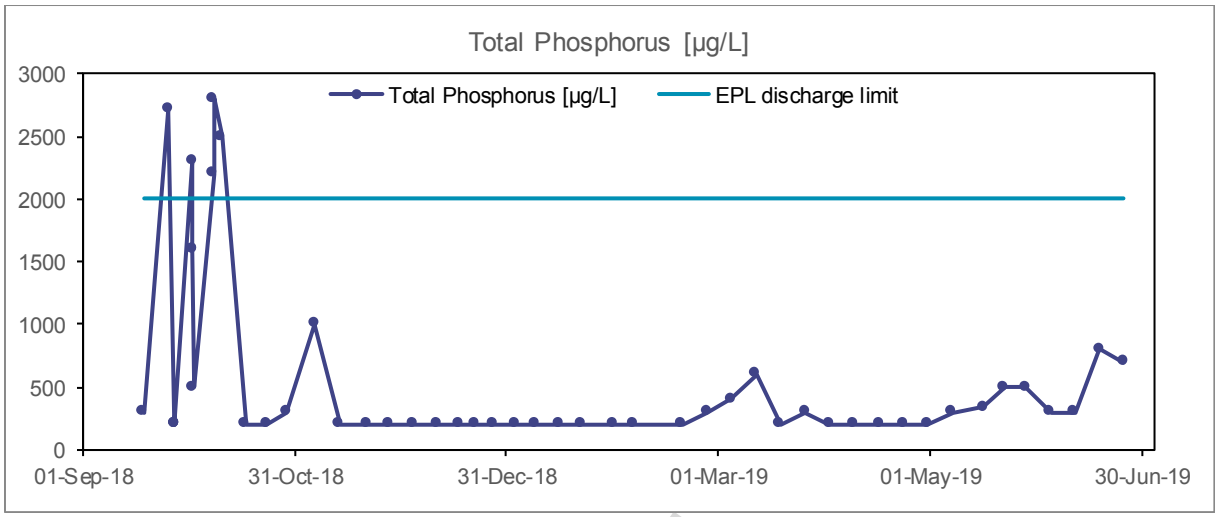
C.12 Ammonia



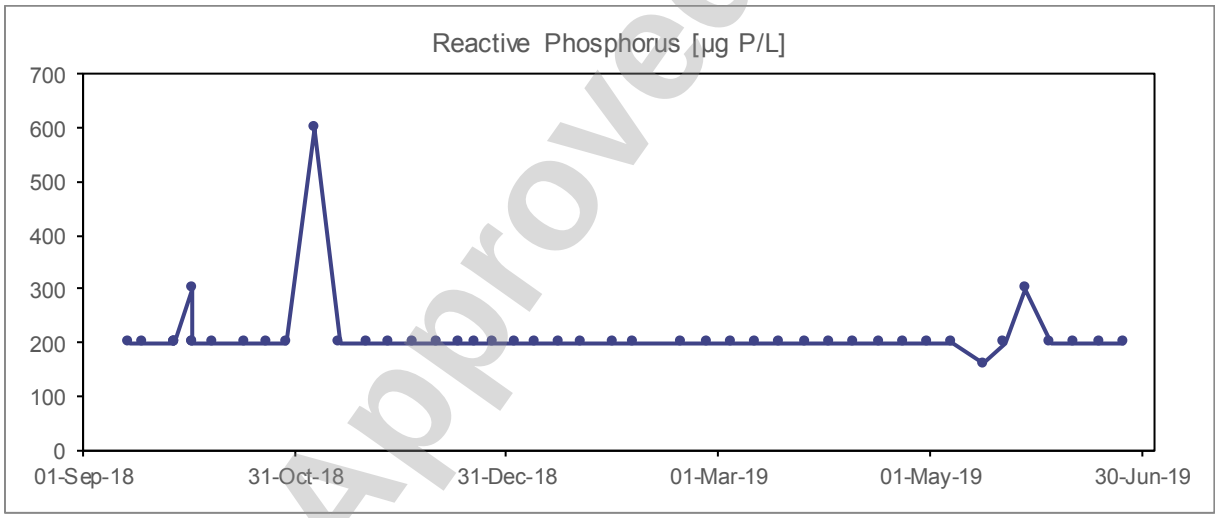
C.13 Total Nitrogen



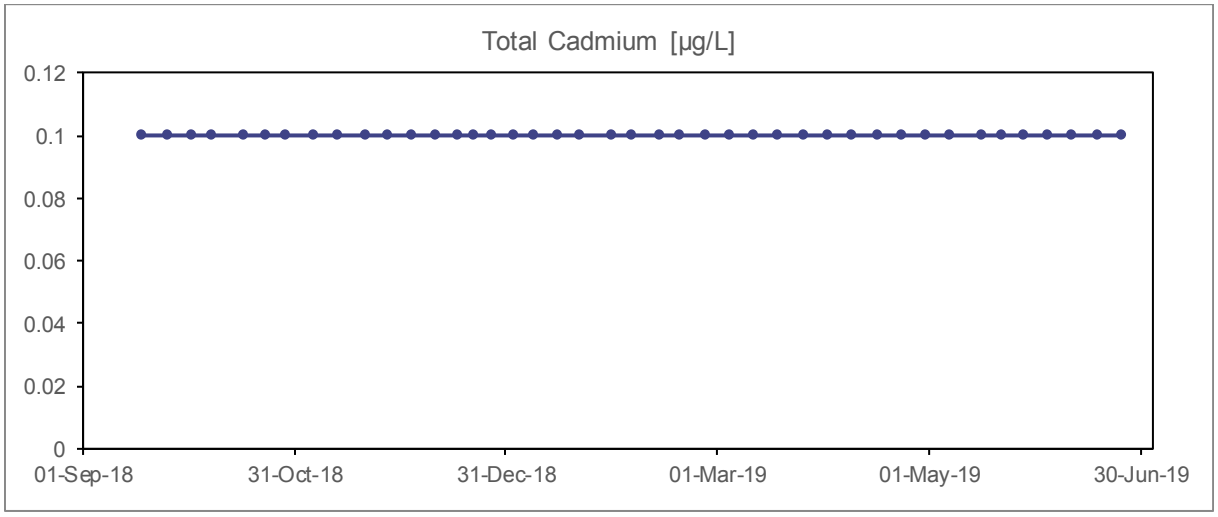
C.14 Total Phosphorus



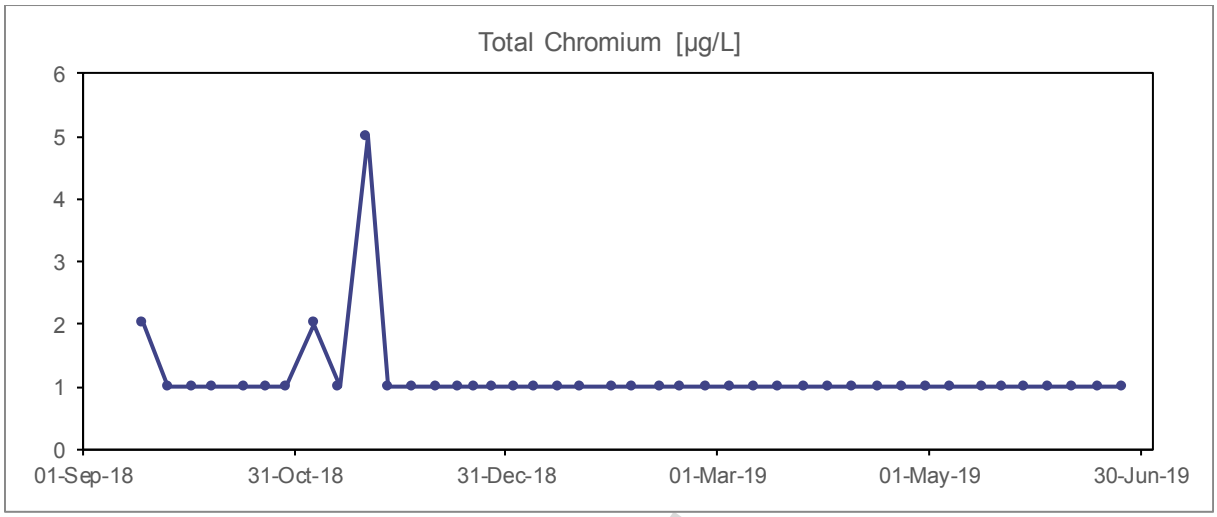
C.15 Filterable Reactive Phosphorus



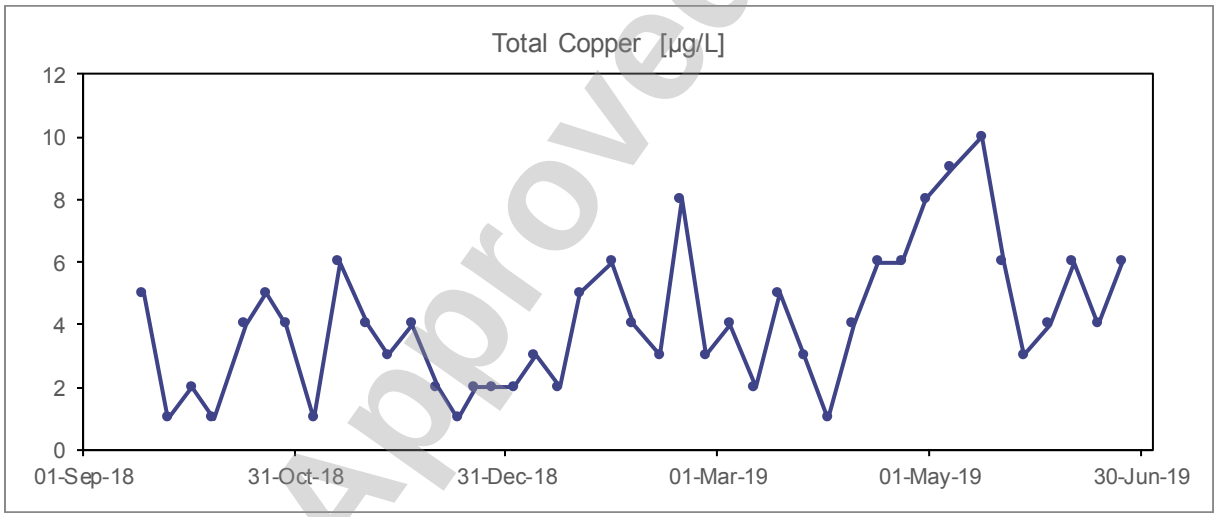
C.16 Total Cadmium



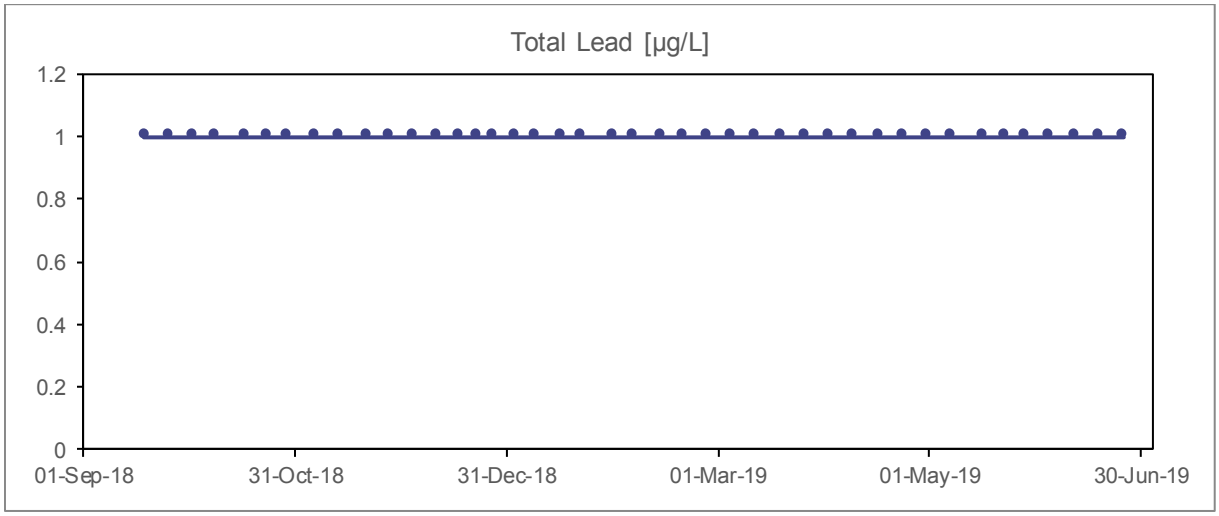
C.17 Total Chromium



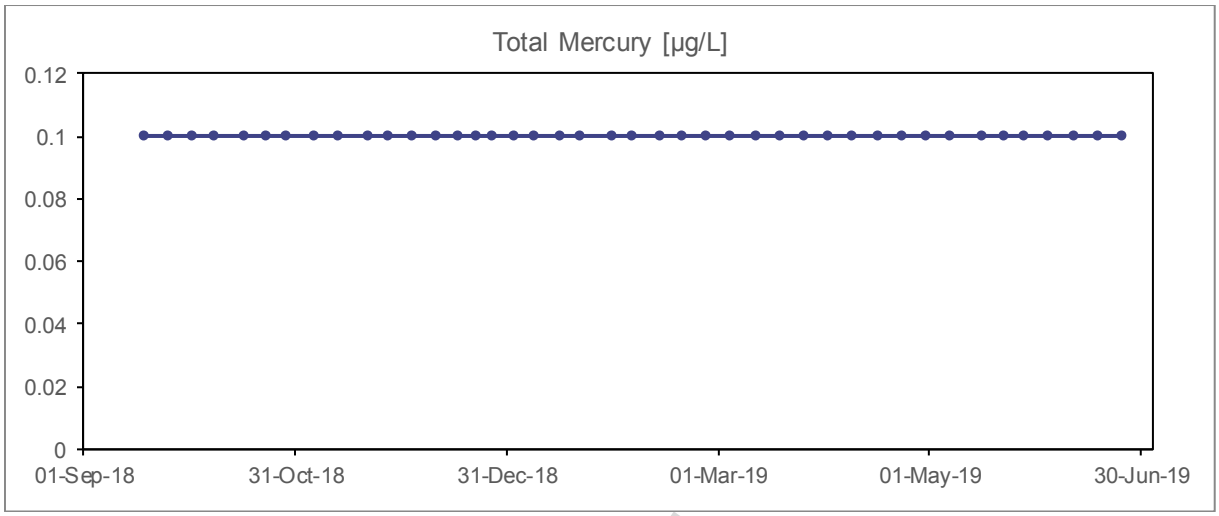
C.18 Total Copper



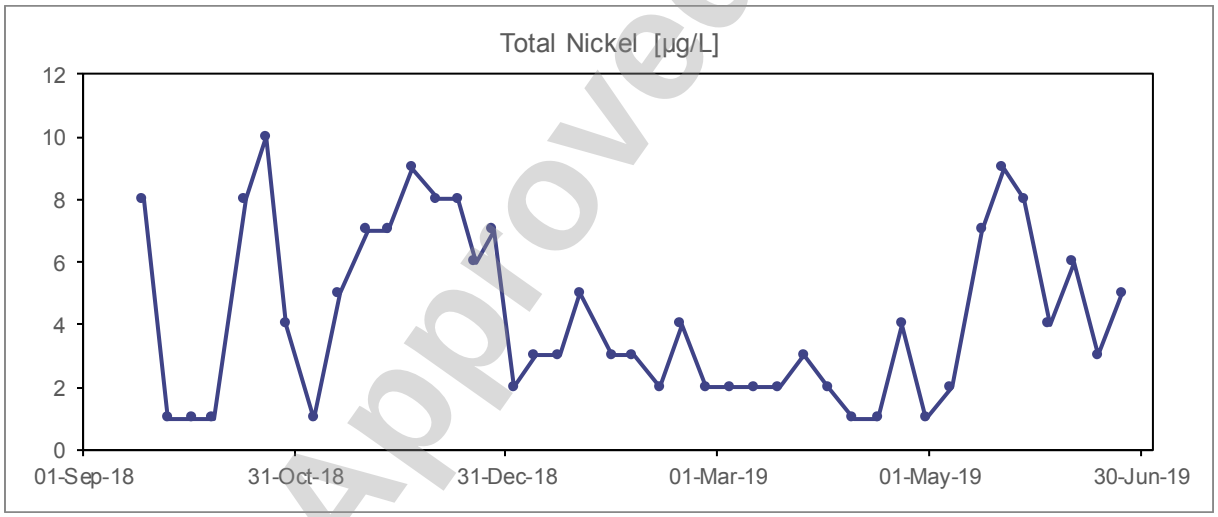
C.19 Total Lead



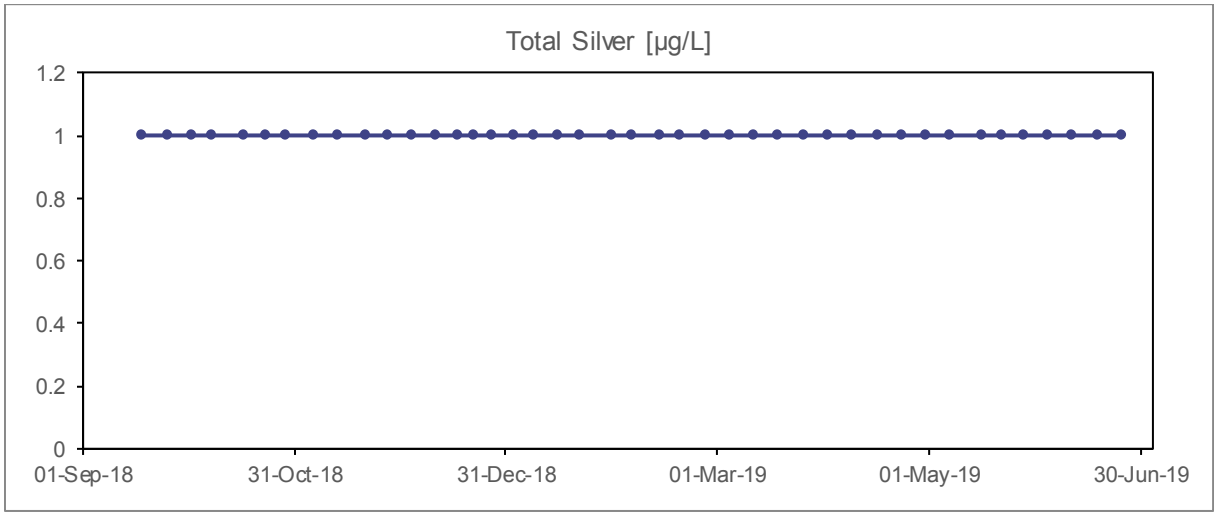
C.20 Total Mercury



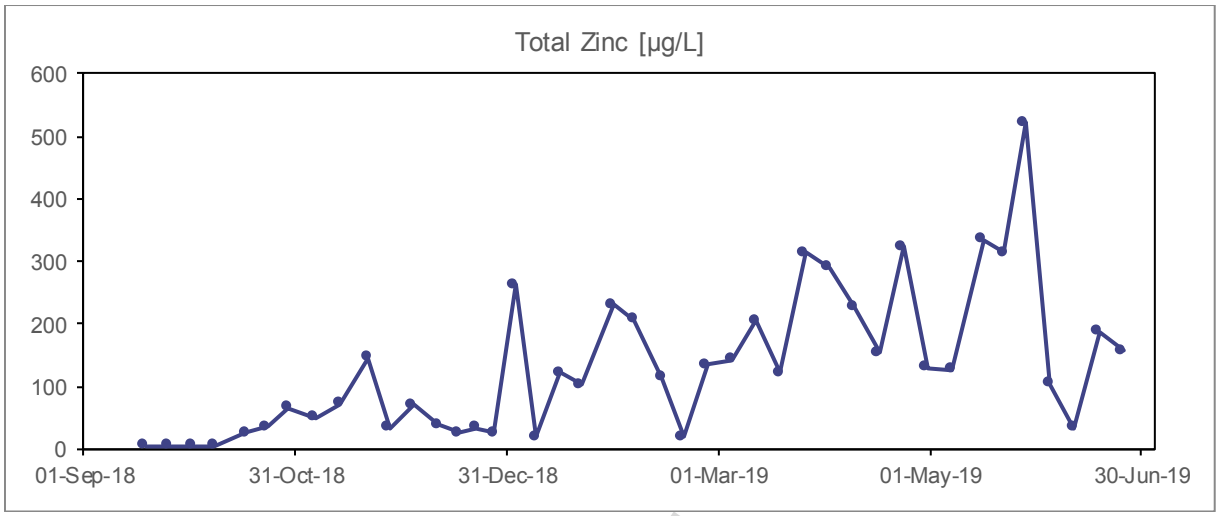
C.21 Total Nickel



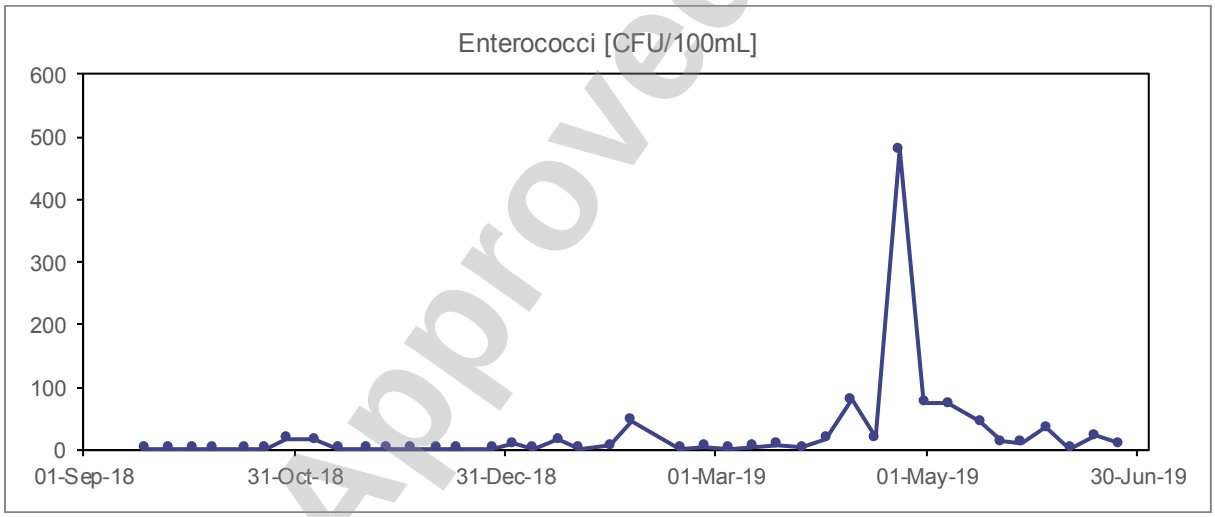
C.22 Total Silver



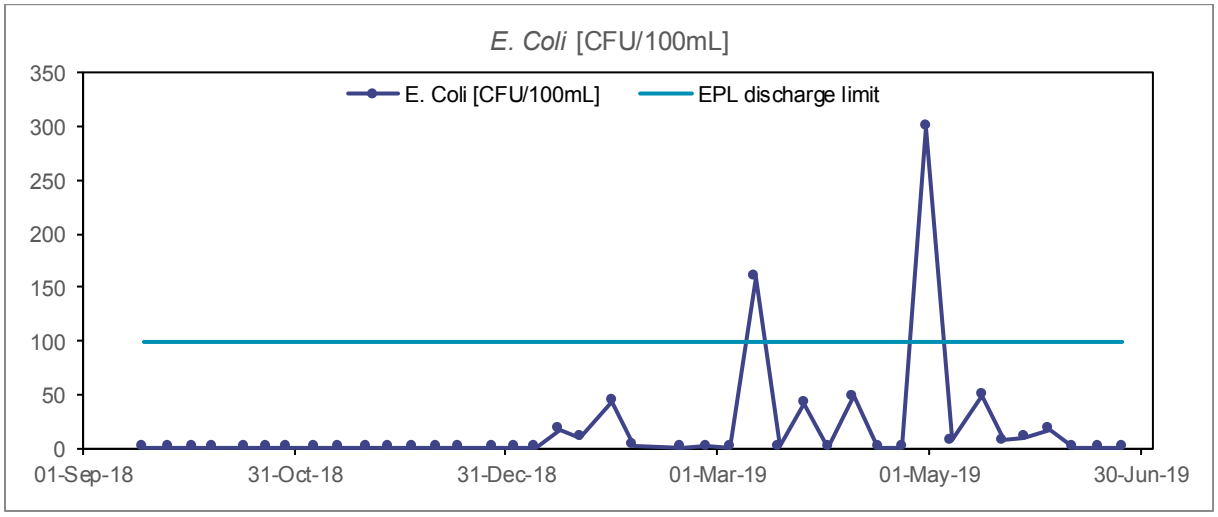
C.23 Total Zinc



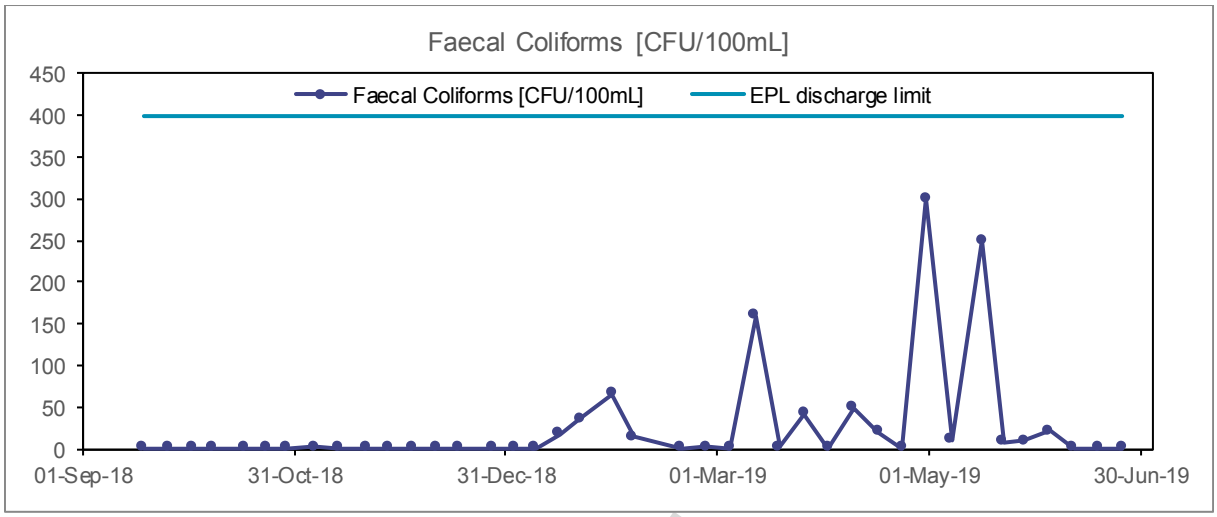
C.24 Enterococci



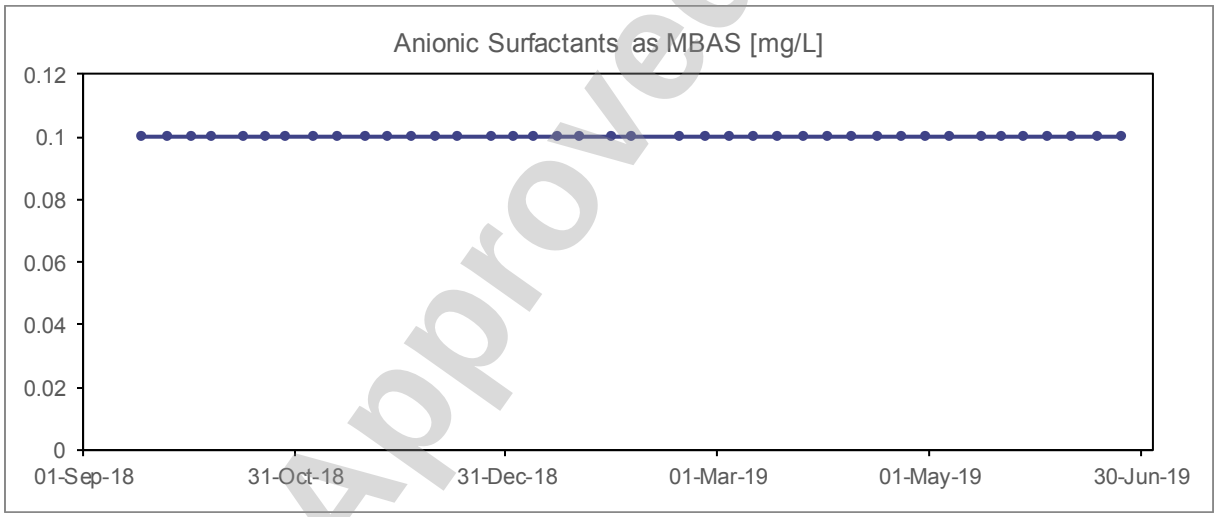
C.25 Escherichia coli



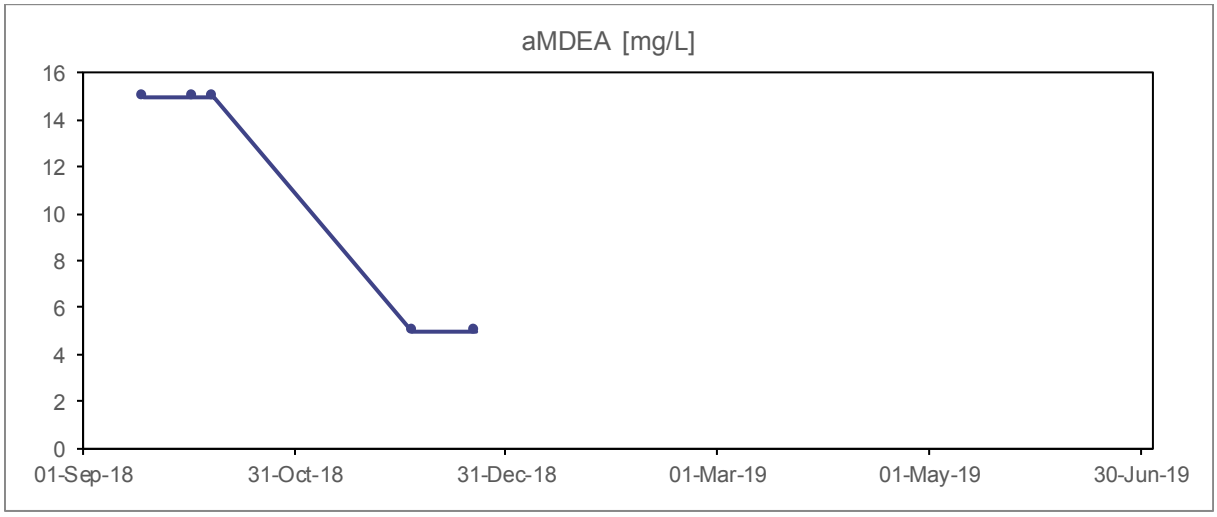
C.26 Faecal Coliforms



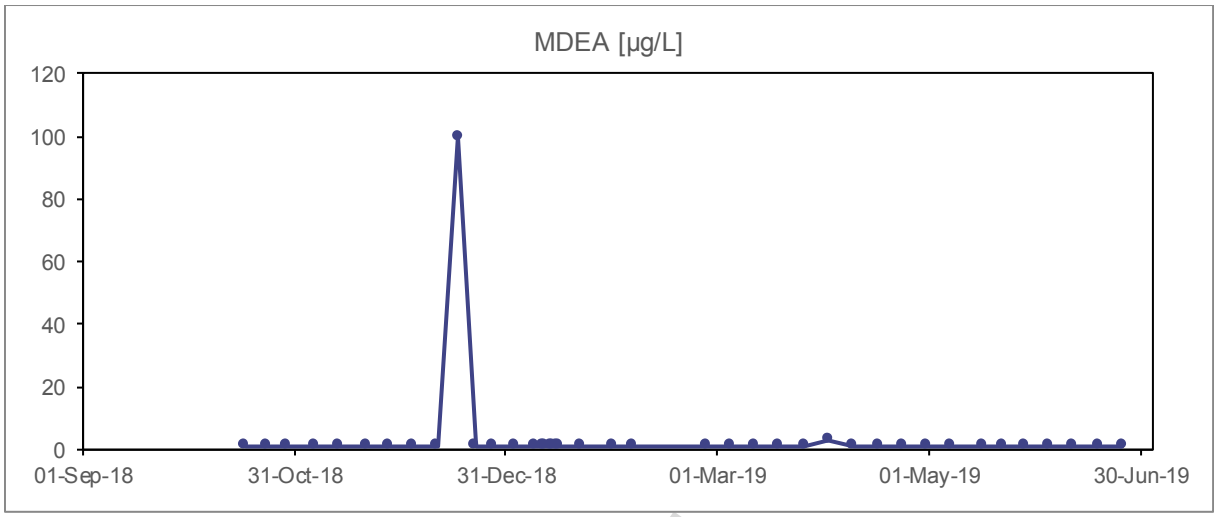
C.27 Anionic Surfactants



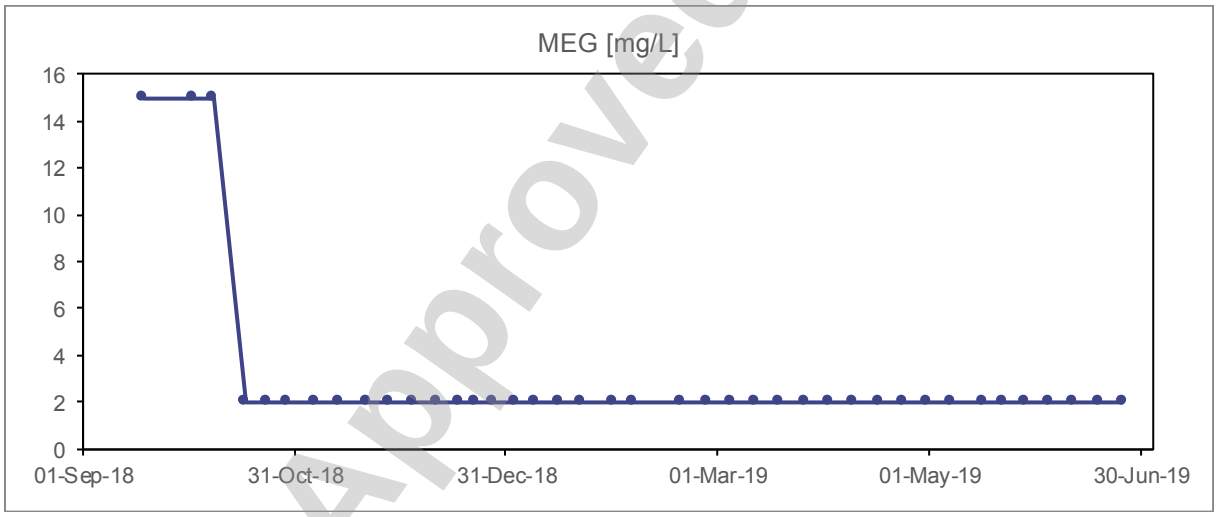
C.28 Activated Methyl Diethanolamine (aMDEA)



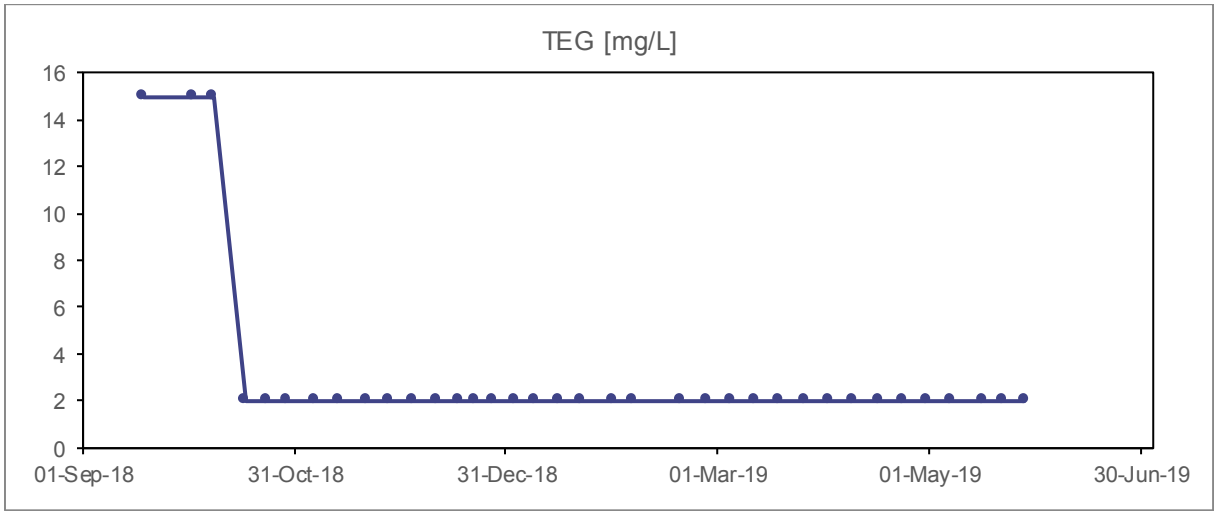
C.29 Methyl Diethanolamine (MDEA)



C.30 Glycol – MEG



C.31 Glycol – TEG



APPENDIX D: JETTY OUTFALL DATA

Survey	Site	Date	pH	EC	Temp	Turbidity	DO	Visual clarity and colour	Surface films	Silver (Ag)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Mercury (Hg)	Nickel (Ni)	Lead (Pb)	Zinc (Zn)	Ammonia	FRP	Total phosphorus	Total nitrogen	TSS	TPH as Oil and grease	TPH as Oil and grease	TPH (C6 – C36)	Enterococci
		Location	pH units	µS/cm	°C	NTU	%	-	-	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	No visible sheen or emulsion, no odour	mg/L	µg/L	mpn/100mL
		Trigger value	6-8.5	-	-	-	80-100	No change from background	None observed	1.4	0.7	4.4	1.3	0.05	7	4.4	15	20	10	30	300	10	No change	-	>LOR	50
1	Jetty 01	17/10/2018	8.0	53930	30.29	2.2	93	No change	None	<0.1	<0.1	0.3	0.3	<0.1	0.3	0.2	<1	5	8	22	150	2	None	<5	<50	<10
	Jetty 02	17/10/2018	8.0	53890	30.37	2.4	92	No change	None	<0.1	<0.1	0.2	0.5	<0.1	0.4	0.1	1	6	9	22	170	2	None	18	<50	<10
	Jetty 03	17/10/2018	8.0	53880	30.28	2.4	93	No change	None	<0.1	<0.1	1.1	0.6	<0.1	3.1	0.3	1	9	8	24	160	2	None	7	<50	<10
	Jetty west	17/10/2018	7.9	54170	30.35	2.1	93	No change	None	<0.1	<0.1	<0.2	0.4	<0.1	0.5	0.2	<1	5	7	22	130	2	None	7	<50	<10
	Jetty east	17/10/2018	7.9	54060	30.36	2.1	93	No change	None	<0.1	<0.1	0.2	0.4	<0.1	0.4	0.2	<1	4	7	21	140	2	None	<5	<50	<10
	Jetty east	17/10/2018	8.0	53960	30.25	2.1	92	No change	None	<0.1	<0.1	0.3	0.6	<0.1	0.5	0.3	1	10	8	22	170	2	None	<5	<50	<10
2	Jetty 01	30/01/2019	8.0	52947	29.50	5	92	No change	None	<0.1	<0.1	0.5	0.6	<0.1	0.8	0.3	1	8	8	21	140	6	None	<5	<50	-
	Jetty 02	30/01/2019	8.0	27808	29.20	3.7	94	No change	None	<0.1	<0.1	0.4	0.7	<0.1	0.4	0.2	2	5	7	19	130	5	None	<5	<50	-
	Jetty 03	30/01/2019	8.0	52707	29.60	4.2	95	No change	None	<0.1	<0.1	0.4	0.6	<0.1	0.4	0.3	2	7	8	19	140	5	None	<5	<50	-
	Jetty west	30/01/2019	7.9	52294	29.60	4.2	92	No change	None	<0.1	<0.1	0.5	0.7	<0.1	0.4	1.5	2	4	7	19	130	4	None	<5	<50	-
	Jetty east	30/01/2019	8.0	43776	29.60	4.9	91	No change	None	<0.1	<0.1	0.4	0.7	<0.1	0.4	0.3	3	12	7	19	140	5	None	<5	<50	-
	Jetty 01	30/01/2019	-	-	-	-	-	-	-	<0.1	<0.1	0.5	0.6	<0.1	0.4	0.2	<1	7	8	19	140	6	None	<5	<50	-
3	Jetty 01	29/04/2019	8.18	56460	30.22	1.3	101	No change	None	<0.1	<0.1	0.2	0.4	<0.1	<0.3	0.1	<1	3	6	19	130	<1	None	<5	<50	<10
	Jetty 02	29/04/2019	8.16	56440	30.20	2.2	98	No change	None	<0.1	<0.1	0.2	0.4	<0.1	<0.3	0.1	<1	<3	5	17	130	<1	None	<5	<50	<10
	Jetty 03	29/04/2019	8.17	56500	30.30	1.6	99	No change	None	<0.1	<0.1	0.2	0.4	<0.1	0.4	0.1	<1	<3	5	17	120	<1	None	<5	<50	10
	Jetty west	29/04/2019	8.17	56540	30.18	1.4	97	No change	None	<0.1	<0.1	0.2	0.4	<0.1	0.4	0.3	1	<3	5	18	130	<1	None	<5	<50	10
	Jetty east	29/04/2019	8.16	46490	30.32	1.4	100	No change	None	<0.1	<0.1	0.2	0.4	<0.1	0.4	0.8	2	<3	5	17	120	<1	None	<5	<50	<10
	Jetty 01	29/04/2019	-	-	-	-	-	-	-	<0.1	<0.1	0.2	0.5	<0.1	0.3	0.1	<1	3	6	18	120	<1	None	<5	<50	<10

APPENDIX E: GROUNDWATER QUALITY DATA

Survey	Site	Date	Ammonia	Total Nitrogen	Oxides of Nitrogen	Total Phosphorus	FRP	TDS	Aluminium (Filtered)	Arsenic (Filtered)	Cadmium (Filtered)	Chromium VI (Filtered)	Chromium III (Filtered)	Cobalt (Filtered)	Copper (Filtered)	Lead (Filtered)	Manganese (Filtered)	Mercury (Filtered)	Nickel (Filtered)	Silver (Filtered)	Vanadium (Filtered)	Zinc (Filtered)	Benzene	Ethylbenzene	Toluene	Xylene Total	TRH C6-C40	Dissolved Oxygen (%)	EC (field)	pH (Field)	Redox	Temp	SWL - Top of Casing
		Unit	µg/L	µg/L	µg/L	µg/L	µg/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	%	µS/cm	pH units	mV	°C	m
		Trigger value	20	300	20	30	10	n/a	24	2.3	0.7	4.4	10	1	1.3	4.4	390	0.1	7	1.4	100	15	500	5	180	75	600	n/a	n/a	6-8.5	n/a	n/a	n/a
1	BPGW01	23/10/2018	240	700	100	20	<10	1400	70	19	0.9	<1	<1	24	1	1	1000	<0.1	29	0.2	<5	160	<1	<1	<1	<3	<100	0.61	2814	4.87	106.9	30.2	5.91
	BPGW07	23/10/2018	340	4400	140	30	<10	71,000	60	12	0.4	<1	<1	27	2	4	1300	<0.1	50	1.3	<5	280	<1	<1	<1	<3	<100	1.1	85233	5.16	73	32	1.22
	BPGW08A	25/10/2018	120	2000	<50	20	<10	8200	710	2	0.5	<1	<1	54	6	13	3800	<0.1	39	0.4	<5	130	<1	<1	<1	<3	<100	1.5	13124	4.18	203.1	31.1	4.28
	BPGW09	30/10/2018	990	1000	<50	70	<10	91,000	<250	19	<1	<1	<5	<5	<5	<5	230	<0.5	11	<25	<25	44	<1	<1	<1	<3	<100	-1.8	113539	6.01	-28.5	31.4	1.08
	BPGW13A	29/10/2018	2400	3200	<50	100	<10	12,000	20	13	0.3	<1	<1	21	<1	<1	920	<0.1	9	<0.1	<5	73	<1	<1	<1	<3	<100	-2.3	16740	5.20	76.7	32.6	4.14
	BPGW14A	30/10/2018	130	670	70	100	<10	23,000	<10	2	0.7	<1	<1	4	10	<1	4700	<0.1	3	<0.1	<5	26	<1	<1	<1	<3	<100	4.9	36900	5.83	117.3	34.1	4.36
	BPGW18	30/10/2018	220	800	<50	120	<10	69,000	<10	10	<0.2	<1	<1	<1	<1	<1	88	<0.1	3	<0.1	<5	110	<1	<1	<1	<3	<100	0.4	88409	5.98	-25.7	30.3	2.35
	BPGW19A	29/10/2018	680	1200	<50	60	20	38,000	40	2	<0.2	<1	2	<1	<1	<1	130	<0.1	10	<0.1	<5	9	<1	<1	<1	<3	<100	0.2	65353	5.43	-22.6	33.4	1.67
	BPGW20	30/10/2018	190	400	<50	50	<10	1100	<10	2	<0.2	<1	<1	3	<1	<1	53	<0.1	5	<0.1	<5	110	<1	<1	<1	<3	<100	1.4	2024	5.20	-52.2	32.9	3.66
	BPGW23	25/10/2018	680	770	70	110	<10	49,000	900	2	1.3	<1	2	150	8	23	14,000	<0.1	70	1.7	<5	550	<1	<1	<1	<3	<100	9.2	67585	3.92	330.2	30	3.85
	BPGW24	30/10/2018	610	1000	<50	40	<10	12,000	<10	7	<0.2	<1	<1	24	<1	<1	200	<0.1	6	<0.1	<5	13	<1	<1	<1	<3	<100	-2.6	17347	5.61	24.1	29.2	2.45
	BPGW25	24/10/2018	340	5300	<50	<10	<10	27,000	30	8	<0.2	<1	<1	48	<1	<1	2100	<0.1	25	0.5	<5	100	<1	<1	<1	<3	<100	0.5	41633	5.19	29.5	30.1	2.33
	BPGW26	29/10/2018	290	400	<50	30	<10	6300	40	6	<0.2	<1	<1	9	<1	<1	3100	<0.1	2	<0.1	<5	8	<1	<1	<1	<3	<100	4.3	13545	5.33	107.4	32.7	4.09
	BPGW27A	29/10/2018	290	400	<50	20	<10	1500	30	1	<0.2	<1	<1	2	1	<1	31	<0.1	17	<0.1	<5	33	<1	<1	<1	<3	<100	-2.2	3147	5.07	112.2	33	3.85
	BPGW28	29/10/2018	1100	1500	<50	140	<10	68,000	<10	5	<0.2	<1	<1	<1	<1	1	230	<0.1	8	<0.1	<5	220	<1	<1	<1	<3	<100	1.1	105271	5.59	-58.1	31.9	3.3
	BPGW38A	25/10/2018	190	300	<50	60	<10	3100	10	<1	22	<1	<1	5	2	<1	150	<0.1	18	0.3	<5	31	<1	<1	<1	<3	<100	-2.6	6746	5.43	92.5	31.8	3.79
	BPGW40	24/10/2018	200	300	<50	<10	<10	3400	20	6	<0.2	<1	<1	<1	<1	<1	70	<0.1	5	0.1	<5	45	<1	<1	<1	<3	<100	0.2	5942	5.44	-15.4	30.9	2.43
	BPGW41	29/10/2018	290	500	<50	60	<10	12,000	<10	6	<0.2	<1	<1	<1	<1	<1	11	<0.1	<1	<0.1	<5	<5	<1	<1	<1	<3	<100	7.3	21919	6.57	-67.4	30.4	2.55
	VWP328	30/10/2018	300	800	<50	280	<10	70,000	<10	590	<0.2	<1	<1	13	1	<1	600	<0.1	4	<0.1	<5	9	<1	<1	<1	<3	<100	-2.3	96500	5.88	-34.5	32.1	4.43
	VWP341	23/10/2018	330	1700	<50	<10	<10	4500	10	4	<0.2	<1	<1	70	<1	<1	970	<0.1	11	0.1	<5	120	<1	<1	<1	<3	<100	0.8	9208	5.41	23	30.9	4.39
2	BPGW01	21/01/2019	20	1300	1300	30	10	110	130	<1	<0.2	<5	<5	1	0	0.5	69	<0.1	1	<0.1	<5	10	<1	<1	<1	<3	<100	1.4	350	4.63	206.7	31.0	2.12
	BPGW07	29/01/2019	450	26000	<50	230	10	77,000	<10	14	0.3	<5	<5	19	0	1.6	880	0.1	20	<0.1	<5	69	<1	<1	<1	<3	<100	4.1	89875	5.65	89.4	31.2	0.82
	BPGW08A	21/01/2019	130	<200	<50	10	10	14000	550	2	0.7	<5	<5	55	3	13.0	4100	<0.1	37	0.6	<5	68	<1	<1	<1	<3	<100	12.7	16998	4.43	233.7	31.3	3.32
	BPGW09	29/01/2019	470	21000	<50	500	10	110,000	<10	51	<0.2	<5	<5	3.3	<0.2	2.1	360	0.1	1	<0.1	<5	53	<1	<1	<1	<3	<100	0.3	117663	6.14	32.0	30.9	0.73
	BPGW13A	23/01/2019	240	1300	1000	10	<10	610	90	<1	<0.2	<5	<1	1	2.4	0.3	73	<0.1	2	<0.1	<5	130	<1	<1	<1	<3	<100	2.5	659	5.37	275.5	32.8	2.29
	BPGW14A	22/01/2019	<10	5400	300	50	10	1,900	<10	<1	<0.2	<5	<5	1	0	<0.1	230	<0.1	2	<0.1	<5	20	<1	<1	<1	<3	<100	1.8	3235	5.94	214.8	33.1	2.46
	BPGW18	24/01/2019	780	1100	<50	50	10	58,000	<10	16	<0.2	<5	<5	0.2	1.3	1.1	79	<0.1	<1	<0.1	<5	<5	<1	<1	<1	<3	<100	0.9	88126	6.07	-38.5	30.4	2.08
	BPGW19A	23/01/2019	1200	1500	60	150	60	44,000	40	4	<0.2	<5	2	<0.2	<0.2	<0.1	110	<0.1	<1	<0.1	<5	<5	<1	<1	<1	<3	<100	0.6	55750	6.13	-48.2	31.3	1.18
	BPGW20	24/01/2019	150	<200	<50	80	10	1400	<10	2	<0.2	<5	<5	3	<0.2	0.2	62	<0.1	1	<0.1	<5	6	<1	<1	<1	<3	<100	9.9	2442	5.26	129.5	32.9	2.58
	BPGW23	21/01/2019	20	<200	90	20	10	4,800	50	<1	0.3	<5	<5	10	0	0.8	1,400	<0.1	7	0.1	<5	12	<1	<1	<1	<3	<100	3.2	7916	4.99	210.4	30.7	1.53
	BPGW24	22/01/2019	770	900	<50	40	10	2,200	<10	4	<0.2	<5	<5	22	<0.2	<0.1	190	<0.1	4	<0.1	<5	12	<1	<1	<1	<3	<100	4.2	4564	5.85	77.9	29.8	1.62
	BPGW25	21/01/2019	310	400	<50	110	10	37,000	<10	8	0.3	<5	<5	69	<0.2	2.1	2700	<0.1	31	<0.1	<5	62	<1	<1	<1	<3	<100	0.6	32406	5.39	55.8	30.4	1.64
	BPGW26	22/01/2019	260	1900	<50	20	10	10000	<10	9	<0.2	<5	<5	6	<0.2	<0.1	2700	<0.1	2	<0.1	<5	9	<1	<1	<1	<3	<100	0.1	14041	5.51	126.5	31.9	3.31
	BPGW27A	23/01/2019	220	220	<50	60	10	2200	<10	<1	<0.2	<5	<1	1	<0.2	<0.1	23	<0.1	<1	<0.1	<5	5	<1	<1	<1	<3	<100	1.7	3550	4.97	162.7	33.6	3.40
	BPGW28	23/01/2019	810	8100	<50	40	10	110,000	<10	4	<0.2	<5	<1	<0.2	1	<0.1	210	<0.1	<1	<0.1	<5	<5	<1	<1	<1	<3	<100	0.6	116552	6.51	5.5	30.5	2.84
	BPGW38A	22/01/2019	210	210	<50	150	10	3400	<10	<1	36	<5	<5	6	2	<0.1	190	<0.1	5	<0.1	<5	15	<1	<1	<1	<3	<100	1.1	6650	5.62	89.1	32.1	2.81
	BPGW40	23/01/2019	260	400	<50	40	10	4200	<10	7	<0.2	<5	<1	0.3	<0.2	0.1	100	<0.1	<1	<0.1	<5	<5	<1	<1	<1	<3	<100	0.4	6136	6.22	-54.0	30.5	1.92
	BPGW41	24/01/2019	300	300	<50	120	10	11,000	<10	5	<0.2	<5	<5	<0.2	<0.2	0.2	11	<0.1	<1	<0.1	<5	<5	<1	<1	<1	<3	<100	0.1	22320	6.61	-29.2	30.2	2.20
	VWP328	24/01/2019	260	7100	<50	290	190	62,000	<10	380	<0.2	<5	<5	11	1	0.9	560	0.1	3	<0.1	<5	7	<1	<1	<1	<3	<100	3.6	95725	5.85	-20.0	31.9	2.36
	VWP341	24/01/2019	350	350	<50	20	10	1900	<10	4	<0.2	<5	<5	78	<0.2	0.1	1100	<0.1	10	<0.1	<5	110	<1	<1	<1	<3	<100	0.3	3330	5.32	94.7	31.3	3.65

Survey	Site	Date	Ammonia	Total Nitrogen	Oxides of Nitrogen	Total Phosphorus	FRP	TDS	Aluminium (Filtered)	Arsenic (Filtered)	Cadmium (Filtered)	Chromium VI (Filtered)	Chromium III (Filtered)	Cobalt (Filtered)	Copper (Filtered)	Lead (Filtered)	Manganese (Filtered)	Mercury (Filtered)	Nickel (Filtered)	Silver (Filtered)	Vanadium (Filtered)	Zinc (Filtered)	Benzene	Ethylbenzene	Toluene	Xylene Total	TRH C6-C40	Dissolved Oxygen (%)	EC (field)	pH (Field)	Redox	Temp	SWL - Top of Casing
		Unit	µg/L	µg/L	µg/L	µg/L	µg/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	%	µS/cm	pH units	mV	°C	m
		Trigger value	20	300	20	30	10	n/a	24	2.3	0.7	4.4	10	1	1.3	4.4	390	0.1	7	1.4	100	15	500	5	180	75	600	n/a	n/a	6-8.5	n/a	n/a	n/a
3	BPGW01	9/04/2019	<10	<200	<50	10	10	70	40	<1	<0.2	<0.5	<0.5	2	0	<0.2	99	<0.1	<1	<0.1	<5	<5	<1	<1	<1	<3	<100	0.2	120	4.88	168.7	29.7	0.85
	BPGW07	10/04/2019	370	400	<50	30	<10	58000	<10	31	0.2	<0.5	<0.5	17	0	0.5	790	<0.1	19	<0.1	<5	47	<1	<1	<1	<3	<100	0.0	88824	5.77	48.6	31.1	0.70
	BPGW08A	9/04/2019	240	240	<50	10	<10	2700	230	2	<0.2	<0.5	<0.5	21	1	0.9	1300	<0.1	13	<0.1	<5	25	<1	<1	<1	<3	<100	-	4376	4.92	6.9	31.5	2.79
	BPGW09	10/04/2019	380	400	<50	30	30	92000	<10	74	<0.2	<0.5	0.6	3	1	1.8	380	<0.1	2	<0.1	<5	23	<1	<1	<1	<3	<100	0.0	104070	6.07	-30.9	31.2	0.63
	BPGW13A	10/04/2019	600	1400	780	30	10	380	40	<1	<0.2	<0.5	<0.5	1	1	<0.2	82	<0.1	<1	<0.1	<5	40	<1	<1	<1	<3	<100	2.7	737	5.07	116.2	31.5	2.20
	BPGW14A	10/04/2019	120	400	100	10	10	820	<10	<1	<0.2	<0.5	<0.5	<0.2	<0.2	<0.2	66	<0.1	<1	<0.1	<5	22	<1	<1	<1	<3	<100	2.3	3144	6.07	94.6	31.4	2.28
	BPGW18	11/04/2019	320	320	<50	60	10	64000	<10	17	<0.2	<0.5	1	0	0	0.3	88	<0.1	<1	<0.1	<5	6	<1	<1	<1	<3	<100	0.0	87534	6.19	-81.4	29.9	2.17
	BPGW19A	9/04/2019	1200	1300	<50	50	10	46000	20	8	<0.2	<0.5	1.5	<0.2	<0.2	<0.2	90	<0.1	<1	<0.1	<5	15	<1	<1	<1	<3	<100	0.2	68655	6.26	-51.8	31.0	1.20
	BPGW20	11/04/2019	150	200	<50	10	<10	1100	<10	2	<0.2	<0.5	<0.5	3	<0.2	<0.2	62	<0.1	2	<0.1	<5	<5	<1	<1	<1	<3	<100	0.3	2262	5.31	75.2	33.0	2.27
	BPGW23	4/04/2019	80	<200	110	20	<10	16000	250	<1	0.8	<0.5	<1	44	2	2.2	4300	<0.1	19	2.3	<5	32	<1	<1	<1	<3	<100	0.3	28698	4.49	220.6	30.4	1.70
	BPGW24	10/04/2019	370	600	<50	100	<10	2200	10	3	<0.2	<0.5	<0.5	16	<0.2	<0.2	150	<0.1	3	<0.1	<5	<5	<1	<1	<1	<3	<100	1.4	4984	5.50	-42.4	29.8	1.43
	BPGW25	4/04/2019	690	700	<50	<10	<10	9700	30	4	<0.2	<0.5	<1	76	<0.2	0.2	2500	<0.1	22	<0.1	<5	41	<1	<1	<1	<3	<100	0.1	13058	5.20	29.5	30.7	1.70
	BPGW26	8/04/2019	120	200	<50	<10	<10	1200	<10	2	<0.2	<0.5	<0.5	2	<0.2	<0.2	770	<0.1	<1	<0.1	<5	8	<1	<1	<1	<3	<100	0.0	6169	5.62	-75.1	32.1	2.92
	BPGW27A	9/04/2019	200	200	<50	30	<10	1800	<10	<1	<0.2	<0.5	<0.5	1	<0.2	<0.2	21	<0.1	<1	<0.1	<5	<5	<1	<1	<1	<3	<100	-	3230	4.85	-123.9	33.7	3.42
	BPGW28	11/04/2019	580	700	<50	30	30	110000	<10	8	<0.2	<0.5	0.9	<0.2	1	0.5	180	<0.1	<1	<0.1	<5	13	<1	<1	<1	<3	<100	2.9	121684	6.64	-112.3	31.8	2.73
	BPGW38A	8/04/2019	<10	470	470	<10	<10	240	<10	<1	<0.2	<0.5	<0.5	<0.2	<0.2	<0.2	<5	<0.1	<1	<0.1	<5	<5	<1	<1	<1	<3	<100	2.1	455	6.78	141.9	32.1	2.17
	BPGW40	8/04/2019	240	300	<50	10	10	2600	<10	4	<0.2	<0.5	<0.5	0	<0.2	<0.2	82	<0.1	<1	<0.1	<5	<5	<1	<1	<1	<3	<100	0.1	4674	6.29	-54.7	29.6	1.87
	BPGW41	8/04/2019	350	400	<50	20	20	11000	<10	3	<0.2	<0.5	<0.5	<0.2	<0.2	<0.2	11	<0.1	<1	<0.1	<5	<5	<1	<1	<1	<3	<100	1.8	18985	6.67	-66.6	29.5	2.12
	VWP328	11/04/2019	340	400	<50	70	20	75000	<10	550	<0.2	<0.5	0.8	14	1	0.4	510	<0.1	4	<0.1	<5	33	<1	<1	<1	<3	<100	0.2	84263	5.89	-26.6	32.5	2.30
	VWP341	8/04/2019	410	500	<50	10	10	1600	10	3	<0.2	<0.5	<0.5	74	<0.2	<0.2	1100	<0.1	9	<0.1	<5	100	<1	<1	<1	<3	<100	0.2	3038	5.36	40.7	31.2	3.66

Document Endorsement and Approvals

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Electronic Endorsement and Approval

Electronic approval of this document complies with the issued INPEX Electronic Approval Standard (0000-A9-STD-60011) and records evidence that the applicable person has either endorsed and/or approved the content contained within this document. The reviewers of this document are recorded in the DMS.

Name	Title	Date and Time	Action
Dawn MacInnes	Environmental Manager HSEQ Environment	27/09/2019 15:02	Endorsed
Ben Schmidt	Operations Production Superintendent	30/09/2019 10:31	Approved