EPL228 Annual Environmental Monitoring Report 2020-2021

Report

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Correction Notice

The following correction notice applies to the EPL228 Annual Environmental Monitoring Report 2020-2021 (Rev 0, L060-AH-REP-70018), herein referred to as the AEMR.

1 REASON FOR CORRECTION

A review of contractor data and quality assurance processes determined that an error had resulted, which lead to the mis-reporting of results for total petroleum hydrocarbons (TPH) in intertidal sediments. Original TPH C10-C36 (sum of TPH) results were reported based on a non-national association of testing authorities (NATA)-accredited method, which is not suitable for assessment of compliance against environment protection licence (EPL) 228-04. The NATA-accredited TPH C10-C36 (sum of TPH) results (used for assessing compliance against EPL228-04) were mis-labelled in the AEMR as TPH C10-C36 (sum of total after silica gel clean-up) results.

The error in TPH reporting occurred because of a data manipulation/transcription error between the analytical laboratory and the contractor report. The laboratory provided the contractor with the incorrect coding for results, which resulted in contractor data analysis software apportioning data to the wrong analysis in the report.

To ensure this error is not repeated in future monitoring, the contracto'r will complete quality assurance and quality control checks on all laboratory provided data to ensure the results match the requested analysis, prior to the data being entered into the contractors data analysis software. Contractor reports to INPEX have also been updated to reflect this amendment.

2 CORRECTIONS

2.1 Correction 1

Page 85, Section 5.1.2, sub-section *Sediment monitoring: Sediment chemistry* is retracted and replaced with the following:

Sediment chemistry

A summary of the mangrove sediment chemistry results is provided in Table 5-4 and Table 5-5. Two exceedances of arsenic were found at control sites but were not investigated further as no exceedances were found at impact sites.

Exceedances of the benchmark levels were recorded at one control site (CSMC01) for hydrocarbons. The exceedance is likely to indicate the presence of biogenic, naturally occurring hydrocarbons (e.g. lipids, plant oils, tannins, animal fats, proteins, humic acids and fatty acids). Previous positive detections of TPH at monitoring sites have subsequently been below laboratory limits of reporting post silica gel clean-up and there are no known sources of petrogenic hydrocarbons into the environment from Ichthys LNG. As the exceedance occurred at a control site, further investigation, including silica gel clean-up, was not completed.

2.2 Correction 2

Page 87, Section 5.1.2, sub-section *Sediment monitoring: Sediment chemistry*, Table 5-5 is retracted and replaced with the following:

Table 5-5: Summary of organic mangrove sediment chemistry (mg/kg)

Site	***TPH C10-C36 (sum of total)****
Guideline value	*280*
Background	*n/a*
BPMC09	*33*
BPMC10	*76.4*
BPMC11	*<3.7*
BPMC16	*103.3*
BPMC17	*236.6*
BPMC25	*52.2*
BPMC26	*141.2*
CSMC01-HM	***335.5***
CSMC01-TF	*171.4*
CSMC01-TC	*51.4*
CSMC03-HM	*194*
CSMC03-TF	*147.1*
CSMC03-TC	*215.3*

**Bold values indicates trigger exceedances*

3 IMPACTS TO ENVIRONMENTAL COMPLIANCE

There are no impacts to environment compliance reported in the AEMR as the reported TPH C10-C36 (sum of total after silica gel clean-up) results were used to assess compliance. There are no reportable environmental trigger exceedances as a result of this amendment.

RECORD OF AMENDMENT

Revision	Section	Amendment

DOCUMENT DISTRIBUTION

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Abbreviation and definitions

Abbreviation	Description
µg/L	microgram per litre
µm	micrometre
µs/cm	microsiemens per centimetre
AEMR	annual environmental monitoring report
AGRU	acid gas removal unit
aMDEA	activated methyl diethanolamine
AOC	accidentally oil contaminated
AQMS	air quality monitoring stations
AS	Australian Standard
ASU	artificial settlement unit
BTEX	benzene, toluene, ethylbenzene, xylenes
BTX	benzene, toluene, xylenes
CCPP	combined cycle power plant
CCR	central control room
CFI	calibrated field instrument
CFU	colony-forming unit
cm	centimetre
CO	carbon monoxide
COA	certificate of analysis
COC	continuously oily contaminated
COD	chemical oxygen demand
COVID-19	disease caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)
DEPWS	Department of Environment, Parks and Water Security (NT)

Abbreviation	Description
DO	dissolved oxygen
EC	electrical conductivity
E. coli	*Escherichia coli*
EPL228	Environment Protection Licence 228 (as amended)
FRP	filterable reactive phosphorus
GEP	gas export pipeline
H_2S	hydrogen sulphide
Hg	mercury
HM	hinterland margin
HRSG	heat recovery steam generator
Ichthys LNG	collectively, the onshore gas export pipeline and the gas processing plant
INPEX	Ichthys LNG Pty Ltd
km	kilometre
LIMS	laboratory information management system
LNG	liquified natural gas
LOR	limit of reporting
LPG	liquified propane gas
m	metre
mm	millimetres
MEG	mono ethylene glycol
MDEA	methyl diethanolamine
mg/kg	milligram per kilogram
ml	millilitres
MLSS	mixed liquid suspended solids

Abbreviation	Description
m^3/h	cubic metres per hour
MPN	most probable number
NAGD	National Assessment Guideline for Dredging
NATA	National Association of Testing Authorities, Australia
NCW	non-contaminated water
NEPM	National Environmental Protection Measure(s)
NGERS	National Greenhouse and Energy Reporting Scheme
NO	nitrogen monoxide
NO_2	nitrogen dioxide
NOx	nitrogen oxide (NO and/or NO_2)
NPI	National Pollutant Inventory
NSW	New South Wales
NT	Northern Territory
NT DITT	Northern Territory Department of Industry, Tourism and Trade
NT EPA	Northern Territory Environment Protection Authority
O_2	oxygen
O_3	ozone
OEMP	Onshore Operations Environmental Management Plan
PAH	polycyclic aromatic hydrocarbons
PCS	process control system
pH	measure of acidity or alkalinity
$PM_{2.5}$	particulate matter with aerodynamic diameter less than 2.5 µm
PM_{10}	particulate matter with aerodynamic diameter less than 10 µm

Abbreviation	Description
ppm	parts per million
ppmv	parts per million by volume
PSD	particle size distribution
QA/QC	quality assurance/quality control
RBL	rating background level
REMP	Receiving Environment Monitoring Program
SFLA	sample for laboratory analysis
SO_2	sulphur dioxide
SQGV	sediment quality guideline value
STG	steam turbine generator
SWL	standing water level
TC	tidal creek
TEG	triethylene glycol
TF	tidal flat
TKN	total Kjeldahl nitrogen
TN	total nitrogen
TOC	total organic carbon
TP	total phosphorus
TPH	total petroleum hydrocarbons
TPP	temporary power plant
TRH	total recoverable hydrocarbons
TSS	total suspended solid
USEPA	United States Environmental Protection Authority
UV	ultraviolet

EXECUTIVE SUMMARY

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

This Annual Environmental Monitoring Report (AEMR) has been developed to meet Condition 86 of EPL228. Condition 86 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 activities conducted during the preceding 12 months (i.e. the reporting period). For the purpose of this AEMR and as agreed with NT EPA, the reporting period is defined as 1 July 2020 to 30 June 2021.

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.

All other terrestrial and marine monitoring programs (e.g. groundwater, mangroves, weeds, marine sediment etc.) found that monitoring results were consistent with those reported during the previous years' AEMR and construction phase.

Based on monitoring results for the reporting period, there were no adverse effects to the declared beneficial uses and objectives of Darwin Harbour or Elizabeth-Howard River Region Groundwater.

The point source emission, ambient air quality and air toxics monitoring programs reported that all permanent plant and equipment were typically within EPL228 air emission limits, and the emissions had no discernible impact on the ambient air quality of the Darwin Region.

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) 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).*

Since the 2019/2020 Annual Environmental Monitoring Report, the Ichthys LNG facility has been in steady state operations. The key milestones are shown in Section 1.4.1.

1.1 Purpose

The purpose of AEMR is to satisfy Condition 86 of the EPL228 for the Licensed Premises (hereafter Ichthys LNG). The reporting period for this AEMR is 1 July 2020 to 30 June 2021.

1.2 Condition 87 requirements

Table 1-1 provides details of Condition 87 of EPL228 as it relates to the AEMR requirements and the relevant section for where it has been addressed within this report.

Table 1-1: Annual environmental monitoring report condition requirements

EPL288 Condition #	Condition detail	Section
87	The Annual Environmental Monitoring Report must:	-
87.1	report on monitoring required under this licence;	This AEMR
87.2	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
87.3	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
87.4	summarise operating conditions of each emission source and the resulting air emission quality;	3

EPL288 Condition #	Condition detail	Section
87.5	provide total emissions to air in tonnes per year for the air quality parameters listed in Table 6 in Appendix 3;	3
87.6	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
87.7	report on outcomes of the Receiving Environment Monitoring Program (REMP) monitoring and assessment;	This AEMR
87.8	summarise measures taken to reduce waste;	6
87.9	consider the NT EPA Guideline for Reporting on Environmental Monitoring;	APPENDIX A:
87.10	be reviewed by Qualified Professional(s); and	APPENDIX B:
87.11	be provided to the NT EPA with the Qualified Professional(s) written, certified review(s) of the Annual Environmental Monitoring Report.	APPENDIX B:

1.3 Program objective

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.	3.2
Point source emissions to air	To determine if air emissions from stationary point sources are within acceptable limits	3.3
Dark-smoke events	To determine if air emissions from the flare systems are within acceptable limits.	3.5

Program	Objective	Section
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 Northern Territory (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.	5.5
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 operational milestones

Table 1-3 provides an overview of the Ichthys LNG key milestones for the reporting period.

A general Ichthys LNG site layout is shown in Figure 1-1.

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

Date	Report
23 July 2020	OEMP revision 5. OEMP updated to reflect requirements of EPL228-04.
Oct 2020	Environmental audit undertaken by a qualified auditor in accordance with EPL228 condition 34.
29 Jan 2021	OEMP revision 6 endorsed. OEMP revised to remove reference to condition 17 of Development Permit 12/0065 and revision of monitoring programs following review of the 2019/2020 AEMR.
March 2021	Addendum to statutory environmental audit submitted to NT EPA, specific to regional air monitoring programs, including additional modelling.
April 2021	Completion of 24 months of jetty outfall monitoring in Darwin Harbour.
May 2021	Addendum to OEMP revision 6, submitted to NT EPA, specifically including provision to undertake onsite training of non-fluorinated firefighting foam.
May 2021	First major shutdown undertaken on both Train 1 and Train 2.

Figure 1-1: Ichthys LNG layout

1.4.2 Environmental context

Ichthys LNG is located on Bladin Point, on the northern side of Middle Arm Peninsula in Darwin Harbour (Figure 1-2). 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 central business district, across Darwin Harbour.

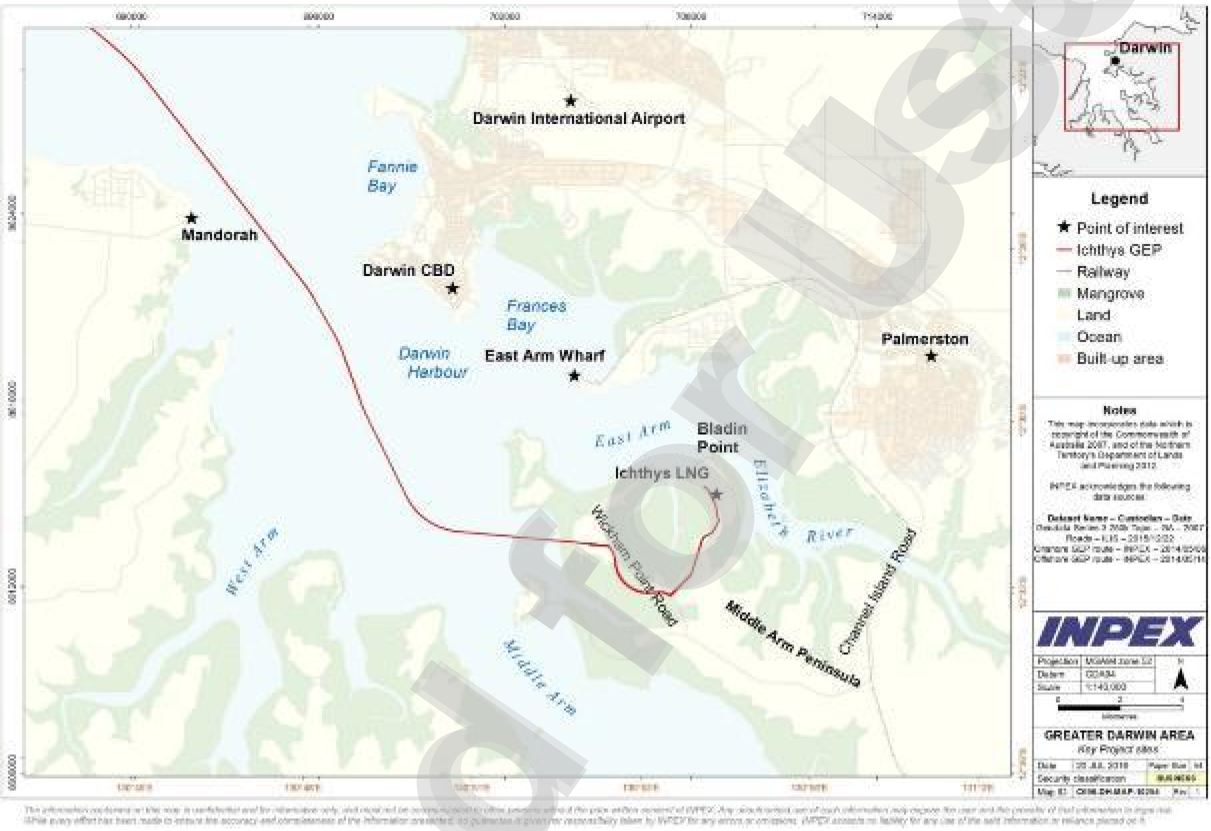


Figure 1-2: Location of Ichthys LNG

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. Darwin experiences an overall mean annual rainfall of ~1,730 mm, the majority of which occurs during the wet season. The 2020/21 wet season was the wettest since 2017/2018, with 1,247.5 mm of rainfall recorded (Table 1-4 and Figure 1-3).

Table 1-4: Bladin Point wet season and transitional months rainfall (mm)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Total
Darwin average	70.6	141.7	250.8	426.3	374.6	319.0	102.2	1,685.2
2012/2013	36.8	199.8	232.4	282.8	291.2	415.2	141.6	1,599.8
2013/2014	134.8	352	268	780	335	14.4	111	1,995.2
2014/2015	13	226.4	175.4	630	492.2	233.8	54.2	1,825.0
2015/2016	12.6	140.6	709.4	243.2	213.4	231.8	63.8	1,614.8
2016/2017	83.8	265.4	469.8	614.2	736	515.8	220.6	2,905.6
2017/2018	93	249.2	125.4	1,031.6	380.4	423.4	39	2,342.0
2018/2019	2.6	183.8	91.6	311.4	159.6	147.8	125.8	1,022.6
2019/2020	24.0	71.2	51.5	327.2	217.7	179.9	72.9	944.3
2020/2021	69.1	87.8	343.5	333.5	194.7	163.4	55.6	1,247.5

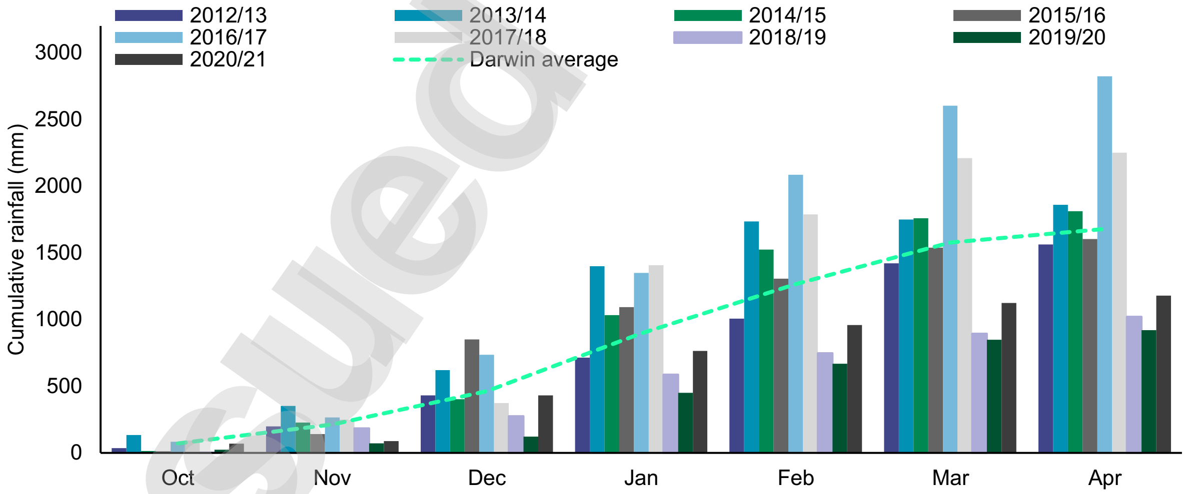


Figure 1-3: Bladin Point cumulative wet seasons

2 DISCHARGES TO WATER

This section describes the outcomes of the following wastewater monitoring programs:

- Comingled treated effluent (Section 2.1)
- Jetty outfall (Section 2.2)
- Harbour sediment (Section 2.3).

2.1 Commingled treated effluent

The key objective of commingled treated effluent sampling (sampling point 750-SC- 003), is to ensure discharge criteria specified in Table 3, Appendix 2 of EPL228 are not exceeded for wastewater discharged from Ichthys LNG.

The monitoring frequency, as specified in Table 3, Appendix 2 of EPL228 was implemented, with sampling occurring monthly (refer to Table 2-1).

In accordance with EPL228 condition 58, monthly sampling was implemented during the reporting period.

Table 2-1: Commingled treated effluent sampling dates

Sample month	Sample collection date
Jul-2020	2*, 5*, 7*, 8*, 11*, 14
Aug-2020	11, 20*
Sep-2020	1*, 7, 15*
Oct-2020	13
Nov-2020	10
Dec-2020	8
Jan-2021	19
Feb-2021	9
Mar-2021	9
Apr-2021	13, 22^, 25^, 28^, 30^
May-2021	5^, 8^, 11
Jun-2021	8, 17*^, 21*

* Additional sampling following an exceedance at location 750-SC-003
^ QA/QC sampling.

2.1.1 Method overview

The commingled treated effluent sampling point (750-SC-003) is located downstream of treated effluent observation basin and upstream of the jetty outfall. Samples collected from 750-SC-003 represent liquid effluent that is discharged to Darwin Harbour via the jetty outfall. The sampling point consists of two valves, 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 Authorities, Australia (NATA) accredited analysis methods by both the INPEX onshore laboratory and external third-party laboratories.

The parameters, sampling methods, limit of reporting (LOR) and discharge limits for the commingled treated effluent monitoring program are provided in Table 2-2.

All results are reported through the INPEX onshore laboratory database systems (laboratory information management system; (LIMS)) that produce sample Certificates of Analysis (COA) inclusive of the laboratory NATA accreditation number. To enable the identification of an exceedance, the discharge limits specified in Table 3, Appendix 2 of EPL228 (refer to Table 2-2) have been input into the LIMS. 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.

Table 2-2: Commingled treated effluent discharge monitoring, methods and discharge limits

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
Free Chlorine (from 8/5/20)	INPEX Lab	mg/L	0.02	2

Parameter	Sampling method*	Unit	LOR	Discharge limit
Ammonia	INPEX Lab	mg N/L	2	n/a
Total nitrogen (TN)†	Calculation	mg N/L	2	10
Total phosphorus (TP)	INPEX Lab	mg P/L	0.5	2
Filterable reactive phosphorus (FRP)	INPEX Lab	mg P/L	0.2 and 0.5	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
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)‡	External lab/INPEX lab	mg/L	0.001 and 5	n/a
Glycol§	External lab/INPEX lab	mg/L	2 and 5	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 until the INPEX laboratory achieved NATA accreditation for aMDEA which occurred in November 2019

§ Measured as mono-ethylene glycol (MEG) and Triethylene glycol (TEG) external laboratory used until the INPEX laboratory achieved NATA accreditation in November 2019

2.1.2 Results and discussion

Routine monitoring results

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.

During the reporting period, there were four occurrences where wastewater quality was above discharge limits, which are further discussed in Section 2.1.3, with the exceedances just limited to just two monthly sampling events. Note following an initial exceedance, further sampling at 750-SC-003 was generally undertaken to confirm the results as part of an investigation. Any elevated results during the investigation sampling process are considered part of an ongoing original event and the results are included in APPENDIX C:.

Overall, there was generally little variability of the wastewater quality, with the majority of results below EPL228 discharge limits. This demonstrates the wastewater treatment systems were operating effectively.

Volumetric flow rate data for the reporting period is shown in Figure 2-1. The data confirms that the volumetric flow rate throughout the period remained well below the 180 m^3/h discharge limit.

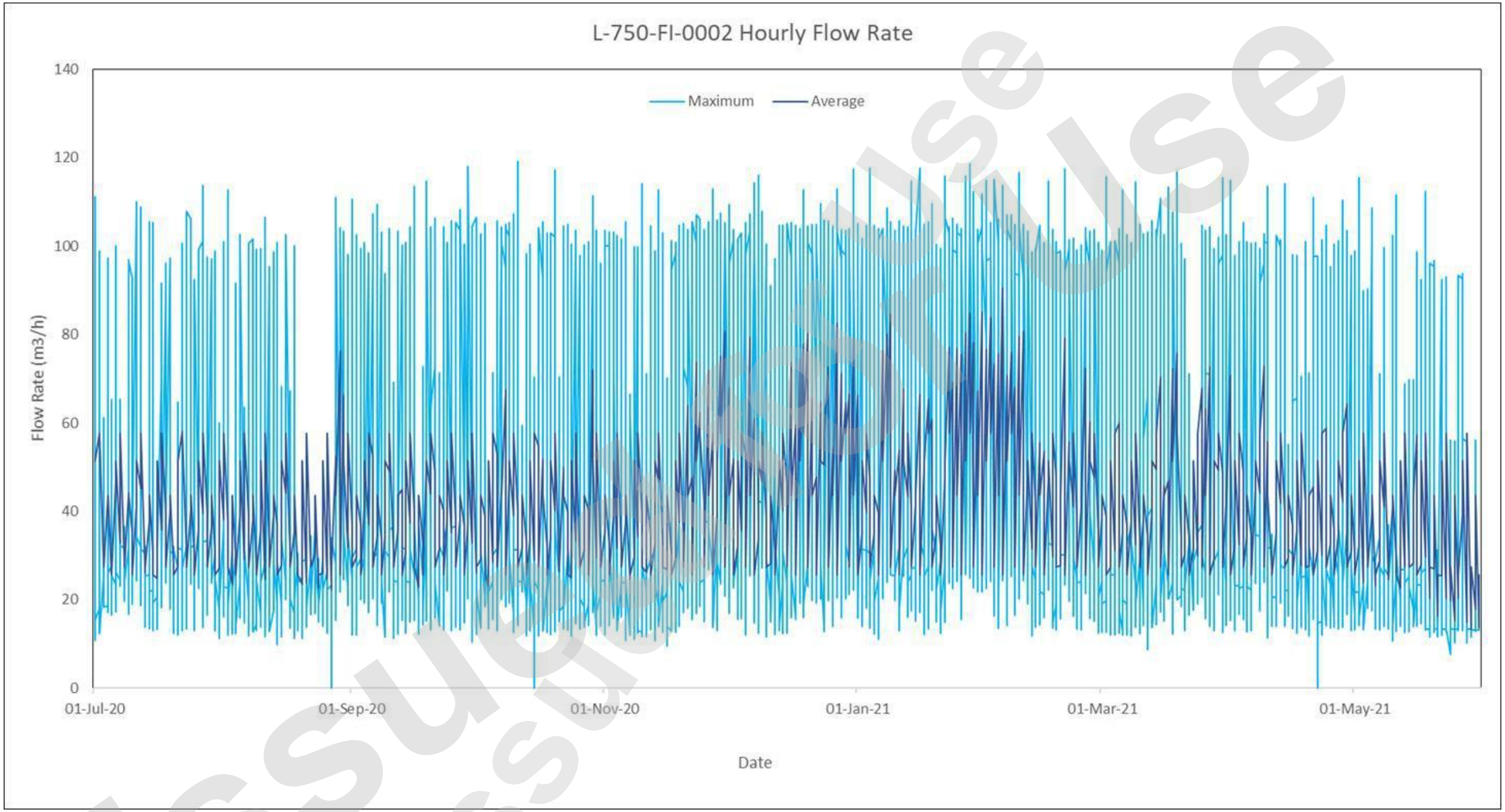


Figure 2-1: Hourly maximum and average flow rate measured by 750-FI-0002 flow meter

Quality assurance/quality control

The quality assurance/quality control (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 or a test method managed under a NATA accredited quality management system was used
- laboratory designated sample holding times met
- 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 INPEX standard method(s) was undertaken.

2.1.3 Limit exceedances assessment outcomes

Throughout the reporting period, and displayed on the COAs, there were four discharge limit exceedances (refer to APPENDIX C:). A summary table of all discharge limit exceedances including corrective actions is provided in Table 2-3. Note the exceedance reported on 5 July 2020 was part of an ongoing investigation related to an exceedance which occurred in June 2020, and was reported in the 2019/2020 annual report. This exceedance is not included in Table 2-3.

Table 2-3: Summary of commingled treated effluent sample point exceedance events

Date sampled	Exceedance reported	Parameter	Result	Limit	Cause and/or contributing factors	Corrective actions
11-Aug-20	20-Aug-20	*E. Coli* and Faecal Coliforms	*E. Coli* 3800 cfu/ 100mL Faecal Coliforms 5700 cfu/100mL	*E. Coli* 100 cfu/ 100mL Faecal Coliforms 400 cfu/100mL	Through follow up sampling at various locations in the wastewater treatment systems, the original sample result was unable to be replicated to confirm the presence of *E. Coli* and Faecal Coliforms and identify a potential source in the wastewater streams at the site. Following the initial exceedance being reported on 20 August 2020, sampling occurred at the sewage treatment plant (post treatment and chlorine and ultra-violet disinfection, sampling locations 750-SC-004 and 750-SC-009) and at the jetty outfall discharge line (sample location 750-SC-003). All results from sampling conducted on 20 August 2020, reported *E. Coli* and Faecal Coliforms at <1 cfu/100mL. Further sampling conducted on 1 September 2020 at location 750-SC-003 reported *E. Coli* and Faecal Coliforms at <1 cfu/100mL and 6 cfu/100mL. There is potential that cross contamination may have occurred in the sampling and laboratory analysis program. The sample was collected by an INPEX Qualified Sampler, following a detailed sampling procedure and the analysis was conducted by an external NATA accredited laboratory. The investigation was unable to confirm that cross-contamination of the sample occurred. The external laboratory conducted a duplicate test of the original sample, collected on 11 August 2020, which reported similar levels to that of the original sample.	INPEX was unable to replicate the original sample results, taken on 11 August and identify a source of contamination. As a precaution the following occurred between 21 and 28 August 2020: • manual chlorine dosing of the accidentally oil contaminated (AOC) treatment system and holding basins, and increased chlorine dosing in the sewage treatment plant; • cleaning of the ultraviolet disinfection system, located in the sewage treatment plant; • installation of floating chlorine dispensers in the AOC treatment system; and • treated sewage and AOC wastewaters were held up from discharging to the jetty outfall between the period 19 to 28 August 2020, which allowed for chlorine dosing in the AOC holding basin.
8-Jun-2021 17-Jun-2021	17-Jun-2021 18-Jun-2021	BOD and TN	BOD 23 mg/L TN 11 mg/L	BOD 20 mg/L TN 10 mg/L	Periodic monthly sampling occurred at location 750-SC-003 on 8 June 2021, this identified a BOD exceedance event, which was reported on 17 June 2021. Additional sampling was undertake on 17 June 2021, to investigate the initial exceedance, which identified an exceedance of TN. Due to the follow up sampling detecting an additional analyte exceedance, the two exceedances were combined into one investigation. During the sampling events on 8 and 17 June 2021, only two of the four wastewater streams were flowing into the combine jetty discharge outfall line, being the demineralised reject brine and treated sewage. Sampling undertaken on 17 June 2021 upstream of location 750-SC-003, of the individual stream of treated sewage (sample location 750-SC-009), as part of the BOD exceedance investigation, identified that the sewage treatment plant was in an upset condition associated with changed conditions for the additional manning levels at the site associated with the shutdown. The BOD levels at the sewage treatment plant were <2 mg/L; however, the TN values reported were 9 mg/L. Sampling conducted on 21 June 2021 at sampling location 750-SC-003 with just the demineralisation plant reject brine flowing and no other streams, reported TN and chemical oxygen demand (COD) levels of 3 mg/L and <3 mg/L, respectively. These results demonstrate that the source of the exceedances was not from the demineralisation plant.	INPEX identified that the main source of the elevated BOD and TN was from the sewage system operating in an upset condition, and the following actions occurred: • Diversion of the treated sewage to the AOC holding basin chambers, and then batch discharging from the holding basin, to allow for mixing and reduction of the TN concentration to below discharge limits. This was undertaken from 17 to 27 June 2021, after which the sewage plant returned to stable operations. • Reduction in the MLSS biomass, to match the influent flow rates. • Manual sugar dosing was undertaken to reduce the TN levels until stable operations in the sewage treatment plant were achieved, following the reduction in MLSS, coupled with maintenance on the sugar dosing pumps. • The BOD concentration was reported below EPL228 limit, for sampling conducted 17 June 2021 at location 750-SC-003, while sampling of the treated sewage at location 750-SC-009 on 23 June 2021 reported the TN at 4 mg/L. Through the incident investigation the following action was identified to prevent reoccurrence:

Date sampled	Exceedance reported	Parameter	Result	Limit	Cause and/or contributing factors	Corrective actions
					Prior to the shutdown the mixed liquor suspended solid (MLSS) mass (as part of the activated sludge process in the sewage treatment plant) was significantly increased to deal with the predicted escalation in sewage waste at the site, due to the manning levels increasing from 500 to ~1500 people. In addition, as part of the shutdown a number of standalone ablution blocks were mobilised to the site and located adjacent to work areas, with the wastewater from the ablution blocks being taken offsite for disposal by a licenced contractor, as the chemicals required in the tanks to prevent odour issues meant the sewage was unable to be treated onsite at the permanent sewage plant. Due to the use of the standalone ablution blocks by the shutdown workforce, the predicted increase in wastewater volume to be treated at the permanent sewage plant did not eventuate, and the increase in MLSS mass resulted in upset conditions in the process of the sewage treatment plant. By increasing the MLSS to a larger volume and having the same wastewater inflows to the sewage treatment plant for standard manning levels (~500 people), the biomass was unable to function effectively and consume appropriately the organic pollutants in the input wastewater stream. Essentially the food to microorganism ratio was placed out of balance and the activated sludge process was not effectively removing (and treating) BOD and TN. This is the considered the main cause of both the BOD and TN exceedance. At the time of sampling on 17 June 2021, the MLSS mass was proactively being reduced (by wasting to biosolid removal) in the sewage treatment plant to ensure the correct volume was re-established to match the input wastewater volumes. The results of the investigation sampling conducted on 17 June 2021 at location 750-SC-003 reported a BOD concentration of <2 mg/L, which indicated that MLSS reduction was effectively removing the BOD at that time; however, the nutrient levels were still elevated due to the plant still being in an upset condition. In addition, through the daily inspection rounds, on 19 June 2021 the sugar dosing pump was identified not to be working properly and a work request was raised to undertake maintenance. The pump was replaced on 20 June 2021. During the period the pump was offline, manual sugar dosing was undertaken (noting that sugar dosing continued for several days after the pump was replaced to ensure the MLSS biomass was in a healthy condition). The sugar dosing system may have potentially been faulty for 24 hours prior to being identified as faulty (18 to 19 June 2021), and this may have contributed to an increase of TN at this time.	• Prior to a significant manning level rise at the site, the MLSS levels will not be pre-emptively increased at the sewage plant. The MLSS levels and overall sewage system is to be managed based on the inflows coming into the plant.

2.1.4 Program rationalisation

Sampling is to remain as per EPL228 requirements, no changes are proposed.

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. The purpose of the jetty outfall monitoring program is to monitor for any potential impacts associated with liquid discharges from the jetty outfall, as required in EPL228.

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 on 19 June 2019 and jetty outfall monitoring program commenced in accordance with EPL228 conditions. The monitoring program ran for 24 months, with the last survey in April 2021. Table 2-4 provides a summary of the four quarterly jetty outfall surveys completed during the reporting period (1 July 2020—30 June 2021).

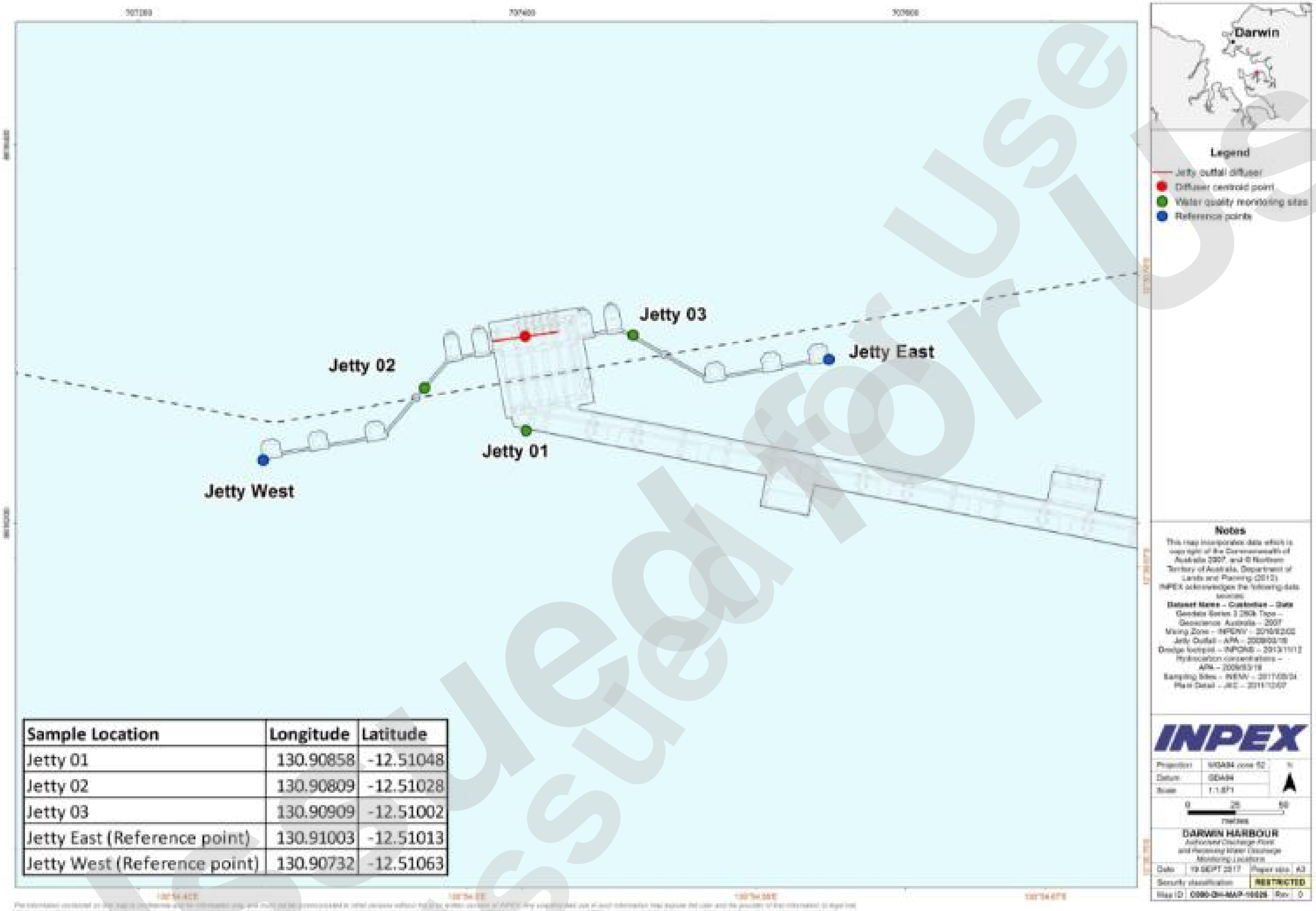
Table 2-4: Jetty outfall survey details

Survey	Date	Report	INPEX Doc #
8	15 Jul 2020	Jetty Outfall Monitoring – Trigger Assessment Report No. 8	F280-AB-REP-60030
		Jetty Outfall Monitoring – Interpretative Report No. 8	F280-AB-REP-60020
9	12 Oct 2020	Jetty Outfall Monitoring – Trigger Assessment Report No. 9	F280-AB-REP-60029
		Jetty Outfall Monitoring – Interpretative Report No. 9	F280-AB-REP-60019
10	20 Jan 2021	ILNG Jetty Outfall Sampling – Results Report 1	L290-AH-REP-70018
11	7 Apr 2021	ILNG Jetty Outfall Sampling – Results Report 2	L290-AH-REP-70023

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. Surficial water samples were collected from the five sampling locations (three potential impact sites and two reference sites) shown in Figure 2-2, during slack water on a neap high tide [1]. Following sample collection, calibrated field instruments were used to measure parameters that could be measured in situ and for those that could not, samples were taken and sent to a NATA accredited laboratory for analysis. Table 2-5 provides a summary of parameters, sampling methods and trigger values. Note, trigger values are provided for information only (see Section 2.2).

[1] 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 to align with EPL228 requirements.



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 2-5: 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 (DO)	%	CFI	Outside 80 to 100
Visual clarity and colour	n/a	O	No decrease in visual clarity or increase in odour
Surface films	n/a	O	None observed
Total Petroleum Hydrocarbons (TPH) as oil and grease	mg/L	SFLA	No visible sheen or emulsion, no odour
TPH/Total Recoverable Hydrocarbons (TRH)	µg/L	SFLA	Greater than reporting limit
Total suspended solids (TSS)	mg/L	SFLA	10
Free chlorine	mg/L	SFLA	0.2
Ammonia	µg N/L	SFLA	20
Total nitrogen (TN)	µg N/L	SFLA	300
Total phosphorus (TP)	µg P/L	SFLA	30
Filtered reactive phosphorus (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	<0.1
Nickel	µg/L	SFLA	7
Silver	µg/L	SFLA	1.4

Parameter	Unit	Sampling method*	Trigger value†
Zinc	µg/L	SFLA	15
Enterococci	cfu/100mL	SFLA	50

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

† Not compliance limits. Exceedance of Trigger Values requires review and assessment of cause at the time results are received as per ANZECC & ARMCANZ recommendations. A trigger for investigation occurs when the median value of the three receiving environment sites from water samples collected in the same day exceeds the trigger value and the exceedance is also not present at the upstream reference site determined form the tidal phase of sampling on the same day.

2.2.2 Results and discussion

Impact and reference site results for the four surveys undertaken in the reporting period are summarised in Table 2-6 (see APPENDIX D: for all results). Where exceedances were detected these are indicated in bold.

Exceedances of trigger values (defined in EPL 228) are flagged in the respective survey Trigger Assessment Report and investigated by INPEX to determine if the exceedance is a result of Ichthys LNG.

Surface films/debris were reported at two impact sites (Jetty 01 and Jetty 03) and a reference site (Jetty East) during Survey 8 (reported in F280-AB-REP-60030 and F280-AB-REP-60020; Figure 2-3). The presence of surface films at the impact sites resulted in a trigger exceedance. The investigation identified the source of this surface film was likely due to the presence of an LNG tanker de-ballasting clean water during loading, and not attributed to liquid discharges from the jetty outfall.

Exceedances were noted at all three impact sites during Survey 9 for Dissolved Oxygen. As reference sites Jetty East and Jetty West also exceeded the trigger value, the exceedance was determined not to be a true exceedance / related to liquid discharges from the jetty outfall.

During Survey 10 an exceedance occurred for turbidity whereby a reference site value (Jetty East; 1.6 NTU) was lower than the median value of the impact sites (1.9 NTU). However, the individual impact site values did not exceed the values for NTU at the upstream reference site (2.1 NTU). No further investigation was subsequently undertaken and this was not considered to be a true exceedance of turbidity.

Generally, results for all parameters in all four surveys show little variability between impact and reference sites, indicating the discharged commingled treated effluent had no discernible influence on samples collected at these locations. As such, discharges have not adversely affected the declared beneficial uses or water quality objectives for Darwin Harbour.

Table 2-6: Median impact (Imp) and reference (Ref) site sample results for jetty outfall surveys 8, 9, 10 and 11

Parameter	Unit	Survey 8		Survey 9		Survey 10		Survey 11	
		Imp	Ref	Imp	Ref	Imp	Ref	Imp	Ref
pH	pH units	7.83	7.905	8.04	8	7.99	8.00	7.1	7.86
EC	µS/cm	54.59	54.33	54.39	54.44	55.13	55.39	52.74	52.83
Temp	°C	25.57	25.6	31.18	31.23	30.63	30.65	30.28	30.23
Turbidity	NTU	-	1.0	0.9	1.05	1.9	1.85	1.1	1.8
DO	%	97.5	96.9	**114**	**116**	96.9	95.8	99	99
Free chlorine	mg/L	0.04 (0.02)	0.025 (<0.02)	0.01 (<0.02)	0.02 (<0.02)	<0.02	<0.02	<0.02	<0.02
Visual clarity and colour	n/a	No change	No change	No change	No change	No change	No change	No change	No change
Surface films	n/a	**Yes**	**Yes**	No	No	No	No	No	No
Silver	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Copper	µg/L	0.4	0.35	0.5	0.5	0.7	0.55	0.4	0.35

Parameter	**Unit**	**Survey 8**		**Survey 9**		**Survey 10**		**Survey 11**	
		Imp	**Ref**	**Imp**	**Ref**	**Imp**	**Ref**	**Imp**	**Ref**
Mercury	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nickel	µg/L	<0.4	<0.3	0.4	0.4	<0.3	<0.3	<0.3	<0.3
Lead	µg/L	<0.1	<0.1	<0.1	0.25	<0.1	<0.1	<0.1	<0.1
Zinc	µg/L	2	1	1	2	2	1	2	<1
Ammonia	µg N/L	<3	<3	<3	<3	7	6.5	<3	<3.5
FRP	µg P/L	7	6.5	4	3.5	6	5.5	4	4
Total phosphorus	µg P/L	17	22	16	15	18	17.5	16	15.5
Total nitrogen	µg N/L	110	150	120	120	140	130	130	120
TSS	mg/L	<1	3	1	<1	3	2.5	2	3.5
TPH as Oil and grease	n/a	None	None	None	None	None	None	None	None
	mg/L	<5	<5	<5	<5	<5	<5	<5	<5
TPH (C6 – C36)	µg/L	<50	<50	<50	<50	<50	<50	<50	<50
Enterococci	MPN/100mL	<10	<10	<10	<10	<10	<10	<10	<10

Note: values in bold represent an exceedance of reference site and trigger value. Values in brackets have been analysed by INPEX at the Ichthys LNG on-site laboratory.

Figure 2-3: Surface slick observed during Survey 8 (July 2020)

2.2.3 Trigger assessment outcomes

There were no trigger exceedances for metals, nutrients, TSS, hydrocarbons or enterococci during the reporting period. Physio-chemical parameter trigger exceedances were found not to be attributable to liquid discharges from the jetty outfall, as discussed in Section 2.2.2.

2.2.4 Program rationalisation

No program rationalisation is proposed. In accordance with EPL228[2], jetty outfall surveys were only required for the first 24 months following completion of start-up of Train 2 (this occurred 19 June 2019). Subsequently no further monitoring will be undertaken post this AEMR.

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 Ichthys LNG wastewater discharges, in surficial sediments surrounding the jetty outfall. The key objective is to determine if changes are attributable to Ichthys LNG operations.

As per the OEMP (L060-AH-PLN-60005), harbour sediment quality is required to be monitored annually for the first 36 months of operations (i.e. EPL288 activation) with longer term requirements assessed based on a review of these results. One survey (Survey No. 3) was undertaken within the reporting period, between 18 and 19 May 2021.

[2] Refer to EPL228, Appendix 2, footnote 7.

2.3.1 Method overview

The harbour sediment quality survey was performed in accordance with the approved Harbour Sediment Quality Monitoring Plan (L290-AH-PLN-70003). Surficial sediment samples were collected using a grab sampler from 16 potential impact sites radiating away from the jetty outfall and two control sites in East Arm (Figure 2-4). 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 2-7. 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 sediment quality guideline value (SQGV; also referred to guideline value) as per ANZG (2018) 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 are normalised for aluminium concentrations based on the methods described in Munksgaard (2013) and Munksgaard et al. (2013)[3] and compared to background levels (i.e. baseline or reference levels).

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

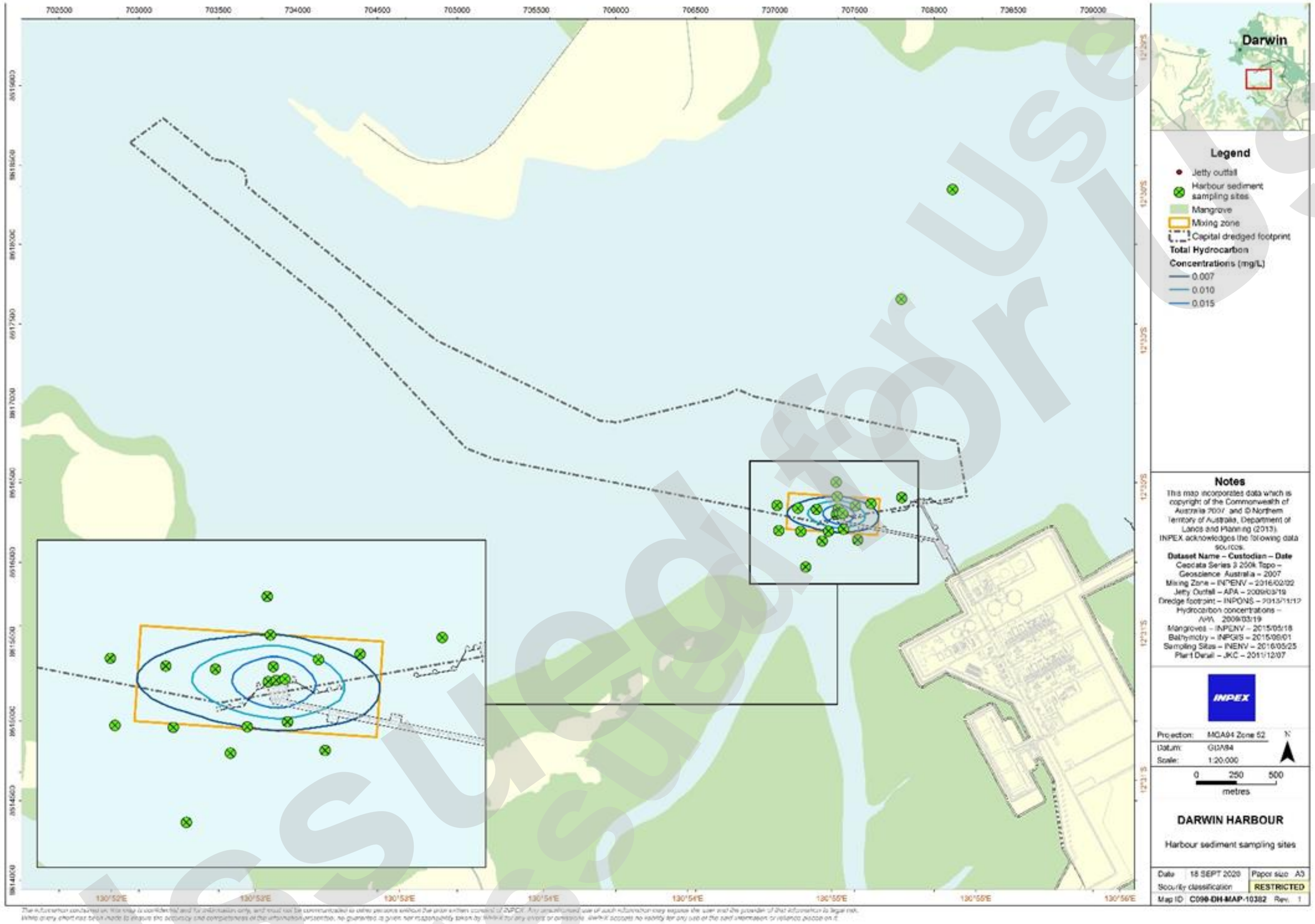


Figure 2-4: Harbour sediment quality sampling locations

Table 2-7: Harbour sediment quality monitoring parameters, trigger and background values

Parameter	Unit	Trigger value*	Background value†
Total organic carbon (TOC)	%	n/a	n/a
TPH / TRH	mg/kg	280	n/a
Benzene, toluene, ethylbenzene and xylene (BTEX)	mg/kg	n/a	n/a
Aluminium	mg/kg	n/a	n/a
Antimony	mg/kg	2	n/a
Arsenic	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

* ANZG (2018) sediment quality guideline value.

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

2.3.2 Results and discussion

Quality assurance quality control

There were no deviations from the monitoring plan for the 2021 harbour sediment monitoring survey. The field samples reached the laboratory within their holding times and were analysed within the required timeframes.

Quality assurance and quality control (QAQC) data for harbour sediment monitoring are presented in Table 2-8. The results of analyses on the triplicate samples were assessed by calculating the Relative Standard Deviations (RSDs) between the results that were above the laboratory LOR. All RSDs were below the performance criteria of 50% showing there was little variation for testing within the laboratory.

The results of analyses on the split sample was assessed by calculating the Relative Percentage Differences (RPDs) between the results that were above the laboratory LOR. A number of RPDs were above the performance criteria of 35%. This was considered to be a reflection of the differences in LORs and low detection levels. However, the results of all laboratories were well below the guideline values and therefore, the variations between laboratories was not considered to be significant.

One transport blank and one field blank were collected as part of the survey. Aluminium, chromium and iron were detected in both samples at similar concentrations. As such it was concluded that the metals were already in the acid washed sand blank and not contributed to by contamination from the sampling process.

Table 2-8: Harbour sediment quality QAQC results (mg/kg)

Site	Al	As	Cd	Cr	Cu	Fe	Ni	Pb	Sb	Zn	Hg	TOC	TPH	BTEX
I2a	15000	14	0.1	32	8.3	26000	10	11	<2	28	0.01	1.34	34	<0.2
I2b	14000	15	0.2	34	8.8	27000	11	12	<2	30	0.01	1.25	25	<0.2
I2c	1400	14	0.1	33	8.6	25000	11	12	<2	29	0.02	-	-	-
RPD A/B	6.9	6.9	**66.7**	6.1	5.8	3.8	9.5	8.7	n/a	6.9	n/a	6.9	30.5	n/a
RPD B/C	n/a	6.9	**66.7**	3.0	2.3	7.7	n/a	n/a	n/a	3.4	**66.7**	n/a	n/a	n/a
RPD A/C	6.9	n/a	n/a	3.1	3.6	3.9	9.5	8.7	n/a	3.5	**66.7**	n/a	n/a	n/a
I5_1	15000	15	<0.1	31	9.4	25000	10	11	<2	30	0.01	1.02	45	<0.2
I5_2	14000	15	0.2	30	8.4	24000	10	10	<2	27	0.01	1	18	<0.2
I5_3	14000	14	0.1	30	8.5	24000	11	10	<2	27	0.01	0.93	24	<0.2
RSD	4.0	3.9	47.1	1.9	6.3	2.4	5.6	5.6	n/a	6.2	0.0	4.8	48.9	n/a
I10_1	15000	15	0.2	32	8.3	26000	11	10	<2	28	0.01	1.04	8	<0.2
I10_2	16000	17	<0.1	34	8.4	27000	11	11	<2	29	0.01	1.23	49	<0.2
I10_3	17000	17	<0.1	35	8.8	26000	12	12	<2	30	0.01	1.23	62	<0.2
RSD	6.3	7.1	57.7	4.5	3.1	2.2	5.1	9.1	n/a	3.4	0.0	9.4	71.1	n/a

Site	Al	As	Cd	Cr	Cu	Fe	Ni	Pb	Sb	Zn	Hg	TOC	TPH	BTEX
Transport Blank	**660**	<2	<0.1	**1.6**	<0.2	**130**	<0.7	2	<2	<0.5	<0.01	<0.02	<3	<0.2
Field Blank	**650**	<2	<0.1	**1.6**	<0.2	**120**	<0.7	1	<2	<0.5	<0.01	<0.02	<3	<0.2

Monitoring sites

Metal and metalloid results for harbour sediment quality are presented in Table 2-9. One minor arsenic trigger exceedance was recorded at impact site I14. 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). Arsenic is not used or produced at Ichthys LNG, therefore there is no impact pathway for arsenic exceedances as part of Ichthys LNG operations. In addition, trigger exceedances for arsenic have historically occurred at both impact and control sites and are not considered cause for concern. As such, no further investigation has been undertaken. Therefore, the Arsenic trigger exceedance is not considered attributable to Ichthys LNG Operations.

All impact and control locations were below the laboratory LOR for Benzene, Toluene, Ethylbenzene and Xylene (BTEX) (Table 2-10). Most sampling locations had at least one result above the LOR for TPH within the petroleum hydrocarbon fraction range of C15 – C36 (excluded I11, I16 and C1). However, none of the results exceeded the guideline value of (280 mg/kg). The presence of TPH in the majority of 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 mangrove sediment samples analysed during the construction and operational phases returning positive results for TPH. Samples were reanalysed following silica gel clean-up, with the majority of samples subsequently returning a result below LOR, indicating the presence of non-petrogenic hydrocarbons.

Table 2-9: Harbour sediment quality survey metal and metalloid results (mg/kg)

Site*	Aluminium	Antimony	Arsenic +	Cadmium	Chromium	Copper	Lead	Nickel	Zinc	Mercury
Guideline values	n/a	2	20	1.5	80	65	50	21	200	0.15
Background level	n/a	n/a	16.0	0.071	17.5	4.7	8.8	8.7	21.4	n/a
I1	15000	<2	14	0.2	30	8.3	10	10	26	0.01
I2-a	15000	<2	14	0.1	32	8.3	11	10	28	0.01
I2-b	14000	<2	15	0.2	34	8.8	12	11	30	0.01
I2-c	14000	<2	14	0.1	33	8.6	12	11	29	0.02
I3	9580	-	10.6	-	25.8	5.6	8.2	7.8	23.4	0.0
I4	13000	<2	12	<0.1	29	8	9	10	26	0.01
I5-1	15000	<2	15	<0.1	31	9.4	11	10	30	0.01
I5-2	14000	<2	15	0.2	30	8.4	10	10	27	0.01

Site*	Aluminium	Antimony	Arsenic †	Cadmium	Chromium	Copper	Lead	Nickel	Zinc	Mercury
I5-3	14000	<2	14	0.1	30	8.5	10	11	27	0.01
I6	18000	<2	14	0.1	34	8.9	11	12	30	0.01
I7	17000	<2	13	0.2	35	11	11	13	32	0.01
I8	15000	<2	14	0.2	33	9.4	11	12	30	0.01
I9	13000	<2	14	0.1	30	8	11	10	26	0.01
I10-1	15000	<2	15	0.2	32	8.3	10	11	28	0.01
I10-2	16000	<2	17	<0.1	34	8.4	11	11	29	0.01
I10-3	17000	<2	17	<0.1	35	8.8	12	12	30	0.01
I11	15000	<2	16	<0.1	32	8.5	11	11	28	0.01
I12	16000	<2	16	0.1	34	8.5	11	11	29	0.01
I13	16000	<2	17	<0.1	34	8.4	11	11	29	0.01
I14	13000	<2	**27**	0.1	59	7	12	8.8	22	0.01
I15	14000	<2	16	<0.1	30	7.6	10	11	26	0.01
I16	3300	<2	17	<0.1	10	1.9	4	2.9	7.3	<0.01
C1	5600	<2	19	<0.1	19	4	6	4.8	12	<0.01
C2	13000	<2	17	<0.1	30	7.8	10	9.2	27	<0.01

* C = Control Site, I = Impact site.

† Bold values indicate trigger exceedance and results in brackets have been normalised for aluminium concentrations as per Munksgaard (2013)[3]

Table 2-10: Harbour sediment quality survey organic results

Site*	TOC (%)	TPH (mg/kg)	BTEX (mg/kg)
Guideline values	n/a	280	n/a
Background level	n/a	n/a	n/a
I1	1.3	58	<0.2

Site*	TOC (%)	TPH (mg/kg)	BTEX (mg/kg)
I2-a	1.34	38	<0.2
I2-b	1.25	30	<0.2
I2-c	1.5	<250	<0.2
I3	0.9	18	<0.2
I4	0.76	10	<0.2
I5-1	1.02	48	<0.2
I5-2	1	22	<0.2
I5-3	0.93	28	<0.2
I6	1.09	23	<0.2
I7	1.06	16	<0.2
I8	0.89	15	<0.2
I9	0.97	10	<0.2
I10-1	1.04	11	<0.2
I10-2	1.23	51	<0.2
I10-3	1.23	64	<0.2
I11	0.93	<3	<0.2
I12	1.07	29	<0.2
I13	1.4	80	<0.2
I14	0.6	5	<0.2
I15	1.33	17	<0.2
I16	0.33	<3	<0.2
C1	0.92	<3	<0.2
C2	0.95	6	<0.2

* C = Control Site, I = Impact site

2.3.3 Trigger assessment outcomes

There was one exceedance for the reporting period at an impact site (I14), arsenic at 27 mg/kg. 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). Additionally, arsenic is not considered to be a contaminant of concern from the Jetty Outfall. No further investigation was undertaken.

2.3.4 Program rationalisation

As per the OEMP, once monitoring has been undertaken annually for the first 36 months, the results will be reviewed, and program frequency reassessed. Given there has been no trigger exceedance in harbour sediment monitoring attributable to Ichthys LNG operations in three years of monitoring, with no planned changes to discharges, it is proposed that the monitoring frequency for harbour sediments is reduced to biennial (every two years).

3 EMISSIONS TO AIR

This section includes the outcomes of the following monitoring programs:

- Ambient air quality and air toxics (Section 3.2)
- Point source emissions (Section 3.3)
- Dark smoke events (Section 3.5)

This section also summarises the operating condition of each emission source and the resulting air emission quality (Section 3.4), and provides a summary of total emissions to air in tonnes per year for the main parameters outlined in EPL228 (Section 3.1).

3.1 Total emissions to air

INPEX is required to provide total emissions to air (tonnes/year) for air quality parameters (Condition 87.5 of EPL228 listed in Table 6, Appendix 3 of EPL228). Estimated total emissions to air for the reporting period are provided in Table 3-1, which are based on INPEX's Commonwealth emission reporting requirements for National Pollutant Inventory (NPI) and National Greenhouse and Energy Reporting Scheme (NGERS).

Table 3-1: Estimated total emissions to air for reporting period

Parameter	Emission (t/yr)
NOx as nitrogen dioxide (NO_2)	1969
Nitrous oxide (N_2O)	4.9
Mercury (Hg)	0.00001
Particle matter 2.5 ($PM_{2.5}$)	103
Particle matter 10 (PM_{10})	103
Carbon monoxide (CO)	3838
Benzene	11
Toluene	8
Ethylbenzene	1
Xylenes	3
Hydrogen sulphide (H_2S)	93

3.2 Ambient air quality and air toxics

The key objective of the ambient air quality and air toxics monitoring program is to ensure compliance with EPL228 Condition 55 which requires:

The licensee must undertake ground level measurements for pollutants specified in National Environment Protection (Ambient Air Quality) Measure and monitoring investigation levels for air toxicants specified in National Environment Protection (Air Toxics) Measure, during the first 24 months of commencement of operations, when both LNG trains and the CCPP are operating at steady state.

In accordance with EPL228 Condition 55, ambient air quality and air toxics monitoring was implemented when the LNG trains and the CCPP (in combined cycle) reached steady-state, which occurred 21 October 2019.

Table 3-2 provides a summary of the ambient air quality and air toxics monitoring surveys completed during the reporting period. Following the completion of the first year of monitoring, the air toxics sampling frequency reduced down from monthly to quarterly.

Table 3-2: Ambient air quality and ambient air toxics survey dates

Date	Report
July 2020	ATM-Monthly-Report-Jul 2020
August 2020	ATM-Monthly-Report-Aug 2020
September 2020	ATM-Monthly-Report-Sep 2020
October 2020	ATM-Monthly-Report-Oct 2020
January 2021	ATM-Quarterly-Report-Jan 2021
April 2021	ATM-Quarterly-Report-Apr 2021

3.2.1 Method overview

Ambient air quality monitoring

As a means of assessing the potential impact of Ichthys LNG air emissions on the broader environment, INPEX reviewed the ambient air monitoring data collected from the NT Government's ambient air quality network. This was conducted weekly and reported on a monthly/quarterly basis, with an annual review after the first 12 months and a final review post 24 months during steady-state operations.

INPEX reviews data from the NT EPA ambient air quality network and reports on the following ambient air parameters: nitrogen dioxide (NO_2), sulphur dioxide (SO_2), particulate matter with aerodynamic diameter less than 10 µm (PM_{10}) and particulate matter with aerodynamic diameter less than 2.5 µm ($PM_{2.5}$). Data is then compared against the standards for pollutants specified in the National Environment Protection (Ambient Air Quality) Measure (Air NEPM), refer to Table 3-3 for the review criteria.

The NT EPA ambient air quality network consists of three air quality monitoring stations (AQMS) (Winnellie, Francis Bay, Stokes Hill site (decommissioned in April 2021), and Palmerston), which have instrumentation set up in accordance with the Air NEPM (NTEPA 2015). The location of the NT EPA ambient air quality monitoring stations is presented in Figure 3-1.

Each station monitors the following parameters:

- PM_{10} and $PM_{2.5}$
- CO

- Nitrogen monoxide (NO) and NO_2
- Ozone (O_3)
- SO_2.

In addition to the air quality data, meteorological data is also collected, including wind direction and speed, rainfall, temperature, humidity and solar radiation levels. The meteorological data is collected directly from instruments housed in the Palmerston, Stokes Hill (now decommissioned) and Francis Bay stations. The Winnellie station sources meteorological data from the Bureau of Meteorology instruments located at the same site.

Table 3-3: Data review criteria – Ambient air quality parameters

Parameter	Averaging period	Existing background*	Review criteria† (Air NEMP)	Units
NO_2	1 hour	0.0038	0.12 (1 day/yr allowable exceedance)	ppm
	Annual	0.0031	0.03	
SO_2	1 hour	0.0005	0.2 (1 day/yr allowable exceedance)	
	24 hour	0.0005	0.08 (1 day/yr allowable exceedance)	
	Annual	0.0004	0.02	
PM_{10}	24 hour	24	50	µg/m³
	Annual	20	25	
$PM_{2.5}$	24 hour	10	25	
	Annual	7	8	

* Existing background nominated as 70th percentile of 2017 AQMS monitoring data (maximum station).

† Weekly review to be limited to short-term (1 hour and 24 hour) criteria. Performance against annual average statistics to be reviewed on an annual basis.

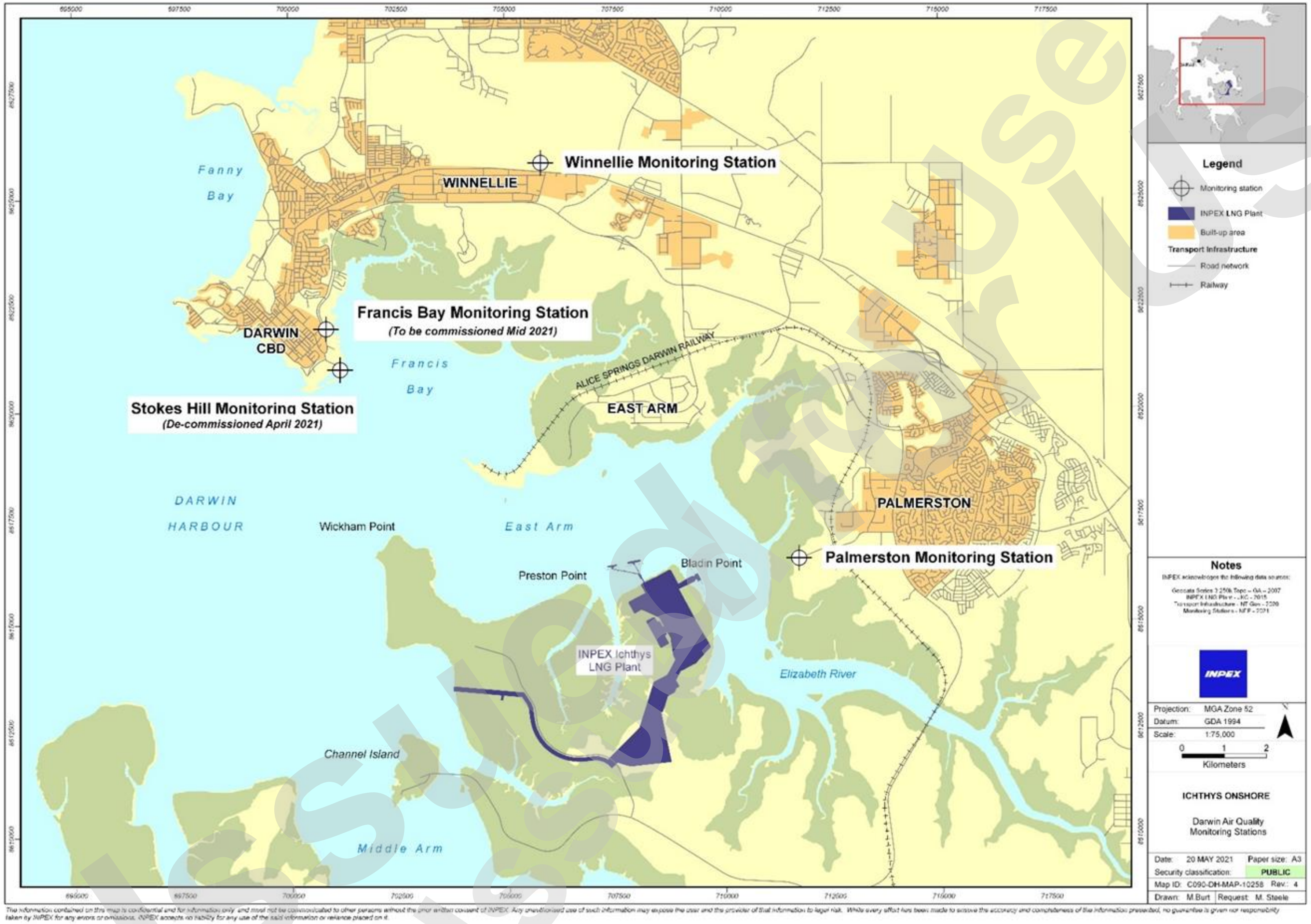


Figure 3-1: NT EPA Ambient air quality monitoring station locations

Air Toxics Monitoring

INPEX commenced air toxics ground level monitoring in October 2019. The program is required for the first 24 months following the commencement of steady state operations (when both LNG trains and the CCPP are operating at steady-state). The program comprises of monthly monitoring for the first year, after which the frequency reduces to quarterly for the second year.

The receptor locations, when considered in conjunction with prevailing winds and peak dispersion modelling predictions, indicate that the NT EPA ambient air quality networks monitoring stations are appropriately located within the Darwin Airshed, in order to be used for the assessment of air toxics from Ichthys LNG.

Accordingly, the three NT EPA ambient air quality network monitoring stations are currently used for the air toxics monitoring program. The locations of the NT EPA ambient air quality monitoring stations are presented in Figure 3-1.

Supplementary to the NT EPA ambient air quality monitoring program, INPEX undertakes periodic air toxics monitoring using evacuated canisters for sample capture (24 hour regulator), with subsequent analysis for Benzene, Toluene and Xylene (BTX) using gas chromatography - mass spectrometry techniques. Consistent with the Air Toxics NEPM monitoring framework, this monitoring is conducted using the United States Environmental Protection Authority (USEPA) TO-15 analytical methodology (USEPA 1995) using a NATA accredited laboratory. The frequency of monitoring is monthly for the first 12 months and reduces to quarterly for the subsequent year, data is then compared against the standards for pollutants specified in the National Environment Protection (Air Toxics) Measure (Air Toxics NEPM), for the Winnellie, Stokes Hill/Frances Bay and Palmerston AQMS.

The review criteria for the monitoring program, as per Air Toxics NEPM monitoring framework, are provided in Table 3-4.

Consideration is also given to potential interference from air toxics sources in the immediate vicinity of each AQMS location. The influence of such emissions may impair the ability to evaluate the potential contribution of Ichthys LNG to ambient air toxics concentrations, and also render monitoring results unrepresentative of air quality within the broader vicinity of the monitoring location. Accordingly, in cases where localised interference sources are present, locations within 1 km of the AQMS location may be used, so that interference is minimised.

Table 3-4: Data review criteria – Air toxics parameters

Parameter	Averaging Period	Review Criteria (Air Toxics NEPM)*	Units
Benzene	Annual	0.03	ppm
Toluene	24 hour	1	
	Annual	0.1	
Xylenes	24 hour	0.25	
	Annual	0.2	

* Air toxics review criteria excludes allowance for background. Upon review, potential project increment (above background) is to be addressed through consideration of spatial variability of sample results.

Review process

An investigation is triggered where results are found to be above the review criteria and cannot be attributed to a regional event. If an investigation is required (i.e. review criteria being met), then the relevant AQMS meteorological data is analysed to determine the most likely source contributing to the exceedance. The process of this review is outlined below in Figure 3-2.

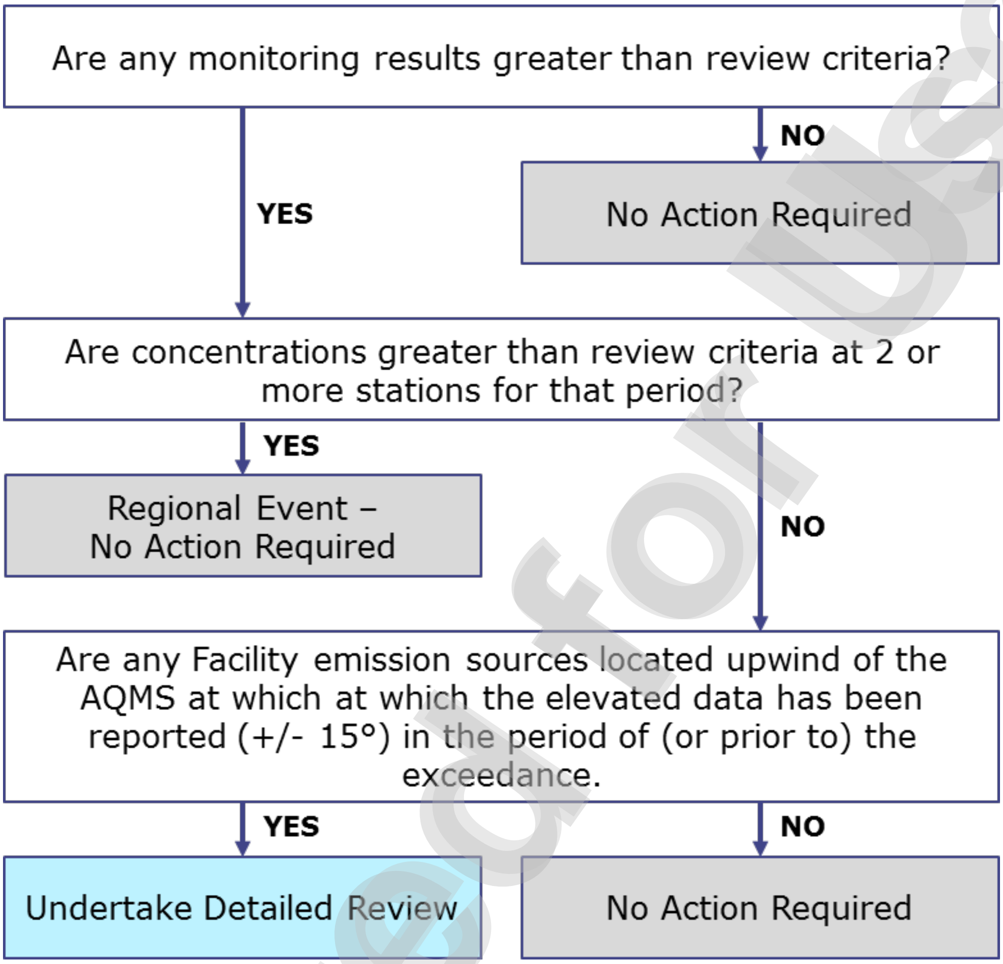


Figure 3-2: Data review process for short-term ambient air quality parameters

3.2.2 Results and discussion

A summary table of results of both the ambient air quality and air toxics monitoring are provided in Table 3-5. Results highlighted in bold exceed the review criteria.

All results of the air toxics monitoring are below the relevant Air Toxics NEPM criteria, (Table 3-4), and generally the limit of reporting. This indicates that during times when the acid gas incinerators are offline for maintenance and venting of the off-gas is occurring, there is no reported impact on the Darwin regional air shed, and no further investigation into the presence of BTX has been conducted.

The majority of ambient air quality results collated from the AQMSs are below the review criteria for each parameter, with the exception of PM_{10} and $PM_{2.5}$.

The NT Department of Environment, Parks and Water Security (NT DEPWS) conduct regular controlled burns in the rural areas and national parks surrounding Darwin during the late wet and early dry season (April-November). Particulates generated from vegetation burning are the primary air pollutants in the Darwin region, and this results in the Darwin area experiencing a high number of days where PM_{10} and $PM_{2.5}$ are above the Air NEPM criteria in the dry season.

A review of the daily (24 hour) exceedances of PM_{10} and $PM_{2.5}$ at each station was conducted using the review process stipulated in Figure 3-2. Based on the outcome of the review process, exceedances of $PM_{2.5}$ and PM_{10} can be attributed to planned controlled burns or bushfires in the Darwin region and these exceedances did not occur downwind of Ichthys LNG (GHD, Ichthys LNG Air Quality Monitoring Air Toxics Monthly Report – July 2020 and GHD, Ichthys LNG Air Quality Monitoring Report – August 2019 to September 2020).

Based on the monitoring results for the reporting period, there were no adverse effects to the ambient air quality of the Darwin Region attributable to Ichthys LNG operations.

Table 3-5: Ambient air quality and air toxic results for the reporting period

Period	Sampling point	NO_2	SO_2		PM_{10}	$PM_{2.5}$	Benzene	Toluene	Xylenes
Monthly (Jul–Oct 20) Quarterly (Nov 20 – Apr 21)	Averaging Period	1 h	1 h	24 h	24 h	24 h	24 h	24 h	24 h
	Unit	ppm	ppm	ppm	$\mu g/m^3$	$\mu g/m^3$	-	ppm	ppm
	Review criteria	0.12	0.2	0.08	50	25	N/A	1	0.25
Jul-20	Palmerston	0.012	0.0027	0.0010	48	**35**	<0.0006	<0.0020	<0.0007
	Stokes Hill	0.019	0.0016	0.0008	38	25	<0.0006	<0.0020	<0.0007
	Winnellie	0.018	0.0012	0.0006	**60**	**36**	<0.0006	<0.0020	<0.0007
Aug-20	Palmerston	0.014	0.0020	0.0011	40	24	<0.0006	<0.0020	<0.0007
	Stokes Hill	0.021	0.0018	0.0007	37	22	<0.0006	<0.0020	<0.0007
	Winnellie	0.015	0.0021	0.0006	35	21	<0.0006	<0.0020	<0.0007
Sep-20	Palmerston	0.013	0.0016	0.0011	46	17	<0.0006	<0.0020	<0.0007
	Stokes Hill	0.010	0.0163	0.0002	29	13	<0.0006	<0.0020	<0.0007
	Winnellie	0.018	0.0084	0.0006	31	23	<0.0006	<0.0020	<0.0007

Period	**Sampling point**	**NO_2**	**SO_2**		**PM_{10}**	**$PM_{2.5}$**	**Benzene**	**Toluene**	**Xylenes**
Oct-20	Palmerston	0.013	0.0023	0.0009	37	13	0.0014	<0.0020	<0.0007
	Stokes Hill	0.014	0.0018	0.0008	30	13	<0.0006	<0.0020	<0.0007
	Winnellie	0.012	0.0010	0.0009	28	13	<0.0006	<0.0020	<0.0007
Jan-21	Palmerston	0.010	0.0035	0.0002	35	20	<0.0006	<0.0020	<0.007
	Stokes Hill	0.011	0.0095	0.0012	31	24	<0.0006	<0.0020	<0.007
	Winnellie	0.018	0.0009	0.0008	23	11	<0.0006	<0.0020	<0.007
Apr-21	Palmerston	0.008	0.0009	0.0007	19	12	<0.0009	<0.0020	<0.0009
	Stokes Hill / Frances Bay	0.013	0.0027	0.0018	19	5	<0.0009	<0.0020	<0.0009
	Winnellie	0.0160	0.0025	0.0019	18	14	<0.0009	<0.0020	<0.0009

3.2.3 Annual review of 2019/2020 ambient air and air toxics data

A summary of compliance, for the first annual review of ambient air and air toxics monitoring data, August 2019 to September 2020 is presented in Table 3-6. It is noted that a number of monthly data reports were assessed in accordance with the now superseded Ichthys LNG Project Environment Protection Licence 228-01 (EPL228-01). In summary, Ichthys LNG operations were not found to contribute significantly to elevated levels or exceedances of any pollutant for any month in the Darwin air shed during this period.

Table 3-6: Air monitoring compliance summary 2019-2020

Month	Compliance with Air Toxics NEPM	Compliance with Air NEPM
August 2019	All air toxics monitoring returned results below the limits of reporting.	Exceedances of the review criteria for particulates were recorded, but were not attributed to INPEX operations.
September 2019		
October 2019		
November 2019	Benzene was detected above the limit of reporting; however, was not in exceedance of the Air Toxics NEPM review criteria.	No exceedances of the review criteria were recorded for the period.
December 2020	All air toxics monitoring returned results below the limits of reporting.	Exceedances of review criteria for particulates were recorded, but were not attributed to INPEX operations.
January 2020		No exceedances of the review criteria were recorded for the period.
February 2020		
March 2020		
April 2020		
May 2020		Exceedances of the review criteria for particulates were recorded, but were not attributed to INPEX operations.
June 2020		
July 2020		
August 2020		No exceedances of the review criteria were recorded for the period.
September 2020		

Table 3-7 provides a summary of the results of data obtained from the NT EPA AQMS, as compared to the review criteria. Where a data cell is bold, this indicates that the site exceeded the relevant criteria value on at least one occasion for the annual ambient air and air toxics review period. Investigation in to these exceedances are shown below, in accordance with the review criteria as outlined in Figure 3-2.

Table 3-7: Ambient air results Aug 2019 - Sep 2020

Table parameter	Averaging period	Review criteria	Palmerston	Stokes Hill	Winnellie	Unit
NO_2	1-Hour	0.12	0.020	0.0021	0.022	ppm
	Annual*	0.03	0.0021	0.0020	0.0016	
SO_2	1-Hour	0.2	0.0029	0.028	0.0084	
	24-Hour	0.08	0.0011	0.0045	0.0011	
	Annual*	0.02	0.00051	0.00037	0.00025	
PM_{10}	24-Hour	50	**60**	**66**	**70**	µg/m³
	Annual*	25	22	21	22	
$PM_{2.5}$	24-Hour	25	**38**	**35**	**39**	
	Annual*	8	**9.0**	8.0	**8.2**	

*The annual average is calculated as the maximum 12-month average within the 14-month data set.

The annual $PM_{2.5}$ review criteria is exceeded at the Palmerston and Winnellie stations for the 14-month review period (refer Table 3-7. This exceedance is not unexpected due to frequently elevated $PM_{2.5}$ levels associated with regional vegetation burning during the dry season. Table 3-8 shows the average $PM_{2.5}$ concentration for dry season, wet season and annual period at each station. The values in the table demonstrate that average $PM_{2.5}$ concentrations during the dry season are significantly greater than during the wet season; therefore, that seasonal influences on regional air quality are likely to be the driver of exceedance of the annual criteria at the AQMS. Review of exceedances of the short-term (24-hour) $PM_{2.5}$ criteria found that Ichthys LNG operations were unlikely to have contributed significantly to exceedances of the criteria, this is further backed through the low PM_{10} and $PM_{2.5}$ concentrating directly measured from the stationary emission point sources at the facility (refer to Section 3.3 and APPENDIX E:). As such it is also unlikely that Ichthys LNG operations have contributed significantly to the exceedance of the annual average review criteria.

Table 3-8: Seasonal average $PM_{2.5}$ concentrations

Period	Average $PM_{2.5}$ concentration for period (µg/m³)		
	Palmerston	Stokes Hill	Winnellie
Wet (01 Nov 19 – 30 Apr 20)	5	4	4
Dry (01 May 20 – 31 Oct 20)	12	11	12
Annual	**9.1**	**8.1**	**8.3**

Table 3-9 provides a summary of the results from the air toxics monitoring program for the review period. For all but one sample (Benzene at Winnellie in November 2019), the sampled concentrations were below the limit of reporting (LoR) for all pollutants. As a conservative assumption, the values presented are based on the assumption that where the LoR is reported, the concentration for this period is equal to the relevant LoR. The results show that air toxics concentrations are significantly below the review criteria for the annual period.

Table 3-9: Air toxics results 2019-2020

Parameter	Averaging period	Review criteria (Air Toxic NEMP)	Sample pollutant concentration			Unit
			Palmerston	Stokes Hill	Winnellie	
Benzene	24-hour	N/A	0.0006	0.0006	0.0013	ppm†
	Annual	0.03	0.0006	0.0006	0.0007	
Toluene	24-hour	1	0.002	0.002	0.002	
	Annual*	0.1	0.002	0.002	0.002	
Xylene	24-hour	0.25	0.007	0.007	0.007	
	Annual*	0.2	0.002	0.002	0.002	

*The annual average is calculated as the maximum 12-month average within the 14-month data set.

† For the purposes of reporting against the NEPM standard, the laboratory data is converted from micrograms per cubic meter (µg/m³) to parts per million (ppm), this calculation assumes a standard temperature and pressure of 25°C and 1 atmosphere.

A review of the ambient air quality data from the NT EPA AQMS found a number of exceedances of the review criteria for PM_{10} (24-hour only) and $PM_{2.5}$ (24-hour and annual). The review process (as presented in Figure 3-2) was carried out and concluded the following:

- The majority of exceedances were associated with regional events during the dry season
- Where regional events were not considered to contribute to exceedances, the INPEX site was not found to be upwind of AQMS for any exceedance.
- Exceedance of the annual average $PM_{2.5}$ criteria is associated with regional influences during the dry season.

Consequently, Ichthys LNG operations are not considered to have significantly contributed to exceedances of the review criteria during the review period.

Air toxics sampling collocated with the NT EPA AQMS returned non-detect (below LoR) results for all but one sample for annual review period. An assessment of all sampling data for the review period found that there were no exceedances of the 24-hour or annual Air Toxics NEPM review criteria.

3.2.4 Program rationalisation

No changes are proposed to the program. In accordance with the EPL228, the program is due to cease in October 2021, following 24 months of the facility operating in a steady-state.

To date there have been no exceedances attributed to Ichthys LNG operations.

3.3 Point source emissions to air

The key objective of the point source emission monitoring (commonly referred to as stack sampling) is to ensure air emissions do not exceed the concentration limit criteria as specified in Table 5, Appendix 3 of EPL228. The frequency of monitoring is outlined in Condition 65 of EPL228, which requires quarterly emissions monitoring for the first 18 months after the completion of first start-up (six monitoring events), and then annually thereafter.

Point source emission monitoring commenced within two months of steady-state, following completion of first start-up of the first LNG (Condition 65 of EPL228). Steady-state operations for Train 1 and 2, occurred on 19 June 2019, and INPEX commenced monitoring from August 2019.

Quarterly monitoring was undertaken in the reporting period, with the exception of the delay of the Q2 2020 (which was completed in August 2020, just prior to the Q3 2020 survey), up until Q4 2020, when the 18 month requirement EPL228 condition of quarterly monitoring was completed

Due to the COVID-19 pandemic and the travel restriction imposed between States and Territories during this time, no stationary source emission monitoring was able to be conducted in Q2 2020. The NT EPA agreed to delay the Q2 2020 survey to no later than 31 August 2020 (prior to the Q3 2020 survey).

Table 3-10 provides a summary of the point source emission monitoring conducted for the reporting period.

Table 3-10: Point source emissions survey dates

Survey	Start date	End Date
Survey 4 – Q2 2020	August 2020	August 2020
Survey 5 – Q3 2020	September 2020	September 2020
Survey 6 – Q4 2020	December 2020	December 2020

3.3.1 Method overview

Stationary source emissions monitoring is undertaken at 13 point sources (with a total of 18 stacks) on the Frame 7 compression turbines, CCPP Frame 6 power generation turbines, CCPP utility boilers, acid gas removal unit (AGRU) Incinerators and heating medium furnaces.

For the CCPP Frame 6 turbines, each turbine has two stacks, one which allows for normal operation of the turbine (with exhaust emissions directed to a conventional stack) and a separate stack with an associated heat recovery steam generator (HRSG), allowing for steam to be generated through the duct burning of fuel. The two stacks cannot be operated together so stack monitoring is dependent on which stack is in use at the time of sampling.

Table 3-11 and Table 3-12 shows the EPL228 air emission target and limits and the constituents that are required to be monitored at the point source locations. Figure 3-3 shows the locations of the stationary source emissions monitoring locations at Ichthys LNG.

The following locations are inline gas sampling points (not ports) and as such are exempt from the standard methods for point source emissions sampling:

- 551-SC-003 (release point number A13-2),
- 552-SC-003 (release point number A14-2),
- 541-SC-001 (release point number A13-3) and
- 542-SC-001 (release point number A14-3)

INPEX conducts inhouse gas sampling and analysis from these locations for BTEX, hydrogen sulphide (H_2S) and mercury (Hg) using conventional industry methods which are not NATA accredited. The analysis of these gases are conducted using test methods that are managed under a NATA accredited Quality Management System.

Stationary source and gas samples are either collected by INPEX laboratory technicians and tested in the on-site NATA-accredited laboratory, or are collected by an external NATA-accredited contractor and analysed in the field or by external laboratories.

All stack sampling ports have been installed in accordance with AS4323.1-1995 stationary source emissions – selection of sampling ports.

All stack sampling, where applicable, is undertaken in accordance with:

- New South Wales (NSW) Department of Environment and Conservation Approved Methods for the Sampling and Analysis of Air Pollutants in NSW; or
- USEPA Method 30B for mercury emissions.

However, currently there are no approved NSW test methods for the sampling and analysis of nitrous oxide, nor any approved Australian Standard or USEPA methods.

For the sampling and analysis of nitrous oxide, INPEX and the stack emission monitoring Contractor have followed the procedures as listed in NSW Test Method 11, which cross references to USEPA Method 7E *Determination of Nitrogen Oxide Emission from Stationary Sources (Instrumental Analyser Procedure)*. This lists comprehensive quality control and calibration procedures that must be followed to ensure accurate and reliable results. The analysis of nitrous oxide is also managed under a NATA accredited Quality Management System.

Table 3-11: Contaminant release limits to air at authorised stationary emission release points

Release point number	Source	Pollutant	Concentration target		Concentration limit	
			mg/Nm^3	ppmv	mg/Nm^3	ppmv
A1, A2, A3, A4	LNG Refrigerant Compressor Driver Gas Turbines (GE Frame 7s)	NO_x as NO_2	50 @ 15% O_2 dry	25 @ 15% O_2 dry	70	35 @ 15% O_2 dry
A5-1, A6-1, A7-1, A8 1, A9-1	CCPP Gas Turbine Generators (GE Frame 6s, 38 MW)	NOx as NO_2	50 @ 15% O_2 dry	25 @ 15% O_2 dry	70	35 @ 15% O_2 dry
A5-2, A6-2, A7-2, A8 2, A9-2	CCPP Gas Turbine Generators (GE Frame 6s, 38 MW) also burning vaporised iso-pentane in duct burners	NO_x as NO_2	150 @ 15% O_2 dry	75 @ 15% O_2 dry	350	175 @ 15% O_2 dry
A13-1, A14-1	AGRU Incinerators	NO_x	320 @ 3% O_2 dry	160 @ 3% O_2 dry	350	175 @ 15% O_2 dry
A15, A16	Heating Medium Furnaces	NO_x	160 @ 3% O_2 dry	80 @ 3% O_2 dry	350	175 @ 3% O_2 dry

Table 3-12: Air emission monitoring program

Release Point Number	Sampling Location Number	Source	Monitoring Frequency	Parameter
A1	L-641-A-001	LNG Train 1 Refrigerant Compressor Driver Gas Turbine (GE Frame 7)	quarterly	NO_x as NO_2, N_2O, Hg, $PM_{2.5}$, PM_{10}, CO, temperature, efflux velocity, volumetric flow rate
A2	L-642-A-001	LNG Train 2 Refrigerant Compressor Driver Gas Turbine (GE Frame 7)		
A3	L-641-A-002	LNG Train 1 Refrigerant Compressor Driver Gas Turbine (GE Frame 7)		
A4	L-642-A-002	LNG Train 2 Refrigerant Compressor Driver Gas Turbine (GE Frame 7)		
A5-1	L-780-GT-001	CCPP Gas Turbine Generator #1 (GE Frame 6) – conventional stack	quarterly	NO_x as NO_2, N_2O, Hg, $PM_{2.5}$, PM_{10}, CO, temperature, efflux velocity, volumetric flow rate
A6-1	L-780-GT-002	CCPP Gas Turbine Generator #2 (GE Frame 6) – conventional stack		
A7-1	L-780-GT-003	CCPP Gas Turbine Generator #3 (GE Frame 6) – conventional stack		
A8-1	L-780-GT-004	CCPP Gas Turbine Generator #4 (GE Frame 6) – conventional stack		
A9-1	L-780-GT-005	CCPP Gas Turbine Generator #5 (GE Frame 6) – conventional stack		
A5-2	L-630-F-001	CCPP Gas Turbine Generator #1 (GE Frame 6) – HRSG stack		
A6-2	L-630-F-002	CCPP Gas Turbine Generator #2 (GE Frame 6) – HRSG stack		
A7-2	L-630-F-003	CCPP Gas Turbine Generator #3 (GE Frame 6) – HRSG stack		
A8-2	L-630-F-004	CCPP Gas Turbine Generator #4 (GE Frame 6) – HRSG stack		
A9-2	L-630-F-005	CCPP Gas Turbine Generator #5 (GE Frame 6) – HRSG stack	quarterly	NO_x as NO_2, N_2O, Hg, $PM_{2.5}$, PM_{10}, CO, temperature, efflux velocity, volumetric flow rate
A13-1	L-551-FT-031	AGRU Incinerator – LNG Train 1	quarterly	NO_x as NO_2, N_2O, Hg, $PM_{2.5}$, PM_{10}, CO, temperature, efflux velocity, volumetric flow rate
A13-2	551-SC-003	AGRU Hot Vent – LNG Train 1, prior to release at A3	quarterly and during incinerator by-pass*	BTEX, H_2S, volumetric flow rate
A13-3	541-SC-001	Feed gas to AGRU – LNG Train 1 – prior to release at A3	quarterly and during incinerator by-pass	Hg
A14-1	L-552-FT-031	AGRU Incinerator – LNG Train 2	quarterly	NO_x as NO_2, N_2O, Hg, $PM_{2.5}$, PM_{10}, CO, temperature, efflux velocity, volumetric flow rate
A14-2	552-SC-003	AGRU Hot Vent – LNG Train 2, prior to release at A4	quarterly and during incinerator by-pass 20	BTEX, H_2S, volumetric flow rate
A14-3	542-SC-001	Feed gas to AGRU – LNG Train 2 – prior to release at A4	quarterly and during incinerator by-pass	Hg

Release Point Number	Sampling Location Number	Source	Monitoring Frequency	Parameter
A15	L-640-A-001-A	Heating Medium Furnaces	quarterly	NO_x as NO_2, N_2O, Hg, $PM_{2.5}$, PM_{10}, CO, temperature, efflux velocity, volumetric flow rate
A16	L-640-A-001-B	Heating Medium Furnaces	quarterly	NO_x as NO_2, N_2O, Hg, $PM_{2.5}$, PM_{10}, CO, temperature, efflux velocity, volumetric flow rate
A17	L-700-F-002	Ground flare #5 warm	all flare events	mass of hydrocarbons flared
A18	L-700-F-001-A/B	Ground flare #2 cold		
A19	L-700-F-003	Ground flare #1 spare		
A20	L-700-F-005-A/B	Tank flare #1 LNG		
A21	L-700-F-006-A/B	Tank flare #2 LPG		
A22	L-700-F-007	Tank flare #3 LNG/LPG		
A23	L-700-F-004	Liquid flare		

* If AGRU off gas quality can be demonstrated to be predictable and does not vary greatly when the by-pass of the incinerator occurs, the NT EPA may approve quarterly sampling for first 18 months after commencement of Steady-State, then annual.

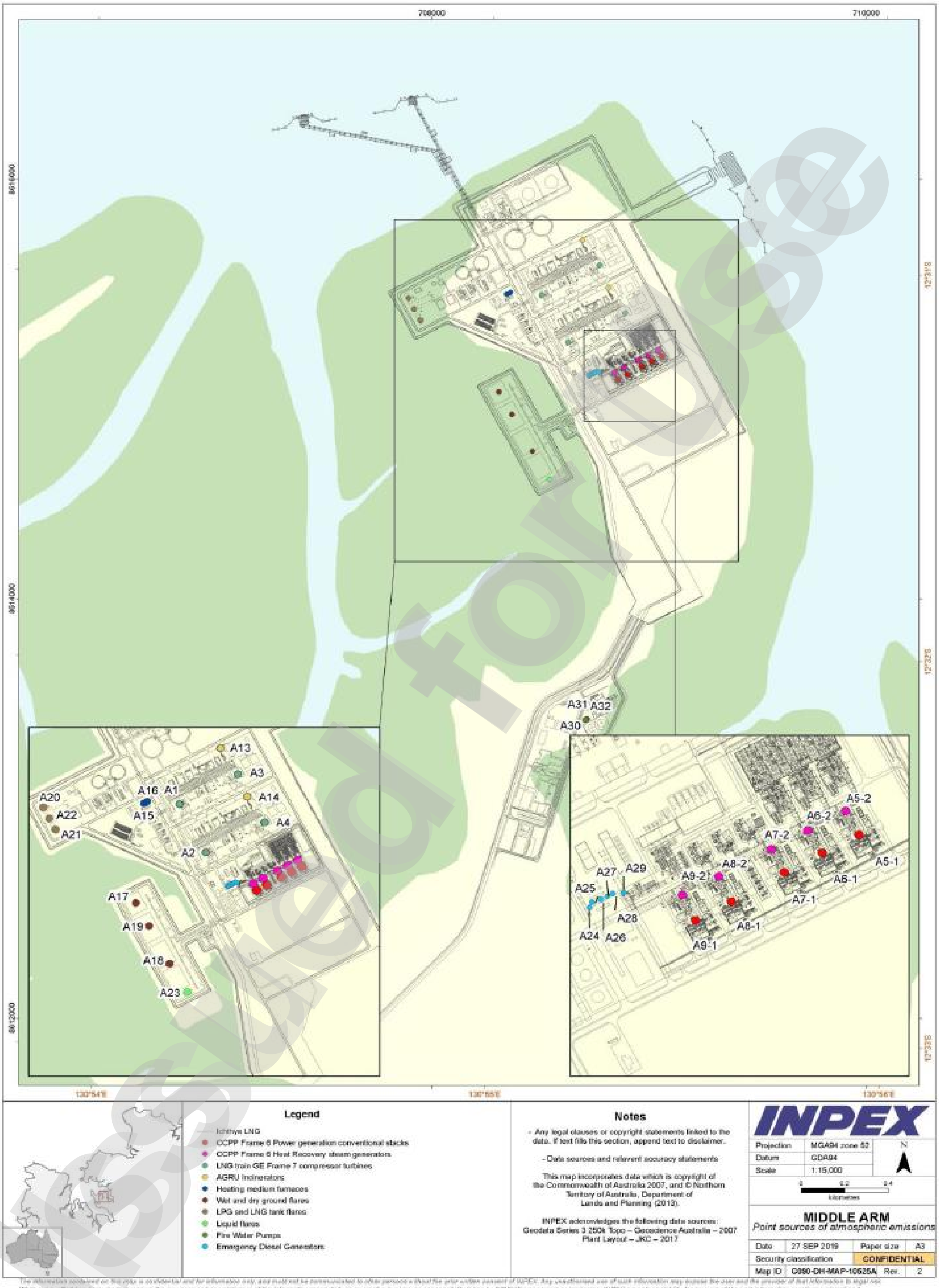


Figure 3-3: Location of authorised stationary emission release points

3.3.2 Results and discussion

All results for the permanent plant were below limit criteria provided in Appendix 3, Table 5 of EPL228.

The stationary source emission monitoring results are provided in APPENDIX E:.

Due to equipment being offline for planned maintenance and extended unplanned equipment fault outages, the following point sources were unable to be tested during various quarterly events:

- release point number A14-1, Train-2 Acid Gas Incinerator was out of service for an extended period of time due to an equipment fault and repair, during the Q2 2020, Q3 2020 and Q4 2020 surveys;
- release point number A61-1/A6-2, CCPP gas turbine generator 2, was offline during the Q4 2020 survey due to planned maintenance;
- release point number A8-1/A8-2, CCPP gas turbine generator 4, was offline during the Q3 2020 survey due to planned maintenance; and
- release point number A9-1/A9-2, CCPP gas turbine generator 5, was offline during the Q2 2020 survey due to planned maintenance.

The NT EPA were informed each time monitoring was unable to be conducted at the above locations. Noting that in normal operations for the CCPP only 4 of the 5 turbines will be online, with one generally on standby or offline.

No monitoring results exceeded concentration limit criteria. However, there were two exceedances reported above the target NO_x concentration for the heating medium furnaces release point A15 (L-640-A-001-A) and release point A16 (L-640-A-001-B). A15 (L-640-A-001-A) reported a NO_x concentration of 97 ppmv @ 3% O_2 dry, above the criteria of 80 ppmv @ 3% O_2 dry on 20 September 2020, and A16 (L-640-A-001-B) reported a NO_x concentration of 98 ppmv @ 3% O_2 dry, above the target concentration criteria of 80 ppmv @ 3% O_2 dry on 21 September 2020. At the time of sampling the heating medium furnaces were operating in a standby mode, with minimal fuel gas being combusted, due to the heating medium being heated through the waste heat recovery units located on the exhaust stacks located on the train's gas turbines. The furnaces are unable to be placed into operation while the heat transfer is occurring through the waste heat recovery units.

The mass of hydrocarbons flared for the reporting period for each flare source is presented in Table 3-13.

Figure 3-4 and Figure 3-5 show the vented acid gas flow rates in m^3/h for Train 1 and Train 2. During the time the acid gas incinerators were offline the acid gas was hot vented. Figure 3-6 and Figure 3-7 provided the flow rate of acid gas to the Train 1 and Train 2 acid gas incinerators, while the incinerator was in service. Note a major shutdown took place in May/June 2021 and the facility was offline during this period (no production occurring).

While the acid gas incinerators were offline and venting was occurring, gas sampling was undertaken in accordance with EPL228 requirements.

The Train 1 acid gas incinerator was generally online for the majority of the reporting period, and venting was mainly required during the restart of Train 1, following a trip or planned maintenance.

The Train 2 acid gas incinerator was offline for a majority of the reporting period due to faults (including with bellows, refractory lining and valves), which required parts and equipment to be manufactured and sent from overseas. Due to the COVID-19 pandemic there were delays in the procurement of parts internationally.

Table 3-13: Mass of hydrocarbons flared

Release Point number	Location Number	Source	Mass of hydrocarbons flared (tonnes)
A17 / A19	L-700-F-002 / L-700-F-003	Ground flare #5 warm/ Ground flare #1 spare	87,004
A18 / A19	L-700-F-001-A/B / L-700-F-003	Ground flare #2 cold / Ground flare #1 spare	71,039
A20	L-700-F-005-A/B	Tank flare #1 LNG	31
A21	L-700-F-006-A/B	Tank flare #2 LPG	8,139
A22	L-700-F-007	Tank flare #3 LNG/LPG	4,852
A23	L-700-F-004	Liquid flare	0

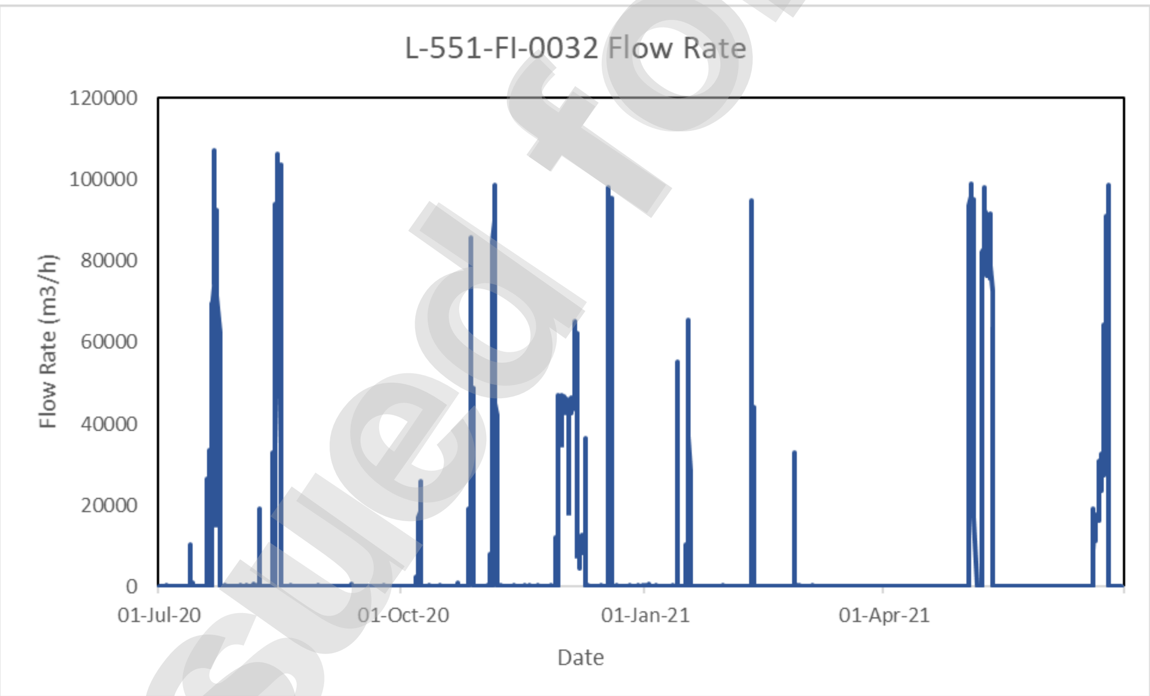


Figure 3-4: Train 1 acid gas venting flow rates

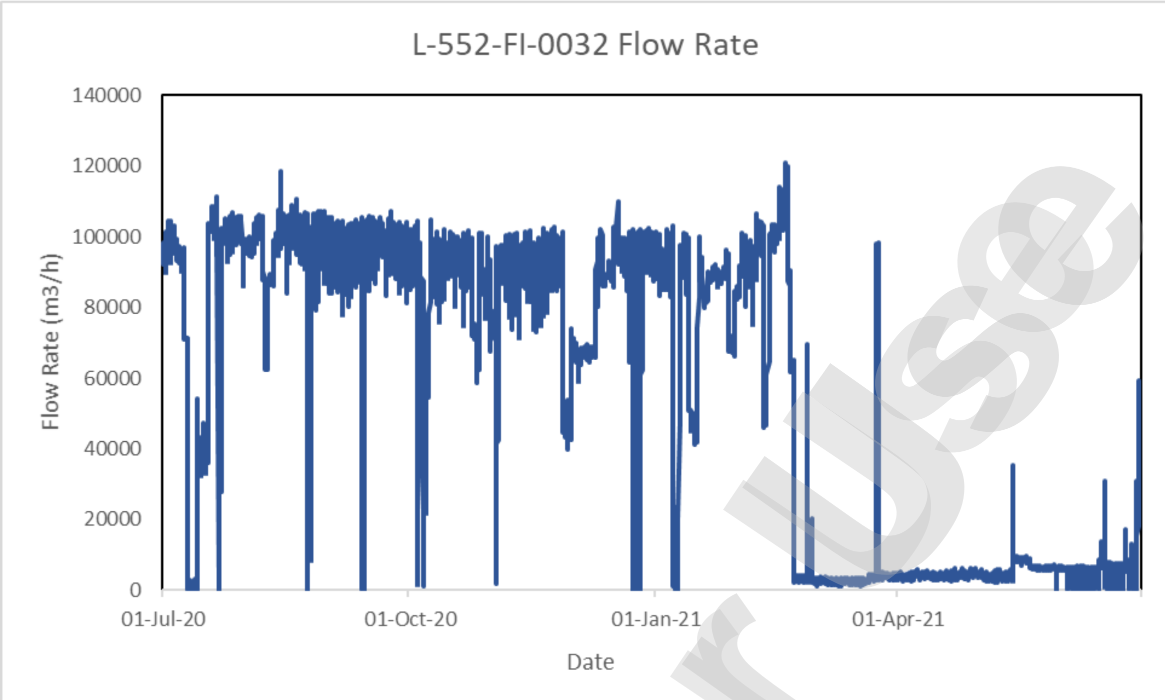


Figure 3-5: Train 2 acid gas venting flow rates

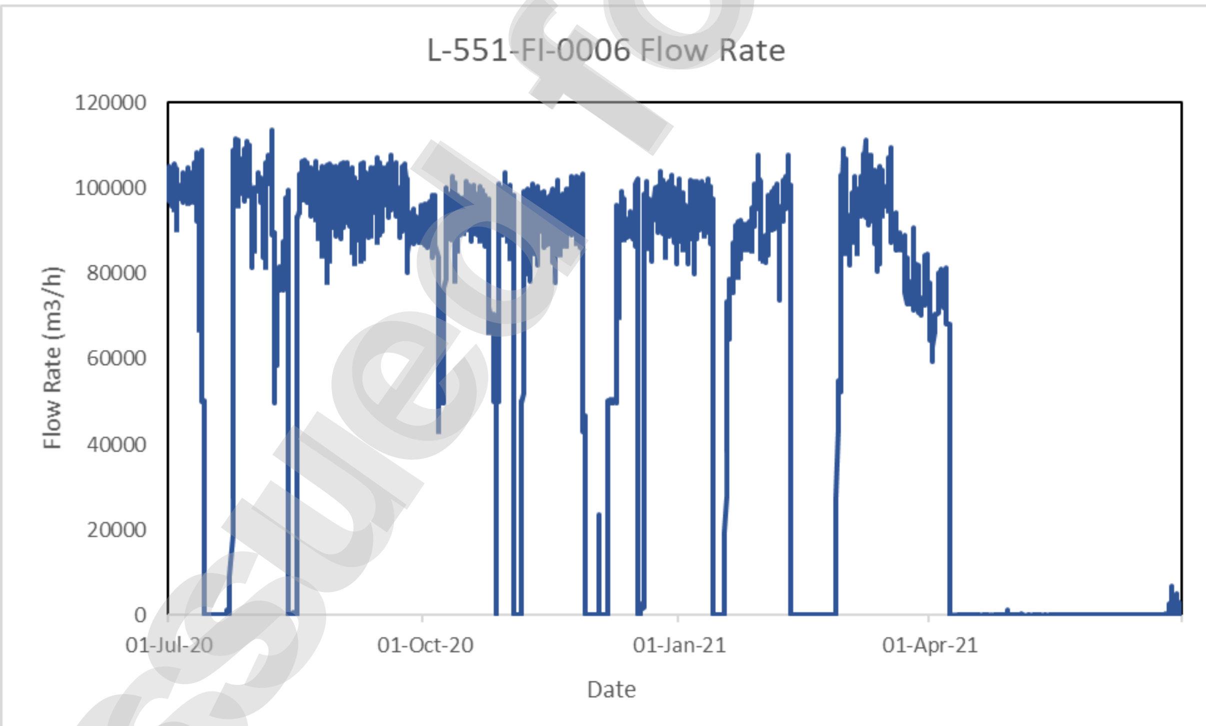


Figure 3-6: Train 1 acid gas incinerator flow rates

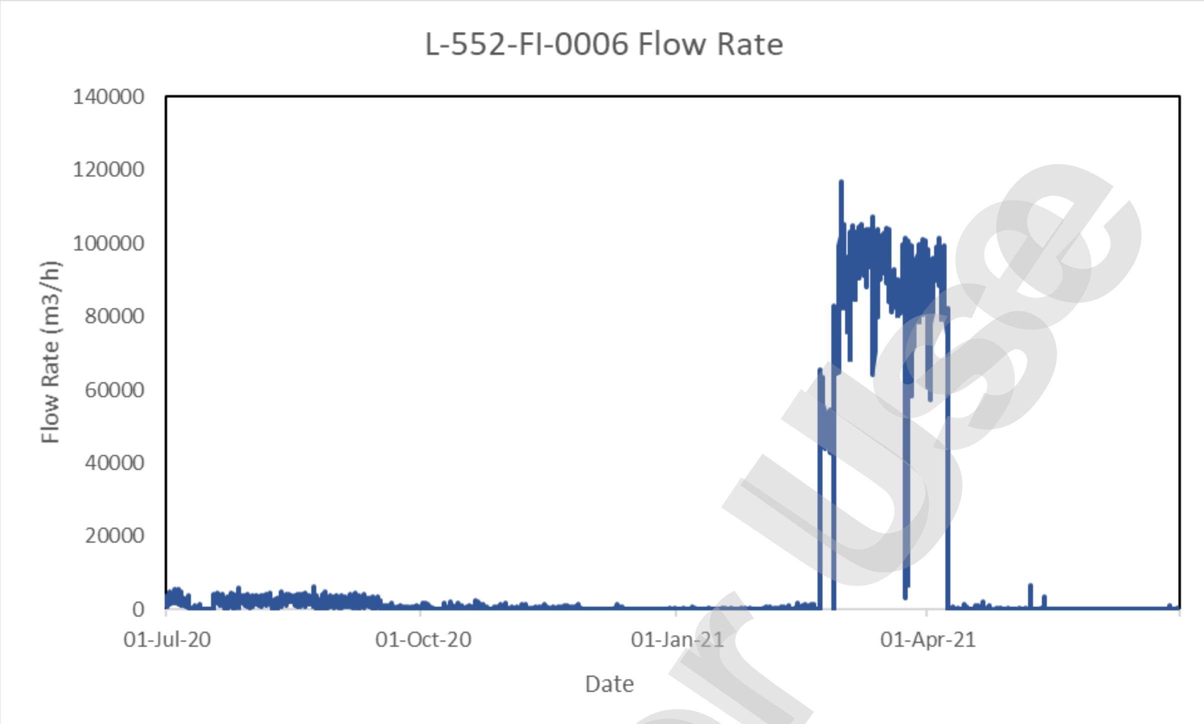


Figure 3-7: Train 2 acid gas incinerator flow rates

3.3.3 Program rationalisation

No rationalisation is currently proposed and monitoring will be conducted as per the EPL228 requirements. Note, as per EPL228, quarterly monitoring was conducted for the first 18 months, following steady state operations, the frequency has now reduced to annually in 2021, with the first annual survey to be conducted in Q3 2021.

3.4 Overall summary of performance of stationary emission sources

The status of the stationary point source emissions at Ichthys LNG is provided in Table 3-14 based on information presented in Sections 3.1, 3.2, and 3.3. As stated above the acid gas incinerator for LNG Train1 was online for the majority of the reporting period, while the incinerator for LNG Train 2 was offline for the majority of the reporting period, due to equipment faults and delays in the delivery of spare parts with impacts on shipping caused by the current COVID-19 pandemic. During the period that the acid gas incinerators were offline, sampling of the vented gas occurred as per EPL228 requirements.

Table 3-14: Stack emission status and air quality

Release point number	Emission source	Status	Air emissions
A1	Compressor turbine WHRU West 1 (Frame 7)	Operational	Acceptable
A2	Compressor turbine WHRU West 2 (Frame 7)	Operational	Acceptable
A3	Compressor turbine WHRU East 1 (Frame 7)	Operational	Acceptable
A4	Compressor turbine WHRU East 2 (Frame 7)	Operational	Acceptable

Release point number	Emission source	Status	Air emissions
A5-1	Power generation turbine 1 (Frame 6)	Intermittent use, when HRSG offline	Acceptable
A6-1	Power generation turbine 2 (Frame 6)	Intermittent use, when HRSG offline	Acceptable
A7-1	Power generation turbine 3 (Frame 6)	Intermittent use, when HRSG offline	Acceptable
A8-1	Power generation turbine 4 (Frame 6)	Intermittent use, when HRSG offline	Acceptable
A9-1	Power generation turbine 5 (Frame 6)	Intermittent use, when HRSG offline	Acceptable
A5-2	Power generation turbine 1 HRSG (Frame 6)	Operational	Acceptable
A6-2	Power generation turbine 2 HRSG (Frame 6)	Operational	Acceptable
A7-2	Power generation turbine 3 HRSG (Frame 6)	Operational	Acceptable
A8-2	Power generation turbine 4 HRSG (Frame 6)	Operational	Acceptable
A9-2	Power generation turbine 5 HRSG (Frame 6)	Operational	Acceptable
A10	Utility boiler #1	Decommissioned	n/a
A11	Utility boiler #2	Decommissioned	n/a
A12	Utility boiler #3	Decommissioned	n/a
A13-1	AGRU Incinerator – LNG Train 1	Operational	Acceptable
A13-2	AGRU Hot Vent – LNG Train 1, prior to release at A3	Operational	Acceptable
A14-1	AGRU Incinerator – LNG Train 2	Intermittent Operations	Acceptable
A14-2	AGRU Hot Vent – LNG Train 2, prior to release at A4	Operational	Acceptable
A15	Heating medium furnace 1	Operational	Acceptable
A16	Heating medium furnace 2	Operational	Acceptable

3.5 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 Ichthys LNG are considered negligible, though smoke could become a cause of visual amenity impact and community concern.

3.5.1 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 is estimated using the Australian Miniature Smoke Chart (AS 3543:2014), which uses Ringelmann shades. The shade and duration of the dark-smoke event is recorded. Dark smoke monitoring targets and limits for all the flare systems are provided in Table 3-15.

Table 3-15: Dark smoke monitoring targets and limits

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

Flaring and other data is stored in the sites Process Control System (PCS). The PCS serves as the primary means to control and monitor Ichthys LNG 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.

3.5.2 Results and discussion

There were no dark smoke events during the reporting period.

3.5.3 Program rationalisation

No program rationalisation is proposed.

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 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 operations.

As per the OEMP, groundwater quality is required to be monitored quarterly for the first 12 months of operations (following EPL228 activation) with potential to change to biannual sampling (e.g. twice yearly) upon review of the first 12 months of data. As per the recommendation made in the 2018/2019 AEMR (L060-AH-REP-60029) and in accordance with the OEMP, sampling frequency changed to biannual following the fourth quarterly survey (Survey 4) and the number of sites monitored was reduced from 20 to 15 following Survey 6.

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 #
6	19 Oct 2020 — 3 Nov 2020	Groundwater Quality Monitoring – Trigger Assessment: Report No 6	F280-AH-REP-60071
		Groundwater Quality Sampling Report No 6	F280-AH-REP-60079
7	12—14 Apr 2021	Groundwater Quality Monitoring – Trigger Assessment: Report No 7	L290-AH-REP-70009
		Groundwater Quality Sampling Report No 7	L290-AH-PLN-70010

4.1.1 Method overview

The groundwater quality monitoring surveys were undertaken in accordance with the Groundwater Quality Monitoring Plan (versions L290-AH-PLN-70000 and F280-AQ-PLN-60003). As detailed in Table 4-2, 20 wells were monitored during Survey 6 (Oct/Nov 2020) and 15 wells during Survey 7 (April 2021) (refer Figure 4-1 for well locations). 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 below.

Prior to sampling, groundwater wells were gauged with an interface probe to determine the standing water level (SWL) and the presence of light non-aqueous phase liquid (LNAPL). Following gauging, groundwater wells were purged using a low flow micro purge pump with SWL and in situ parameters being measured every three to five 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 4-3. 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 4-3) and the same analyte also exceeding the background level for each groundwater well. Well specific background level trigger values were calculated using the approach described in ANZG (2018). 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 wells monitored during Survey 6 and Survey 7

Well	Survey 6	Survey 7
BPGW01	X	X
BPGW07	X	X
BPGW08A	X	X
BPGW09	X	X
BPGW13A	X	-
BPGW14A	X	-
BPGW18	X	X
BPGW19A	X	X
BPGW20	X	X
BPGW23	X	-
BPGW24	X	-
BPGW25	X	-
BPGW26	X	X
BPGW27A	X	X
BPGW28	X	X
BPGW38A	X	X
BPGW40	X	X
BPGW41	X	X
VWP328	X	X
VWP341	X	X

Table 4-3: Groundwater quality monitoring parameters, methods and trigger values

Parameter	Unit	Sampling method*	Trigger value	Trigger value reference
pH	pH units	CFI	Outside 6.0 and 8.5	NRETAS 2010
EC	µS/cm	CFI	n/a	n/a
Dissolved oxygen	%	CFI	n/a	
Oxygen reduction potential	mV	CFI	n/a	
Temperature	°C	CFI	n/a	
Total dissolved solids	mg/L	SFLA	n/a	
Oxides of nitrogen	µg N/L	SFLA	20	NRETAS 2010
Ammonia	µg N/L	SFLA	20	
TN	µg N/L	SFLA	300	
TP	µg P/L	SFLA	30	
FRP	µg/L	SFLA	10	
Phenols	µg/L	SFLA	n/a	n/a
TRH[‡]	µg/L	SFLA	600	Ministry of Infrastructure and the Environment (2009)
Benzene	µg/L	SFLA	500	ANZG 2018
Toluene	µg/L	SFLA	180	
Ethylbenzene	µg/L	SFLA	5	
Xylenes	µg/L	SFLA	75	
Aluminium	µg/L	SFLA	24	Golding et al. 2015
Arsenic	µg/L	SFLA	2.3	ANZG 2018
Cadmium	µg/L	SFLA	0.7	
Chromium III	µg/L	SFLA	10	
Chromium VI	µg/L	SFLA	4.4	

Parameter	Unit	Sampling method*	Trigger value	Trigger value reference
Cobalt	µg/L	SFLA	1	
Copper	µg/L	SFLA	1.3	
Lead	µg/L	SFLA	4.4	
Manganese	µg/L	SFLA	390	J. Stauber and R. Van Dam Pers.Com. 23 March 2015 cited in Greencap (2016)
Mercury	µg/L	SFLA	0.1	ANZG 2018
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	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

‡ Where TRH is detected over the prescribed limits a silica gel clean-up will be undertaken and reanalysed to remove false positive natural oil results

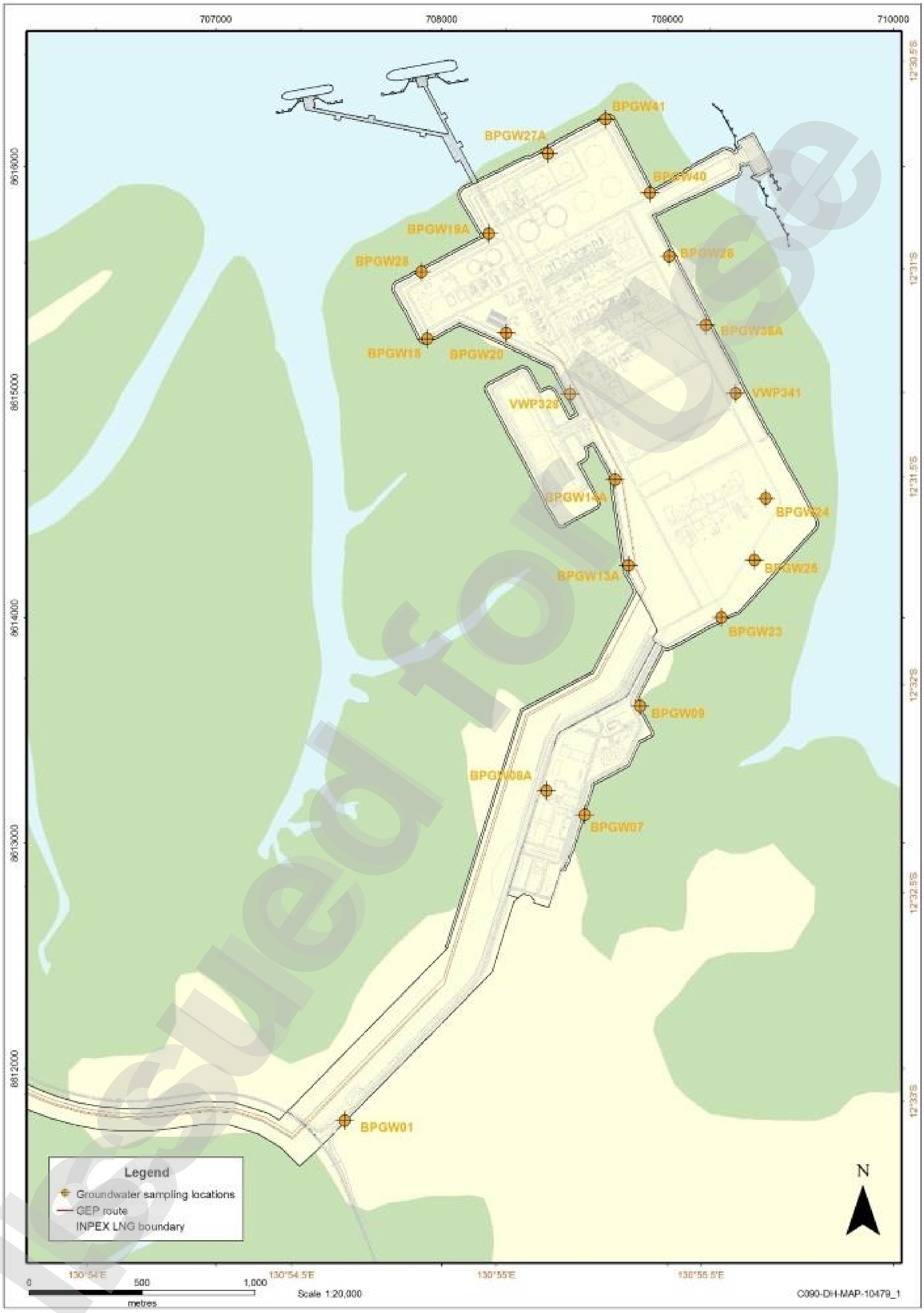


Figure 4-1: Groundwater quality sampling locations

4.1.2 Results and discussion

A high-level summary of groundwater results and trends is provided in the following sections, with data collected during the reporting period provided in APPENDIX F:. Note presentation of groundwater data trends include data collected during the construction phase. Groundwater surveys undertaken during the reporting period in accordance with the OEMP are specified in Table 4-1. To date, groundwater monitoring during the operations phase of Ichthys LNG has shown there has been no change in groundwater quality (i.e. Elizabeth-Howard Rivers Region groundwater declared beneficial uses or objectives have not been adversely affected).

Physio-chemical

Physio-chemical monitoring results measured during the reporting period are consistent with those from the construction period and 2019/2020 AEMR.

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 30,000 to 40,000 µS/cm (Figure 4-2). Groundwater is also acidic to neutral with average pH typically between 5.2 and 5.8 (Figure 4-3).

Similar to previous surveys, groundwater elevation was higher (e.g. water table was shallower) following the wet season and decreased during the dry season (Figure 4-4). The SWL of groundwater at Ichthys LNG is influenced by rainfall recharge, although some bores are located slightly below the highest astronomical tide line and are tidally influenced. As such, these wells have less variability in their SWL. Note, the reduced SWL in the reporting period is likely to be associated with low rainfall over the 2018/2019, 2019/2020 and 2020/2021 wet seasons (see Section 1.4.2).

An assessment of groundwater fluctuations during the construction phase of Ichthys LNG (2013 to 2019) concluded that construction of Ichthys LNG had not adversely impacted groundwater levels (Greencap 2019).

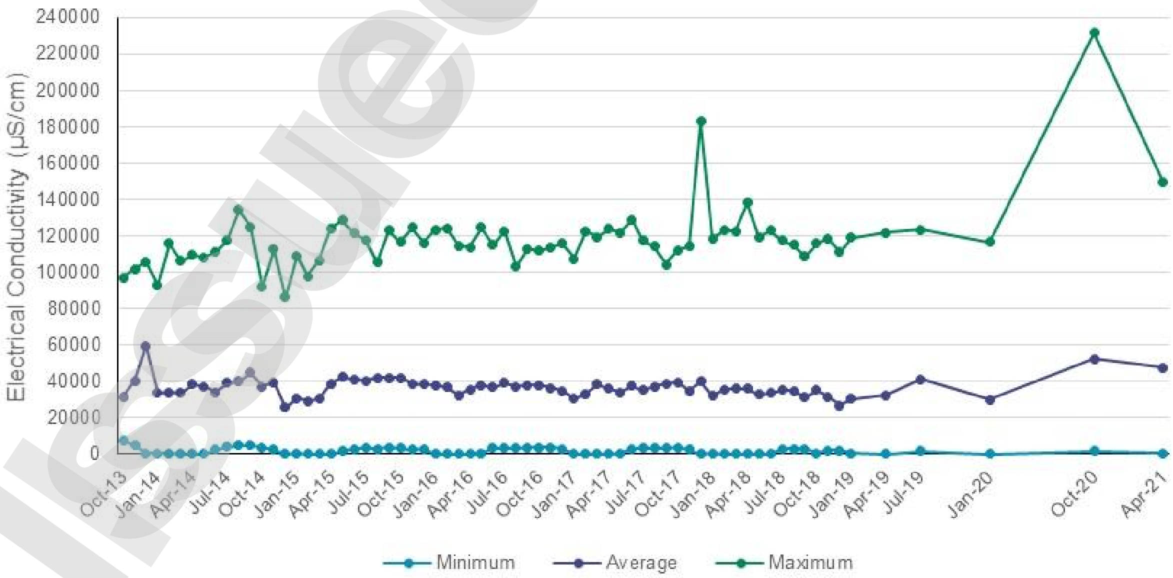


Figure 4-2: Mean, minimum and maximum electrical conductivity for Ichthys LNG groundwater wells

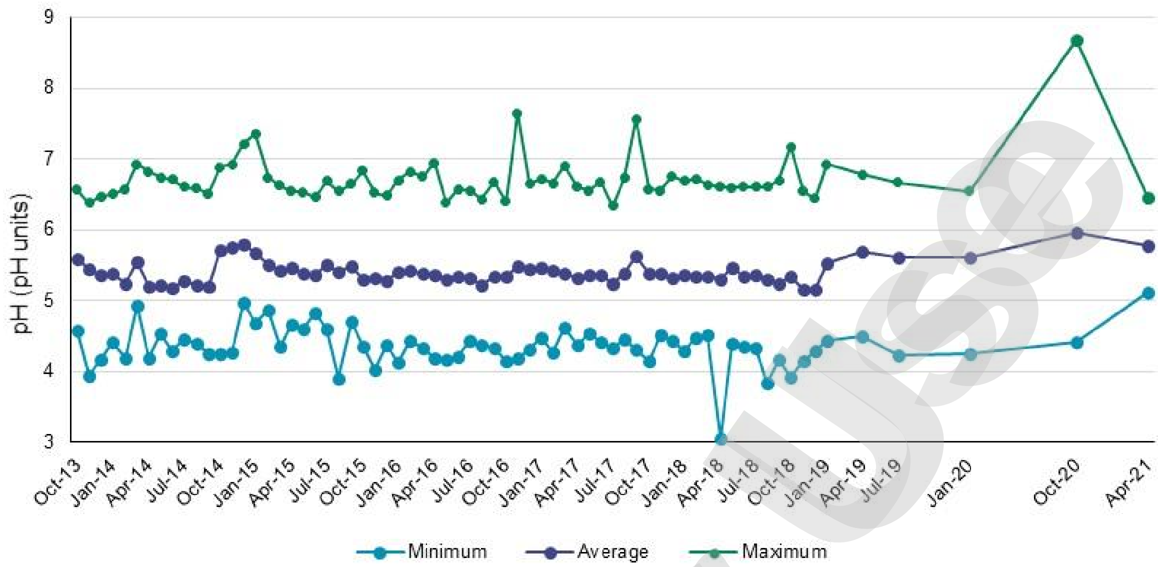


Figure 4-3: Mean, minimum and maximum pH for Ichthys LNG groundwater wells

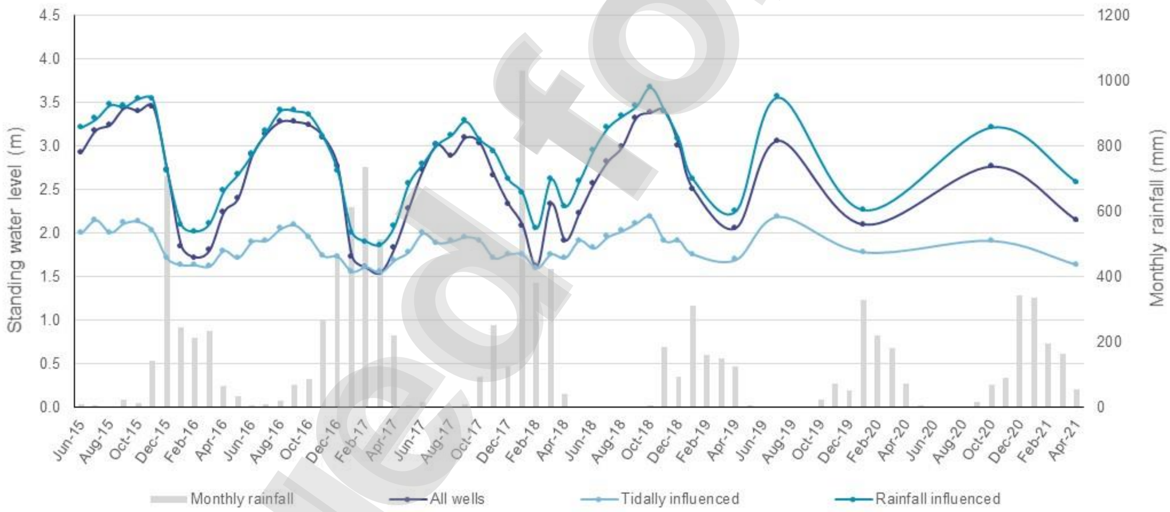


Figure 4-4: Mean SWL for Ichthys LNG groundwater wells

Nutrients

Nutrient monitoring results measured during the reporting period were generally consistent with those reported during the construction period and the 2019/2020 AEMR. Nutrient concentrations are known to vary inter-annually and seasonally (Figure 4-5 and Figure 4-6). Nutrients can also be highly variable between groundwater wells (as an example refer to Figure 4-7).

During the reporting period, and similar to 2019/2020 AEMR, ammonia was the nutrient that had the greatest number of trigger exceedances (nine in Survey 6; Oct/Nov 2020 and six in Survey 7; April 2021). Ammonia also demonstrated a strong seasonal trend, with concentrations increasing during the dry season and decreasing in the wet season (Figure 4-5). Inter-annual 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 2020/2021 wet season rainfall was below average and one of the driest wet season since construction of Ichthys LNG began. The dry 2020/2021 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.

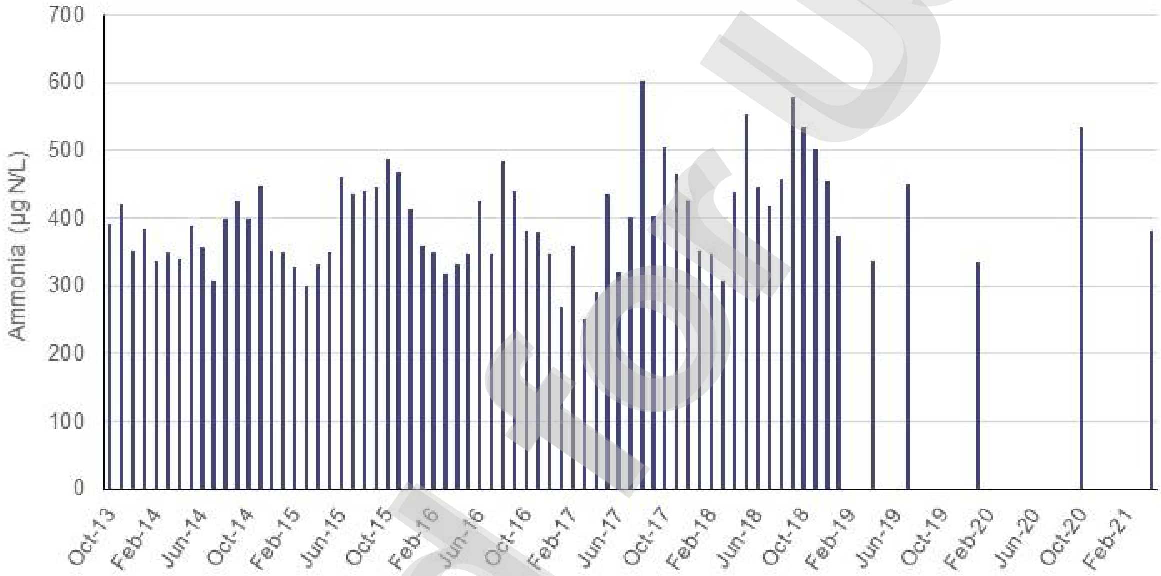


Figure 4-5: Mean ammonia concentrations for all groundwater wells

Figure 4-6: Mean total phosphorus concentrations for all groundwater wells

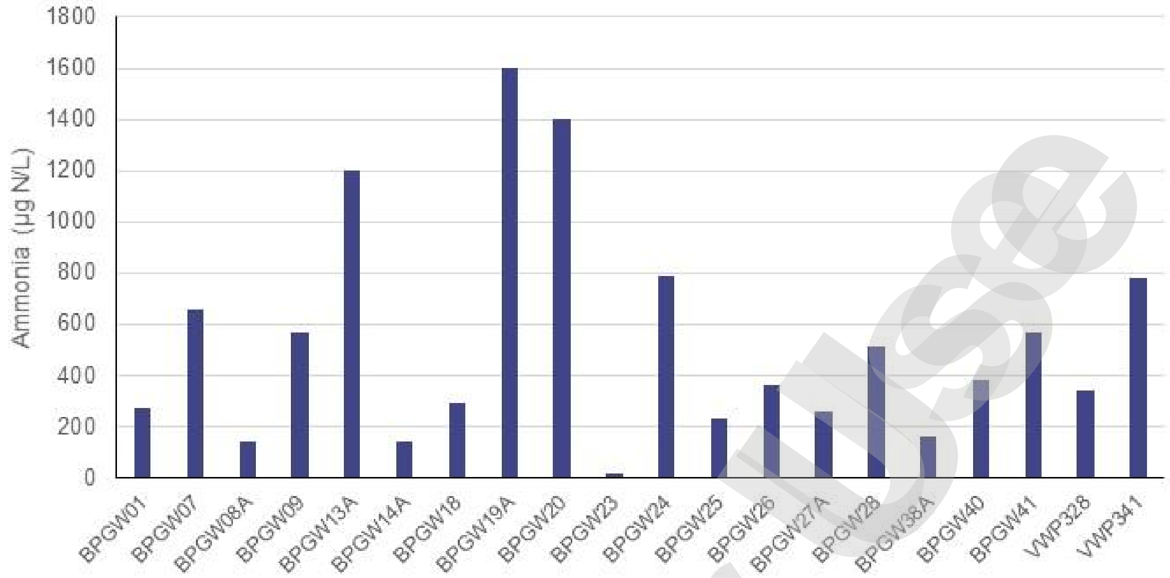


Figure 4-7: Groundwater survey 6 ammonia concentrations

Metals and metalloids

Groundwater metal concentrations measured during the reporting period were generally consistent with those from the construction period and previous operations 2019/2020 AEMR. Similar to nutrients, metal concentrations are known to vary inter-annually and seasonally (see Figure 4-8 for an example). Metals can also be highly variable between groundwater wells (see Figure 4-9 for an example).

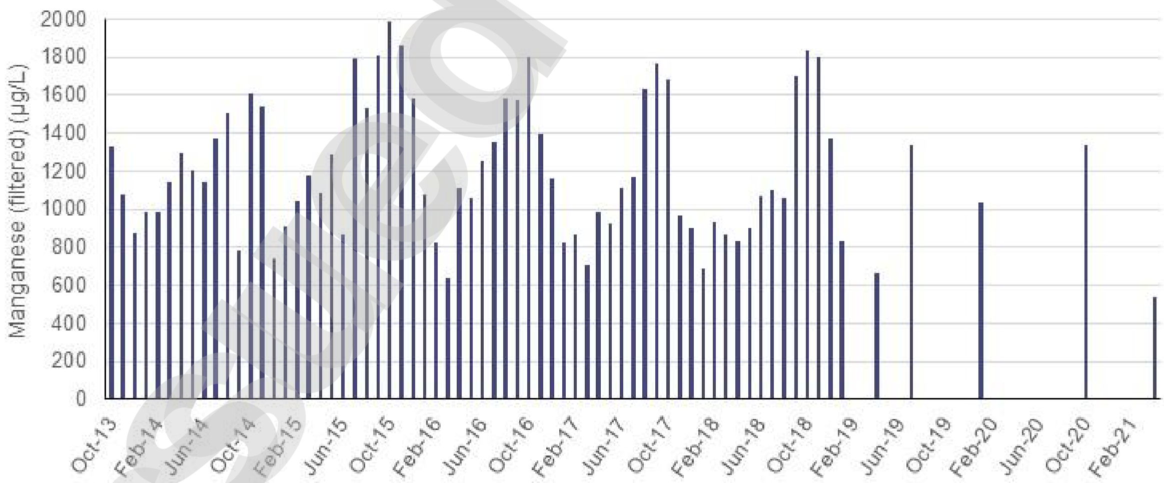


Figure 4-8: Mean manganese concentrations for all groundwater wells

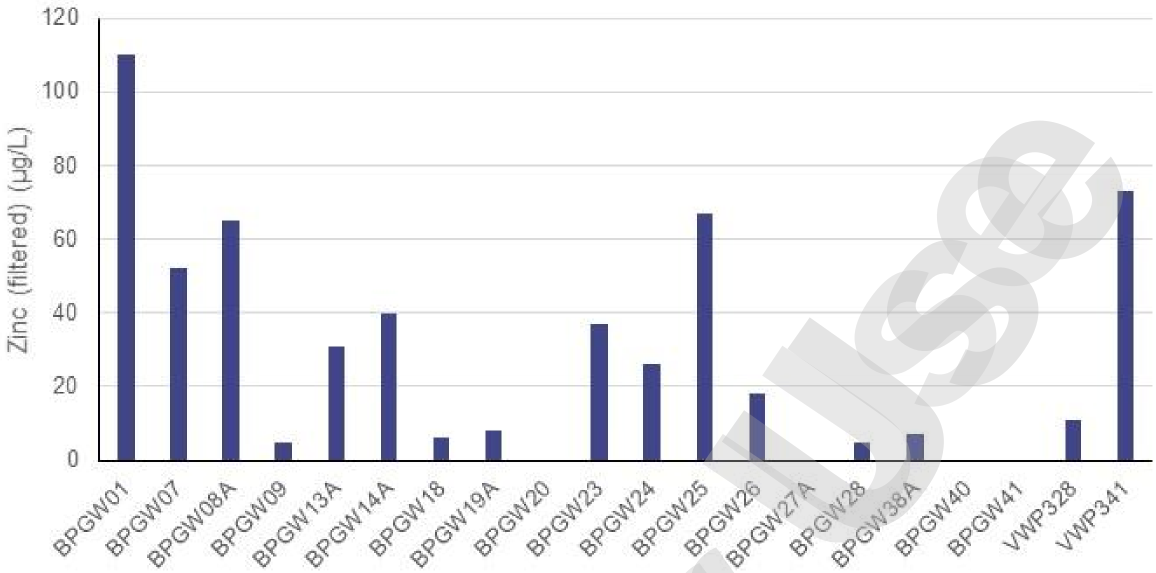


Figure 4-9: Groundwater survey 6 zinc concentrations

During the reporting period and similar to 2019/2020 AEMR, zinc was the metal that had the greatest number of trigger exceedances (five in October/November 2020 and two in April 2021) and showed a strong seasonal trend; concentrations typically increase during the dry season and typically decrease in the wet season following the onset of wet season rainfalls.

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 2020/2021 wet season rainfall was below average and the driest wet season since construction of Ichthys LNG began. The dry 2020/2021 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.

Organics

No TRH, BTEX or phenols were reported in any of the samples from any of the wells during the reporting period, there was also no detection of LNAPL at any well during the reporting period.

Microbiological

Faecal coliforms (total) and *E. coli* were not detected at BPGW19A during the reporting period; however, a LOR of 10 mpn/100 mL was used for Survey 7 instead of the normal 1 mpn/100 mL. Low concentrations of faecal coliforms and *E. coli* were detected during Survey 7 at BPGW27A (Table 4-4).

There was one detection of BOD above the LOR, during the reporting period at BPGW19A in October 2020. Although concentrations were otherwise below the LOR, BOD was analysed to a LOR of 5 mg/L during Survey 7. Samples were also analysed outside of the sample holding times.

Faecal coliform and *E.coli* detections were at or just above the LOR. Detections occurred in the same sample, therefore are likely attributable to bacterial growth within the sample during transport, and are unlikely to be attributable to Ichthys LNG operations. The BOD result in Survey 6 was not repeated in Survey 7, and there is no trigger value for BOD.

Table 4-4: Microbiological results for the reporting period

Well	Survey	*E. coli* (mpn*/100mL)	Faecal coliform (total) (mpn*/100mL)	BOD (mg/L)
BPGW19A	Survey 6	<1	<1	4.3
	Survey 7	<10[†]	<10[†]	<5[†]
BPGW27A	Survey 6	<1	<1	<1
	Survey 7	1	2	<5[†]

*cfu/100 mL, equivalent to mpn/100 mL

†Incorrect LOR applied to analyses. LOR required by monitoring program is 1 mpn/100 mL

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 (i.e. results that exceeded benchmark levels, see Section 4.1.1). A summary of the number of trigger exceedances by survey is provided in Table 4-5 with corresponding investigation reports listed below:

- Groundwater Survey 6 – Trigger Investigation Report (L290-AH-REP-70017)
- Groundwater Survey 7 – Trigger Investigation Report (L290-AH-REP-70024).

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 4-5: Summary of groundwater trigger exceedances

Date	Month	Physio-chemical	Nutrients	Metals
Survey 6*	Oct / Nov	4	23	26
Survey 7[†]	April	7	22	8

* Includes 1 technical trigger exceedance, which occurred as a result of laboratory LOR not being achieved due to matrix interference.

† Includes multiple technical trigger exceedances, which occurred as a result of samples being analysed to LORs higher than those required for the monitoring program, as well trigger exceedances resulting from the relative percentage difference (RPD) of QA/QC samples above the performance criteria of <30%.

4.1.4 Program rationalisation

No changes to groundwater monitoring at Ichthys LNG are proposed, as the current biannual monitoring is appropriate to capture seasonal impacts from unplanned discharges to ground.

5 FLORA, FAUNA AND HERITAGE

5.1 Mangrove health, intertidal sediment and bio-indicators

Mangrove health and intertidal sediments 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 Ichthys LNG
- detect changes in intertidal sediment quality attributable to Ichthys LNG.

As per the OEMP, mangrove health is required to be monitored annually for the first 36 months of operations (following EPL228 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 #
3	7— 9 Apr 2021	Mangrove Health and Intertidal Sediment Trigger Assessment Report - No. 3	L290-AH-REP-70013
		Mangrove Health and Intertidal Sediments Monitoring: Report No 3	L290-AH-REP-70014

5.1.1 Method overview

The mangrove health and intertidal sediment was undertaken in accordance with the Mangrove Health and Intertidal Sediment Monitoring Plan (L290-AH-PLN-70002). This included monitoring at 9 sites; two control and seven potential impact sites. 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, 13 quadrats (i.e. seven potential impact and six control quadrats) are monitored during each annual survey. Each of the 13 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 52 subplots).

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

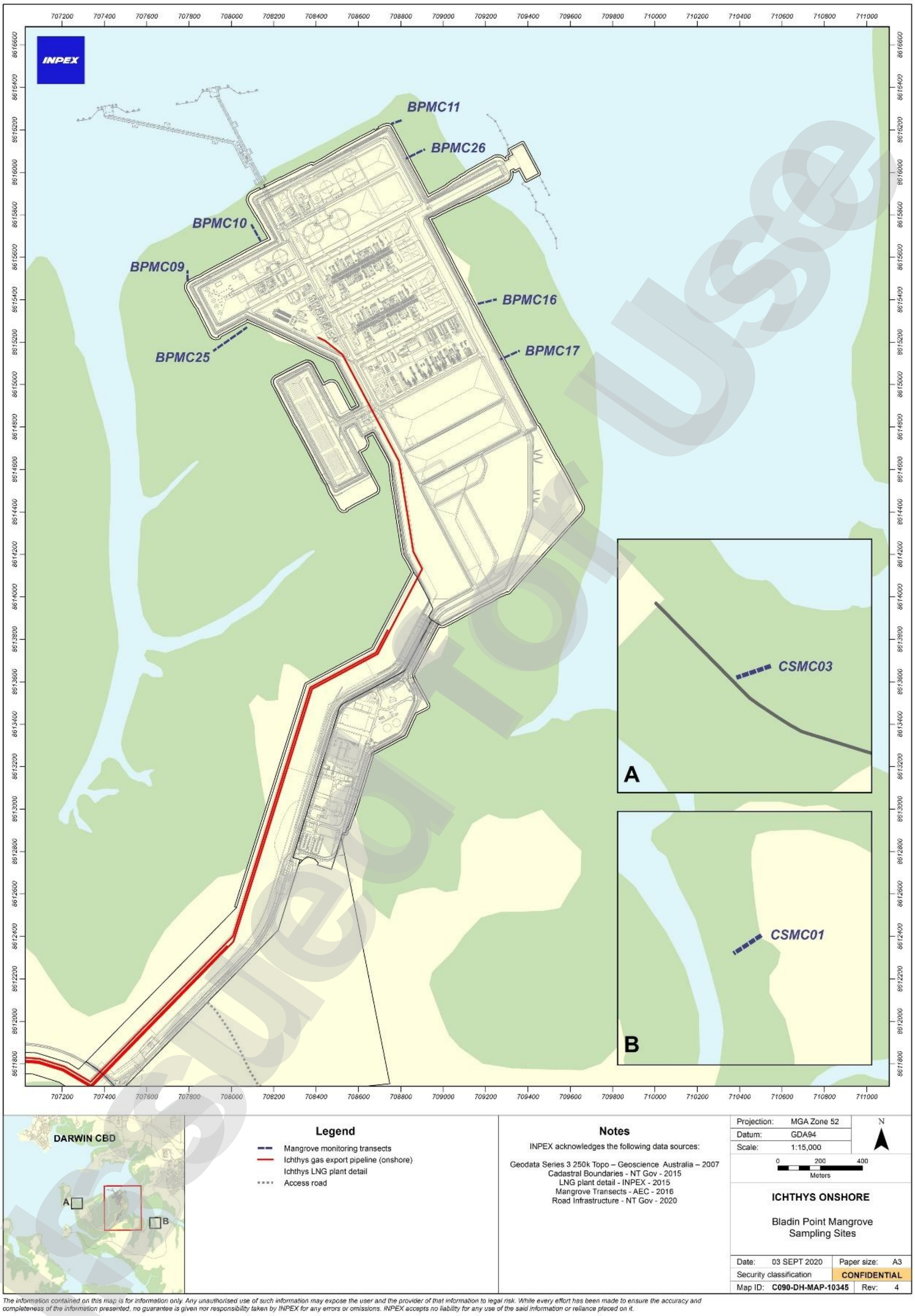


Figure 5-1: Mangrove health and intertidal sediment monitoring locations

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

Parameter	Methodology	Monitoring Parameters
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) • TPH • pH (measured in field) • Redox (measured in field)

Mangrove health monitoring

Mangrove canopy cover was measured at each site using established fixed quadrats using a spherical densitometer (Stickler 1959) to provide an estimate of foliage cover. Three replicate foliage cover measurements were taken within each 5 m × 5 m (25 m^2) subplot formed by the fixed quadrat four corner posts and a centre post in the assemblage adjacent to Ichthys LNG and a subset of transects in high risk areas. The canopy cover for each quadrat was then calculated by averaging the mean of the foliage cover readings from each subplot. The spherical densitometer was not modified according to the Stickler method due to human error, which represents a deviation from the monitoring plan.

A known limitation of densitometers is that they are slightly subjective and known to potentially produce observer bias (Cook et al. 1995; Korhonen et al. 2006). However, consistent and reliable results can be achieved if the same scientist is used. To eliminate potential future bias, a digitised method for measuring canopy cover (e.g. Percentage Cover application) was trialled for the reporting period. Percentage Cover (%Cover) combines photography and smart device technology to allow rapid assessment of canopy cover, while also providing a digital archive of canopy cover in a vertical direction, which is a 'true' measurement of canopy cover (Jennings et al. 1999). This method was trialled at control site CSMC01. Two records were taken within each of the three subplots at this site, and a mean value of canopy cover was calculated.

Mangrove surveillance photo-monitoring was also undertaken in quadrats adjacent to Ichthys LNG to provide a visual record of the communities' appearance and condition (e.g. leaf colour). Repeatable photos were captured facing away from the quadrat centre post towards each of the four corner posts.

Sediment monitoring

To test for potential changes in sediment composition and sediment quality a single surficial sediment sample was taken (top 2—5 cm) from within each of the 13 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 Sediment Quality Guideline Value (SQGV; also referred to default guideline value) as per ANZG (2018) 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) were 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.

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). During Survey 3, canopy cover at sites BPMC09, BPMC25 and CSMC01-TF was lower than baseline values. Canopy cover was reduced by 18.2%, 19.9% and 20.5% respectively. Notably, the monitoring report (L290-AH-REP-70014) indicated that site BPMC25 was incorrectly identified and the appropriate location was not surveyed. No sites showed decreases in canopy cover near to levels considered to indicate ecologically significant change (a 30% decrease in canopy cover).

Trial of the digital percentage cover method (%Cover application) at site CSMC01 indicated that the results differ significantly when compared with the spherical densitometer method. However, it was noted that the results represented a small sample size. Notably, the inability to bring mobile phones onto the Ichthys LNG site under a hot works permit also prevented trial of this method at impact sites.

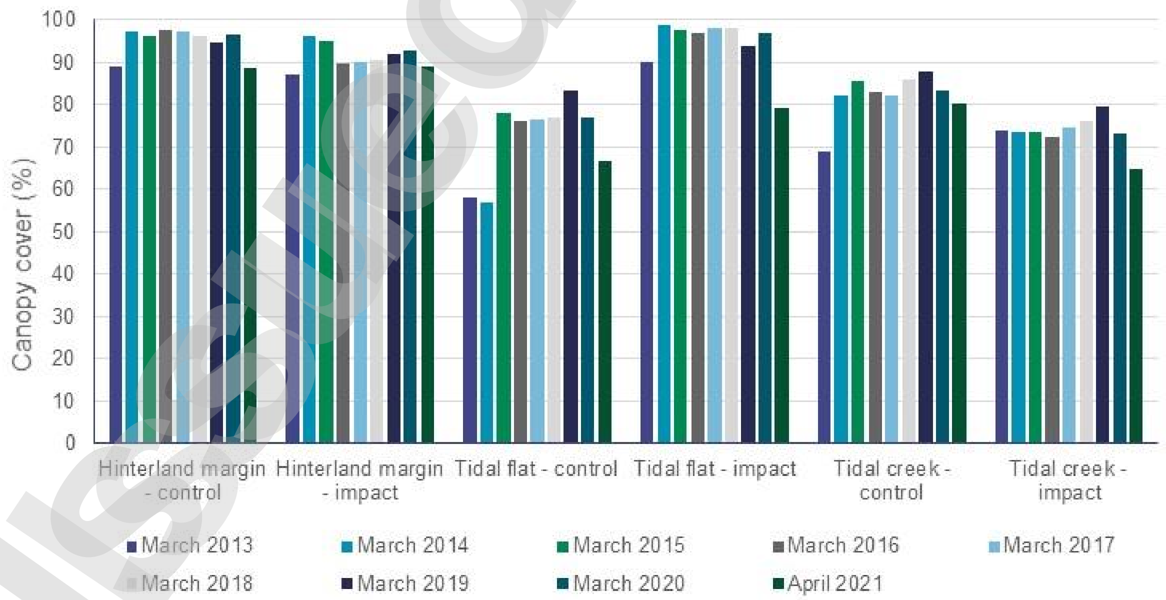


Figure 5-2: Mangrove canopy cover

Community health

All sites were classified as healthy in 2021 with no signs of deterioration or abnormal stress based on indices of leaf colour, regeneration (i.e. seedlings and saplings), visible vertebrate fauna and infaunal bioturbation.

Sediment monitoring

In-situ sediment measurements

In-situ sediment measurements indicate that sediment at all sites range from being slightly alkaline to slightly acidic (5.72—8.10). This range in pH is attributed to the conditions experienced by surface sediments, which are regularly flushed by tidal waters and well oxygenated. The surface sediments are subsequently oxidising, as indicated by the positive values in Table 5-3.

Table 5-3: Average mangrove sediment in situ monitoring results by assemblage

Assemblage	pH		Redox potential (mV)	
	Impact	Control	Impact	Control
Hinterland margin	6.04	7.05	92.10	91.00
Tidal flat	7.72	6.77	47.2	114.20
Tidal creek	7.88	6.95	53.73	104.20

Sediment chemistry

A summary of the mangrove sediment chemistry results is provided in Table 5-4 and Table 5-5. Two exceedances of arsenic were found at control sites but were not investigated further as no exceedances were found at impact sites.

Exceedances of the benchmark levels were recorded at one impact and two control sites for hydrocarbons. In accordance with recommendations made in the 2018/2019 AEMR, silica gel clean-up was performed on samples that exceeded the TPH trigger value to remove non-petrogenic hydrocarbons. Following silica gel clean-up, TPH results for the one impact and two control sites were below initial concentrations; and below the trigger value for the impact and one control site. This indicates the presence of naturally occurring hydrocarbons (e.g. lipids, plant oils, tannins, animal fats, proteins, humic acids and fatty acids).

Table 5-4: Summary of inorganic mangrove sediment chemistry (mg/kg)

Site	Aluminium	Antimony	Arsenic*	Cadmium	Chromium	Copper	Lead	Nickel	Zinc	Mercury
Guideline value	n/a	2	20	1.5	80	65	50	21	200	0.15
Background	n/a	n/a	16.0	0.071	17.5	4.7	8.8	8.7	21.4	n/a
BPMC09	5,500	<2	6	<0.1	14	1	4	4	16	0.05
BPMC10	5,200	<2	7	<0.1	12	3	4	4	18	<0.02
BPMC11	1,300	<2	<5	<0.1	6	<1.0	<1.0	<1.0	2	<0.02
BPMC16	1,400	<2	<5	<0.1	8	<1.0	<1.0	<1.0	<1.0	0.02
BPMC17	5,200	<2	18	<0.1	46	4	2	3	25	0.04
BPMC25	5,000	<2	13	<0.1	17	6	7	6	89	0.05
BPMC26	4,300	<2	9	<0.1	11	1	5	4	39	0.02
CSMC01-HM	3,600	<2	<5	<0.1	8	2	1	1	4	0.03
CSMC01-TC	13,000	<2	12	<0.1	33	1	10	8	33	0.03
CSMC01-TF	2,500	<2	6	<0.1	12	<1.0	2	1	10	<0.02
CSMC03-HM	7,500	<2	14	<0.1	37	11	11	6	24	0.07
CSMC03-TC	13,000	<2	**31**	<0.1	32	4	9	11	27	0.1
CSMC03-TF	16,000	<2	**36**	<0.1	40	5	13	11	32	0.1

*Bold value indicates trigger exceedance.

Table 5-5: Summary of organic mangrove sediment chemistry (mg/kg)

Site	TPH C10-C36 (sum of total)*	TPH C10-C36 (sum of total after silica gel clean-up)*
Guideline value	280	280
Background	n/a	n/a
BPMC09	45	33
BPMC10	88	76.4
BPMC11	3.5	<3.7
BPMC16	140	103.3
BPMC17	**310**	236.6
BPMC25	56	52.2
BPMC26	170	141.2
CSMC01-HM	**450**	**335.5**
CSMC01-TF	250	171.4
CSMC01-TC	89	51.4
CSMC03-HM	260	194
CSMC03-TF	200	147.1
CSMC03-TC	**300**	215.3

*Bold values indicates trigger exceedances

5.1.3 Trigger assessment outcomes

There were no trigger exceedances for the 2021 mangrove health and intertidal sediment survey. Two samples had elevated arsenic and one site had elevated TPH following silica gel clean-up; however, these occurred at control sites and are not attributed to Ichthys LNG activities and no further investigation was undertaken.

5.1.4 Program rationalisation

As per the OEMP, mangrove health is required to be monitored annually for the first 36 months of operations (following EPL228 activation), with longer term requirements assessed based on a review of these results.

To date, monitoring during the operations phase has shown there has been no demonstratable change in mangrove health, intertidal sediment or bio-indicator quality attributable to Ichthys LNG operations. In consideration of this, mangrove health, and intertidal sediments will be monitored biennially (every two years). This frequency is considered adequate to detect any change to mangrove health or intertidal sediment as a result of Ichthys LNG operations.

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 LPG/condensate product loading jetties (Figure 5-3) using artificial settlement units (ASUs; Figure 5-4). 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 Industry, Tourism and Trade (NT DITT).

Photo-monitoring of ASUs is undertaken monthly with ASUs collected and replaced every fourth month (an example of monitoring photographs is shown in Figure 5-5). Collected ASUs are sent to NT DITT for identification.

The ASUs were installed in September 2018 with monthly monitoring commencing in October 2018. Table 5-6 provides a summary of nearshore marine pest monitoring dates for the reporting period.

Table 5-6: Nearshore marine pest monitoring dates

Monitoring date	Sample collection/ replacement
17-Jul-20	No
19-Aug-20	No
16-Sep-20	Yes
13-Oct-20	No
17-Nov-20	No
16-Dec-20	Yes LPG/Condensate Jetty Only. Note LNG jetty unable to be retrieved
21-Jan-21	Yes LNG Jetty Only – retrieval by vessel (anchor rope replaced)
18-Feb-21	No
17-Mar-21	No
15-Apr-21	No
14-May-21	Yes
15-Jun-21	No

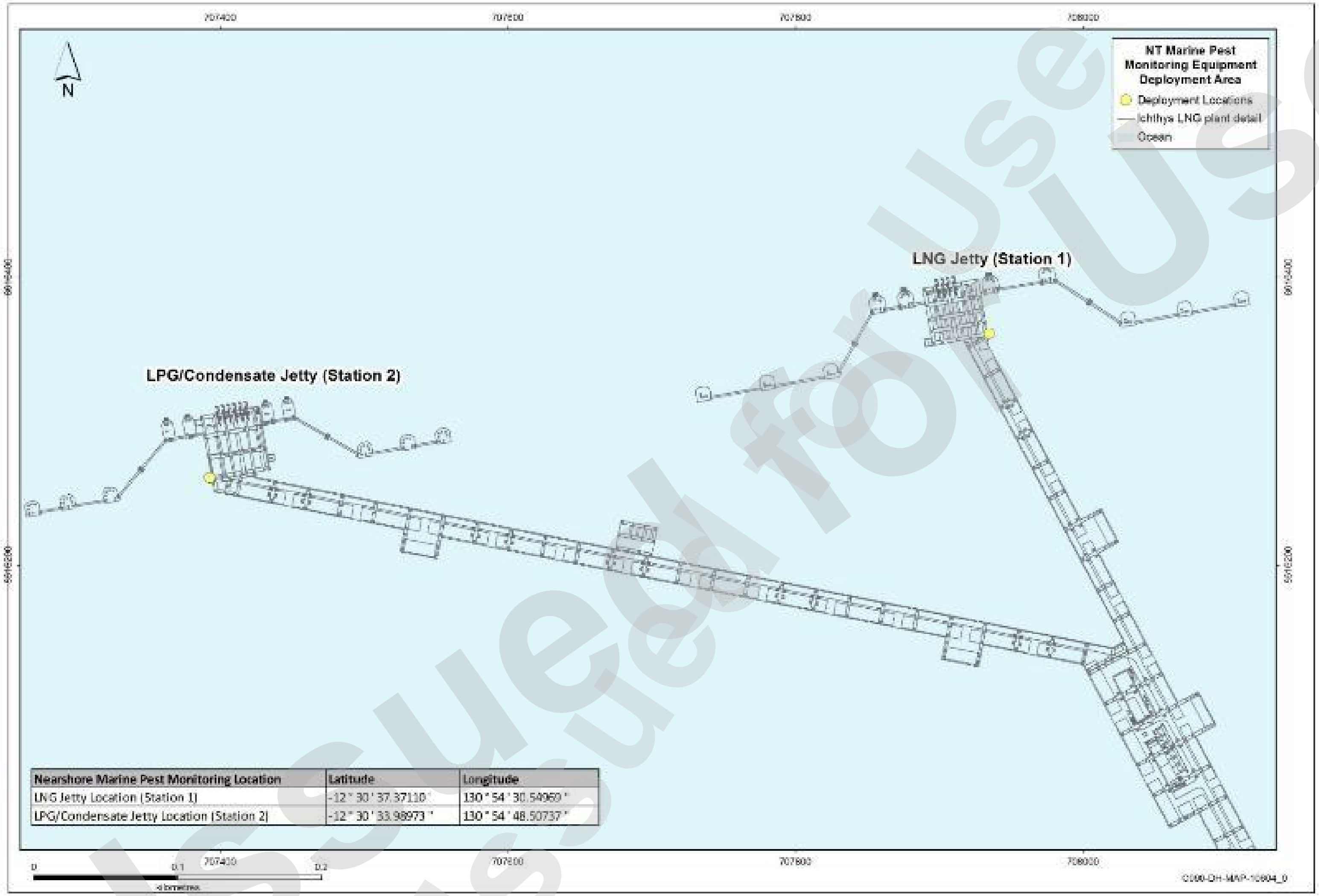


Figure 5-3: Nearshore marine pest monitoring locations

Figure 5-4: Nearshore marine pest ASU

Figure 5-5: Example of monitoring photographs taken during monthly inspection a) rope mop, b) inside the plates and c) plates surface biofouling conditions

5.2.2 Results and discussion

No invasive marine species were identified by the NT DITT during four monthly inspections, or by INPEX during the monthly visual inspections during this reporting period. Table 5-7 provides a summary of organisms identified by NT DITT on the LNG and LPG/condensate jetty ASUs.

Table 5-7: Organisms identified on ASUs during reporting period by NT DITT

Jetty	ASU	Sep 2020	Dec 20/Jan 2021	May 2021
LNG	Plates	Moderate level of fouling. Hydroids, barnacles, colonial ascidian, serpulids, oysters, encrusting bryozoans and sabellids, algae.	Very heavy level of fouling. Barnacles, hydroids, colonial ascidian, oysters, encrusting bryozoans, solitary ascidian, sabellids and serpulids.	Very heavy level of fouling. Barnacle, oyster, colonial ascidian, serpullid, algae, sponge and amphipod tube.
	Rope mops	Heavy level of fouling. Solitary ascidian, colonial ascidian, sabellids, serpulids, silt, branching bryozoans, scallop, sponge, Didemnum and oysters.	Heavy level of fouling. Sabellids, colonial ascidians, oysters, solitary ascidians, Didemnum, serpulids, branching bryozoans, scallops, barnacles and hairy mussel.	Very heavy level of fouling. Amphipod tube, colonial ascidian and algae.
LPG/ condensate	Plates	Moderate level of fouling. Oysters, colonial ascidian, serpulids, encrusting bryozoans, barnacles and sabellids.	Heavy level of fouling. Barnacles, sponge, hydroids, colonial ascidian, oysters, encrusting bryozoans, solitary ascidian, sabellids and serpulids.	Heavy level of fouling. Barnacles, sponge, hydroids, colonial ascidian, oysters, encrusting bryozoans, solitary ascidian, sabellids and serpulids.
	Rope mops	Moderate level of fouling. Solitary ascidian, sabellids, serpulids, silt, branching bryozoans, scallop, sponge, Didemnum and oysters.	Heavy level of fouling. Colonial ascidian, solitary ascidian, serpulids, sabellids and branching bryozoans.	

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 were 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 5-8 provides a summary of surveys completed during the reporting period.

Table 5-8: Weed survey details

Survey	Date	Report	INPEX Doc #
Survey 5	October 2020	Weed Management Report No. 5	F280-AH-REP-60104
Survey 6	April 2021	Weed Management Report No. 6	L290-AH-REP-70015

5.4.1 Method overview

Weed surveys were performed in accordance with the INPEX LNG Weed Mapping and Vegetation Surveillance Monitoring Plan (L290-AH-PLN-70001). The area surveyed is shown in Figure 5-6.

Parameters monitored during the weed surveys are listed in Table 5-9. Where identification of a species was not possible in the field, a voucher sample, together with photographs were taken to facilitate post survey identification.

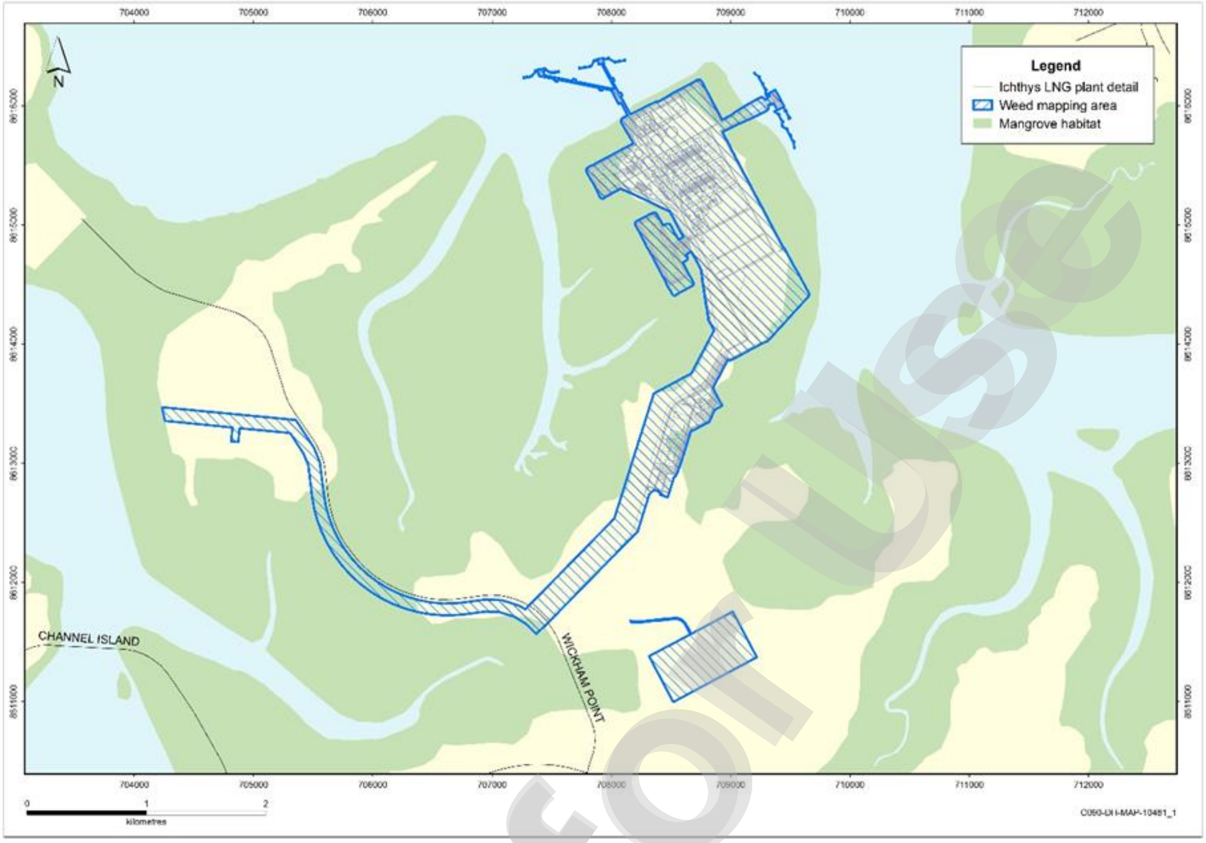


Figure 5-6: Weed survey area

Table 5-9: Weed survey parameters

Key Parameter	Descriptor
Weed names	Scientific and common names
Physical locations	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

2020/2021 reporting period results

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 and operations phase. Weed maps covering surveyed areas can be found in Weed Survey reports (Table 5-8). Declared weed species previously identified 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 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 operations phase weed monitoring surveys in 2019/20, 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 construction phase weeds monitoring, indicating no significant change in weeds species present on the site.

Weeds identified during the weed mapping surveys were communicated to the weed management contractor and managed accordingly (see Section 5.5).

Declared weed infestation trend analysis

A trend analysis for weed results from all surveys was completed (Figure 5-7). Gamba grass infestations substantially increased during the 2020-2021 wet season. While individual gamba grass plants have remained relatively consistent; there has been a significant decrease in wet season surveys (Survey 6 compared to Survey 4) and a slight increase in dry season surveys (Survey 5 compared to Survey 3).

No horehound was recorded during Survey 5; however, this survey took place at the end of the dry season, when this annual species is harder to detect. The favourable growth conditions over the 2020/21 wet season has resulted in significant patches of Horehound establishing with the GEP Corridor and Bladin Point Road Corridor. Previous surveys have detected Horehound in both of these weed management zones and also within Area 1888, where Horehound was not found to occur during Survey 6. The overall extent of horehound infestation recorded has increased compared to previous weed surveys.

A single patch of perennial mission grass was observed at the northern end of the GEP. This patch is a very high priority for control. While a decrease in the extent of annual mission grass infestations was recorded during Survey 6, comparison with the previous wet season (Survey 4) is not accurate, as the Operations Area, Production Area and Bladin Point Road Corridor have not been included in the current weed survey area. This is because the weed is currently not declared under the NT Weed Management Act, nor is listed as a Weed of National Significance, and therefore was not prioritised within heavily managed areas (i.e. Operations, Production and Bladin Point Road Corridor). The survey demonstrated that there has been an overall increase in the overall density of patches of annual mission grass observed.

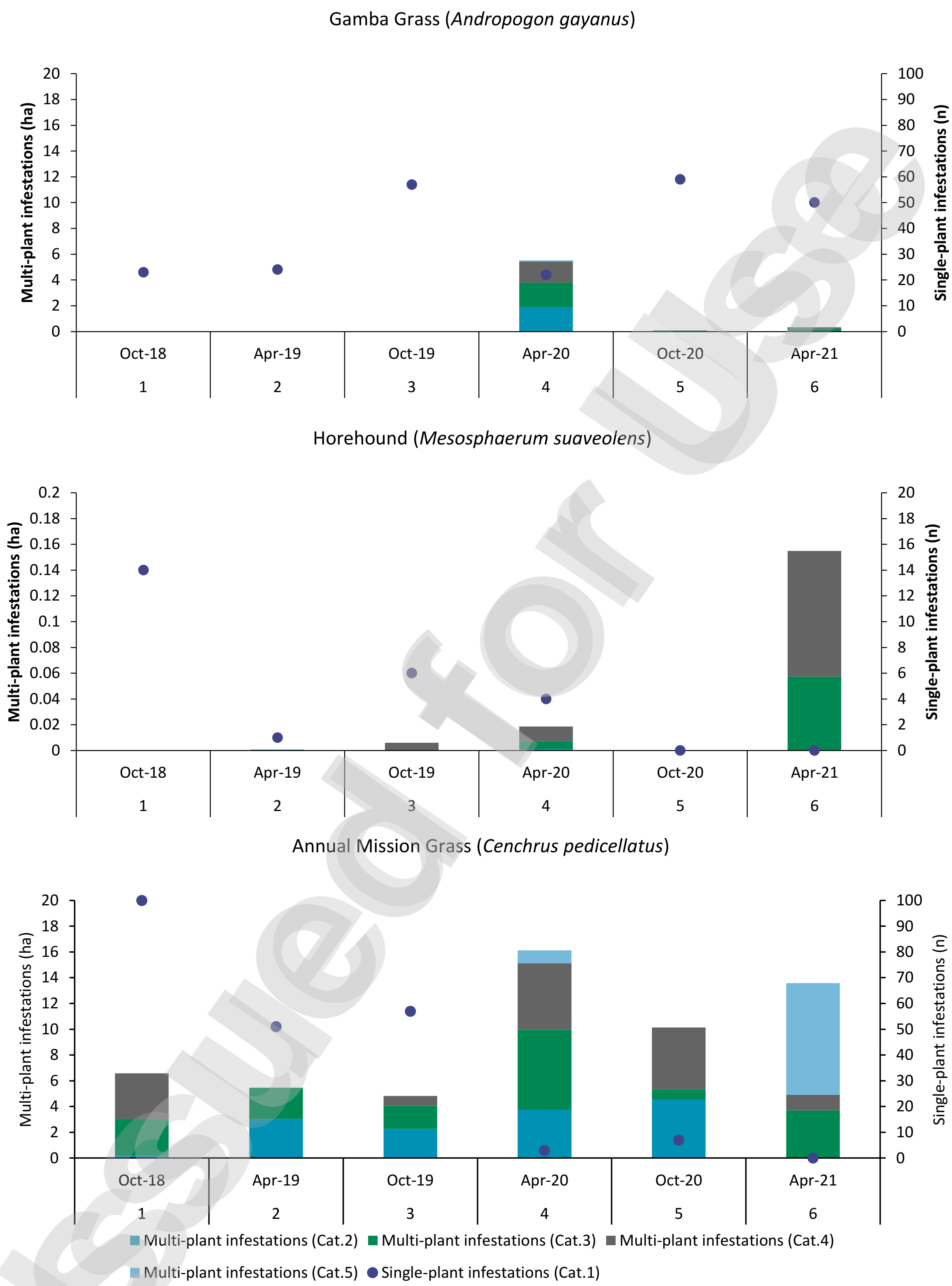


Figure 5-7: Comparison of declared weed infestations between AEMR reporting periods

5.4.3 Program rationalisation

No changes to weed surveys is proposed. As recommended in the 2019/2020 AEMR, weed surveys reverted to annually in April 2021. The current annual weed surveys will still allow INPEX to fulfil its commitments under the OEMP and *Weeds Management Act* (NT).

5.5 Weed management

5.5.1 Method overview

Weed control at the site was undertaken and managed by a weed management contractor during the reporting period. Vegetation control at the site occurred along the fence lines, drains, inside the facility and along the GEP corridor, including the Section 1888 laydown yard. Weed control was conducted in the wet season through spray application of herbicides, boom spray, quick-spray handguns and backpacks.

Total vegetation and woody weed control was undertaken through hand pulling and slashing along the GEP corridor.

5.5.2 Results and discussion

Overall weed management measures undertaken during the reporting period were adequate.

5.5.3 Program rationalisation

No changes are proposed to weed management at Ichthys LNG.

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 Section 5.6.2.

5.6.1 Method overview

An annual vegetation surveillance survey (Survey No. 3) was performed in accordance with the INPEX Vegetation Surveillance Plan (L290-AH-PLN-70001). Key parameters assessed during the surveillance survey are shown in Table 5-10. Rehabilitation categories (discussed in Section 5.6.2) are provided in Table 5-11. The areas surveyed is shown in Figure 5-8.

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

Table 5-11: Rehabilitation categories – assessment criteria

Vegetation Community	Category 1	Category 2	Category 3
Low Eucalypt woodland	• Annual grassland / herbland • Total vegetation cover less than 30% (post wet season, with large bare areas) • Tree or shrub seedlings or juveniles absent • Large continuous areas of bare ground • Low litter levels • Surface structures very sparse or absent • Evidence of accelerated surface run-off	• *Acacia* spp. low sparse shrubland • Scattered individuals or small patches of juveniles and seedings of Acacia and other native shrub species • Evidence of more than one shrub recruitment event i.e. mixed-age stands • Moderate litter levels • Stable soil surface	• Mixed Acacia shrubland • Several life forms presenting including shrubs, woody forbs, annual and perennial grasses • Evidence of several recruitment events of perennial species i.e. a range of cohorts • Continuous litter cover • No evidence of accelerated surface water run-off

Vegetation Community	**Category 1**	**Category 2**	**Category 3**
Low mangrove closed forest	• Seedlings or juvenile mangroves absent or present as very scattered individuals of single age cohort	• Seedlings and juvenile mangroves widespread with canopy cover > 5% • Usually evidence of more than one recruitment event, as shown by multiple age-classes	• Moderately dense stands of mangrove juvenile and seedlings with canopy cover >20% • Evidence of several mangrove recruitment events i.e. a range of age cohorts are present
Low *Melaleuca* sp. open woodland / sedgeland	• Sparse patchy cover of sedges • Melaleuca sp. seedlings or juveniles absent or present as very scattered individuals of single age cohort • Evidence of accelerated surface water run-off	• Open sedgeland with < 50% cover with small discontinuous bare patches. • Scattered individuals or sparse patches of Melaleuca sp. and other native perennials on slightly elevated ground (*Note establishment of native perennial tree and shrub species were not observed during Survey No. 2) • Moderate litter levels	• Elevated areas with Melaleuca shrubland • Evidence of several recruitment events of perennial species i.e. a range of age cohorts • Extensive litter cover • Stable soil surface with no accelerated surface run-off

Figure 5-8: Vegetation surveillance survey area

5.6.2 Results and discussion

The results of Survey No. 3 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* - Results show an overall improvement in low eucalypt woodland revegetation community establishment along the GEP Corridor. An increase of 41.8% to the area allocated to Category 3 (total 54.1% or 4.17 ha) occurred compared with Survey 2. Approximately 42.4% (3.27 ha) of the area was allocated to rehabilitation Category 2 and 3.5% (0.27 ha) allocated to rehabilitation Category 1. Acacia sp. made up most of the native regeneration tree and shrub species observed during previous surveys (Survey 1 and Survey 2). A small number of Eucalypt seedling were also observed within the GEP Corridor low eucalypt woodland rehabilitation communities during the previous surveys and it is anticipated that Eucalyptus sp. will continue to establish from adjacent remnant vegetation. Surface soils were observed to be stable, with previous actions to manage small areas of low to moderate gully erosion proving successful.
- *Mangrove low closed forest* - Low mangrove closed forest rehabilitation communities demonstrated some improvement since the previous survey, with a 41.8% increase in this community reaching rehabilitation Category 3 since the previous survey. It is expected that areas originally cleared of the dominant mangrove species *Ceriops* australis will remain suitable for the species to re-establish. This applies also to tidal flat areas that were originally mangroves before clearing of the GEP corridor and it is anticipated that non-mangrove tidal flat areas are unlikely to provide suitable conditions for the establishment of *Ceriops* australis. Surface soils were observed to be stable through the community.
- *Melaleuca open woodland/sedge land* - A decrease in rehabilitation establishment was recorded within this community, with a 32.5% increase in area allocated to rehabilitation Category 1 compared with Survey 2. This also corresponded with a substantial increase in the area attributed to this community within the GEP corridor Survey No. 3 area. This variation in area attributed to this community means that trend analyses over time are not accurate. It is anticipated that most of the rehabilitation areas described as Low Melaleuca sp. open woodland / sedgeland will establish as sedgelands, providing a stable ground cover and opportunity for Melaleuca sp. to establish in future.
- *Monsoon vine forest* – There has been an increase in the area assigned to Categories 2 and 3 (from 39.7% to 68.7%) since Survey 2. However, given the change in survey area between surveys for this community due to variable mapping techniques, trend analysis was considered likely to be inaccurate. *Acacia* spp. were the dominant revegetation species within Land unit 2a2 (low rounded hills adjacent to estuarine areas) and Melaleuca spp. were dominant within lower areas of Land Unit 2b2 (gentle side slopes on the western end of the GEP corridor).

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

Given good progress in rehabilitation is being reported, and long term nature of regeneration of vegetation, the vegetation surveillance survey frequency will be revised to biennial (every two years).

5.7 Cultural heritage

The objective of cultural heritage surveys is to determine if there has been any interference to cultural heritage sites as a result of Ichthys LNG operations.

5.7.1 Method overview

Visually inspections of cultural heritage sites will be undertaken when required at a frequency determined by the Larrakia Advisory Committee.

5.7.2 Results and discussion

No inspections of heritage site were required during the reporting period. No heritage breaches occurred within the reporting period.

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

6 WASTE REDUCTION MEASURES

Following the activation 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).

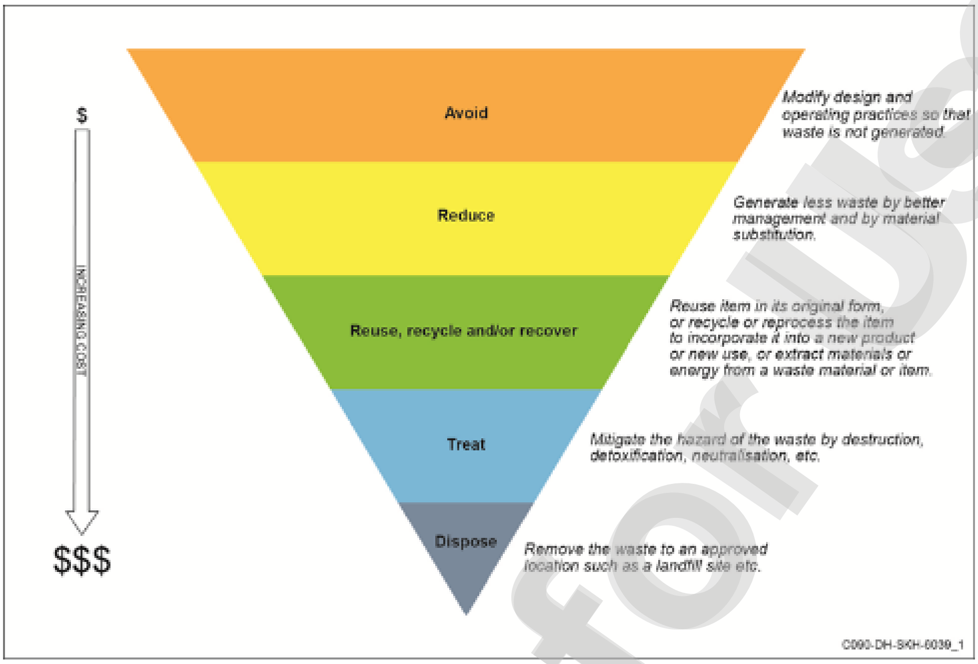


Figure 6-1: INPEX waste control hierarchy

Waste streams at the site are categorised into four broad classes (which include both liquid and solid waste, as outlined in section 3.8.3 of the OEMP):

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

Note the onsite treatment of wastewater and disposal via the onsite evaporation basin are exclude from regulated waste data (refer to Table 6-1), and only records from licenced waste contractors are used for Table 6-1.

Solid 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 following classification by waste contractors. Table 6-1 presents a comparison of the waste streams between the 2019-2020 and the 2020-2021 reporting periods. The increase in waste in 2020-2021 is attributed to the major shutdown which occurred in May 2021, when significant amounts of both liquid and solid waste were generated through the planned maintenance activities, which involved the change out dehydration and mercury guard beds. There was a decrease in recyclable hazardous waste due to the facility generating less of these waste types during the reporting period from the last, it is not attributed any specific waste initiative.

Note PFAS foam is included in Table 6-1 as a non-recyclable hazardous waste stream. In the reporting period a small amount of firefighting foam was disposed of by the laboratory following annual testing of the foam systems at the site. Approximately 5.5 kg of foam was disposed of from the site in July 2020, with the waste being classified as non-recyclable hazardous liquid waste, which underwent plasma arc destruction.

Table 6-1: Waste stream data comparison 2019-2020 and 2020-2021

Waste Stream	2019-2020 (tonnes)	2020-2021 (tonnes)
Recyclable / non-hazardous	251.113	304.348
Recyclable / hazardous	16.218	6.378
Non-recyclable / non-hazardous	1241.768	2413.149
Non-recyclable / hazardous	569.319	1122.224

The main waste reduction measure implemented during the reporting period (i.e. reduce waste being disposed or treated offsite) was through the use of the onsite evaporation basin and transfer to the sites waste water treatment plants (mainly daily sewage transfers due to the transfer pumps being taken offline for maintenance and cleaning). The evaporation basin is designed to handle low level chemical and hydrocarbon contaminated water generated at Ichthys LNG, while inter-site transfers to the wastewater treatment plants took place. Approximately 5,273 tonnes of liquid waste was transferred to the evaporation basin and 6,118 tonnes of wastewater transferred to the various water treatment plants during the reporting period, which resulted in this liquid waste not being taken offsite for treatment and disposal.

In addition, measures were put in place to minimise the amount of liquid waste being generated at Ichthys LNG. These measures included:

- The capture and storage of chemical waste streams to avoid the mixture of waste streams and rainwater runoff from Ichthys LNG. This prevents the generation of large volumes of waste water predominately in the AGRU of each LNG train, where amine is used as a solvent to extract acid gases (including carbon dioxide).
- During the May 2021 shutdown a small water recycling plant was brought onsite for the use in high pressure cleaning activities. Waste wash-water was collected, filtered and then reused. This reduced the amount of water being used for high pressure water washing, and the amount of wastewater produced from this activity

Although not directly related to solid and liquid waste, there was a significant amount energy recovery that occurred at the site through the use of the waste heat recovery systems. Heat recovery units are located on the GE Frame7 gas turbine stacks, which capture the heat of the turbine exhaust and then transfer the energy to the sites heating medium system. A similar heat transfer method is also used in the CCPP, where the exhaust heat form the GE Frame 6 turbine stacks are used to generate steam, which is then transferred into energy in the steam turbines. Use of the waste heat recovery systems reduce the overall fuel consumption and air emissions at the site.

7 PROGRAM RATIONALISATION SUMMARY

Based on the results presented in 2 to 6 a number of recommendations to rationalise monitoring programs have been presented. These changes will only be implemented once the relevant approvals or management plans have been amended and endorsed. A summary of the proposed rationalisation to the monitoring programs is provided in Table 7-1.

Table 7-1: Summary of monitoring program rationalisation

Program	Changes Proposed to Monitoring Program	Section
Commingled treated effluent (750-SC-003)	No changes are proposed.	2.1.4
Jetty outfall	No changes are proposed. Program to cease following the 2020/2021 reporting period.	2.2.4
Harbour sediment	Change in monitoring frequency from annual to biennial.	2.3.4
Ambient air quality	No changes are proposed.	3.2.4
Point source emissions to air	No changes are proposed.	3.3.3
Dark-smoke events	No changes are proposed.	3.5.3
Groundwater quality	No changes are proposed.	4.1.4
Mangrove health and intertidal sediment.	Change in monitoring frequency from annual to biennial.	5.1.4
Nearshore marine pests	No changes are proposed.	5.2.3
Introduced terrestrial fauna	No changes are proposed.	5.3.3
Weed survey	No changes are proposed.	5.4.3
Weed management	No changes are proposed.	5.5.3
Vegetation rehabilitation monitoring	Change in monitoring frequency from annual to biennial.	5.6.3
Cultural heritage	No changes are proposed.	5.7

7.1 Discharges to water

No program changes are proposed for the commingled treated effluent monitoring program, which will remain as per the EPL228 requirements.

In accordance with EPL228, jetty outfall surveys will cease following the reporting period as they were only required for the first 24 months following completion of start-up of Train 2 (19 June 2019).

It is proposed that the harbour sediment monitoring frequency is reduced from annual to biennial (every two years) as there have been no trigger exceedances attributable to Ichthys LNG operations in the three years of monitoring.

7.2 Emissions to air

No program rationalisation is proposed, and monitoring will continue in line with EPL228 conditions and OEMP commitments.

7.3 Unplanned discharges to land

No program rationalisation is proposed. Groundwater monitoring will continue biannually.

7.4 Flora, fauna and heritage

To date, monitoring during the operations phase has shown there has been no demonstrable change in mangrove health or intertidal sediments. It is proposed then that mangrove health and intertidal sediments be monitored biennially (every two years) going forward.

As good progress in rehabilitation is being reported, and due to the long term nature of vegetation regeneration, it is proposed that the vegetation surveillance survey frequency also be revised to biennial (every two years).

There are no changes proposed to any of the other flora, fauna and heritage programs.

8 REFERENCES

ANZECC/ARMCANZ—*see* Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

ANZG—*see* Australian and New Zealand Governments and Australian State and Territory Governments

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Northern Territory Environment Protection Authority. 2013. Guidelines for the environmental assessment of marine dredging in the Northern Territory. Northern Territory Environment Protection Authority, Darwin, NT.

NRETAS—see Department of Natural Resources, Environment, the Arts and Sport

NT EPA—see Northern Territory Environment Protection Authority

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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 • 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	Each section includes a subsection with monitoring methods for each monitoring program.

NT Guideline for Environmental Reporting	NT Guideline Information	AEMR Reference
	• 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:
	  ◦ units
	  ◦ assessment criteria (e.g. limits/trigger values specified in licences/approvals, or in relevant standards or guidelines2)
	  ◦ analysis type (e.g. for filtered/unfiltered with filter pore size, five-day or
	  ◦ three-day biological oxygen demand, wet or dry weights)
	  ◦ analytical methods
	  ◦ limit of reporting (LOR), or level of precision for results obtained from
	  ◦ field instruments
	  ◦ 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 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)?	Monitoring plans (referenced in the method overview section) include QA/QC processes.

NT Guideline for Environmental Reporting	NT Guideline Information	AEMR Reference
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	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.* Note: significant penalties may apply where it is demonstrated that false or misleading information has been supplied to the NT EPA.	APPENDIX B:
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).	Appendices

APPENDIX B: EPL228 AEMR 2020-2021 CERTIFICATION

B.1 INPEX

INPEX	I Tetsuhiro Murayama confirm that to the best of my knowledge and ability all the information provided in the EPL228 Annual Environmental Monitoring Report 2020-2021 [L060-AH-REP-70018] is true and accurate.
Name	Tetsuhiro Murayama
Position	Director | INPEX
Signature	
Date	28 September 2021

B.2 Qualified Professional

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INPEX Corporation
Maris Steele
Senior Environmental Advisor
Onshore Operations
144 Wickham Road
Wickham NT 0822

23 September 2021

Reference: ERM 0565508

Dear Maris

Subject: 2020-2021 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 87 of the Environmental Protection Licence (EPL) 228-04, stated as follows:

87 The Annual Environmental Monitoring Report must:

87.1 report on monitoring required under this licence;

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

87.3 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;

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

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

87.6 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;

87.7 report on outcomes of the REMP monitoring and assessment;

87.8 summarise measures taken to reduce waste;

87.9 consider the NT EPA Guideline for Reporting on Environmental Monitoring

87.10 be reviewed by Qualified Professional(s); and

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

[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.

Page 1 of 2

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ERM Group

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 EPL228-04. The review was undertaken by three qualified professionals as deemed appropriate for the content of the AEMR. The qualified professionals are listed in Table 1.

Table 1. Qualified professionals

Area of expertise	Qualified professional
Discharges to Water	Ken Kiefer
Waste	Paul Fridell
Air Quality	Christopher Thomson

Each of the qualified professionals individually reviewed the AEMR with respect to the EPL228-04 condition 87 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.

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 87 of the EPL228-04 for the 2020-2021 period.

Area of expertise	Qualified professional	Qualified profession Signatures
Discharges to Water	Ken Kiefer	
Waste	Paul Fridell	
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

ANNEX A: - COMMENTS REGISTER

INPEX

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2020/2021

Contract Number	INPEX PO 4500072962 (ERM proposal 0550625)
Reviewer	ERM
Document Name	EPL228 Annual Environmental Monitoring Report 2020-2021
Company Document No#	L060-AH-REP-70018
Document Revision No# / Date	Revision A / 24 Aug 2021

No.	Context	Reviewer Comment/Recommendation	INPEX Response	ERM response
Air Quality (Qualified Professional - Chris Thomson)				
1	Pg 49 monitoring in the event of AGRUs being down.	Under the section on Air toxics monitoring on page 49 of the AEMR, some comment should be made regarding the monitoring required for VOCs in cases where one or more of the AGRUs are offline for 90% or more of any 30 day period. (as per revision 3 of the AQMP). Along with this there should be some comment stating that the extent to which the AGRUs were offline – I know this is detailed later in the section.	This is outside of the reporting period for 2020/2021 monitoring and will be included in next year's AEMR. The revision of the endorsed OEMP with the updated air toxics monitoring requirements was provided to the NT EPA in July 2021 .	Agreed / Accepted
2	Second paragraph pg 51	The AEMR talks about investigations into PM10 and PM2.5 exceedances being attributed to planned controlled burns or bushfires in the Darwin region and these exceedances did not occur downwind of Ichthy LNG. Is there report or internal document related to the review process	Reference to the GHD monitoring reports has been included in the text in the section. Text updated to include: *'(GHD, Ichthys LNG Air Quality Monitoring Air Toxics Monthly Report – July 2020 and GHD, Ichthys*	Agreed / Accepted

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2020/2021

No.	Context	Reviewer Comment/Recommendation	INPEX Response	ERM response
		stated that can be referenced so that this information can be verified if necessary?	*LNG Air Quality Monitoring Report – August 2019 to September 2020)'*	
3	Table 3-5	Embolden the exceedances in the table as indicated in first para of 3.2.2.	Typographical error, exceedances bolden in Table 3-5.	Agreed / Accepted
4	Table 3-6	November 2019 entry second row, *"INPEX was not located upwind of the facility during this period."* Review text.	Due to the ambiguity of the text the line has been deleted from Table 3-6.	Agreed / Accepted
5	Second paragraph page 55	Modify the first sentence of the second paragraph which says that *The annual $PM_{2.5}$ review criteria is exceeded at all stations for the 14-month review period."* Or alternatively embolden annual PM2.5 for stokes hill. The reference to *previously discussed* appears to be out of place in this paragraph *"Furthermore, as previously discussed, review of exceedances of the short-term (24-hour) $PM_{2.5}$ criteria found that Ichthys LNG operations were unlikely to have contributed significantly to exceedances of the criteria."* Not sure which review of short term 24hr exceedances are being referred to here. Referring back to the emission sources of PM10 and PM2.5 would better inform this conclusion if the sources of PM within Ichthys operations are not exceeding	The text in the section was revised to address the context issues. The followed text has been included in the section: *'The annual $PM_{2.5}$ review criteria is exceeded at the Palmerston and Winnellie stations for the 14-month review period (refer Table 3-7).'* *'Review of exceedances of the short-term (24-hour) $PM_{2.5}$ criteria found that Ichthys LNG operations were unlikely to have contributed significantly to exceedances of the criteria, this is further backed through the low PM_{10} and $PM_{2.5}$ concentrating directly measured*	(suggest 'backed' is replaced with 'supported' – no change to outcome Agreed / Accepted

INPEX

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2020/2021

No.	Context	Reviewer Comment/Recommendation	INPEX Response	ERM response
		criteria or black smoke events were not experienced during this period.	*from the stationary emission point sources at the facility (refer to Section 3.3 and APPENDIX E:)'.* The footnote from Table 3-9 was replicated in Table 3-7. (*The annual average is calculated as the maximum 12-month average within the 14-month data set).	
6	Table 3-7	The footnotes beneath Table 3-9 should also be applied to table 3-7.	Refer to comment 5 above.	Agreed / Accepted
7	Appendix E	Concentration limit in ppm has criteria as 35@15%O2, should this be 25@15%O2?	As per EPL228 -04the target is 25@15%O2 and limit is 35@15%O2.	Agreed / Accepted
8	3rd bullet section 3.3.2	Third bullet erroneously identifies A7-1/A7-2 as being down during Q3 2020. Results in appendix 3 refers to A8-2 being down during this time.	Typographical error text amended to reference A8-1/A8-2.	Agreed / Accepted
9	Appendix E	Appendix E clarification question September 2021 sampling results L-640-A-001 A and B.	Typographical errors, NOx target and limit columns revised to correct transcription errors.	Agreed / Accepted
Discharges to Water (Qualified Professional – Ken Kiefer)				
1	Table 2-1	Please add clarification on samples taken: July 2020 samples - 2, 5, 7, 8, 11	Table 2-1 updated to separate out QA/QC and follow up investigation monitoring dates.	Agreed / Accepted

INPEX

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2020/2021

No.	Context	Reviewer Comment/Recommendation	INPEX Response	ERM response
		April 2021 - 22, 25, 28, 30 May 2021 - 5, 8 If they are QA/QC samples, use of a second foot note would be helpful to differentiate between QA/QC sampling vs sampling following an exceedance at location 750-SC-003. Based on Section 2.1.3, The extra July 2020 samples appear to be related to the TN exceedances from June 2020 exceedances (reported in 2019-2020 AEMR). This clarifying this in Table 2-1 or Section 2.1 would be helpful.		
2	Appendix C	The results for the 20 Aug 2020 sample is not provided in Appendix C	Typographical error. Sampling information from 20 Aug 2020 included in Appendix C.	Agreed / Accepted
3	Section 2.1.2	The text lists notes four exceedances. This is correct based on individual parameter exceedances, but the exceedances were limited to just two monthly events. Clarification that exceedances were observed in only two months would be beneficial.	The following text was included in Section 2.1.2: *'with the exceedances just limited to just two monthly sampling events.'*	Agreed / Accepted
4	Table 2-3	*E. Coli* and Faecal Coliforms exceedance Add discussion of the 1 Sep 2020 results as well.	The following text was included in Table 2-3:	Agreed / Accepted

INPEX

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2020/2021

No.	Context	Reviewer Comment/Recommendation	INPEX Response	ERM response
		A summary bullet in the corrective action that no further exceedances were reported for the remainder of the monthly monitoring	*'Further sampling conducted on 1 September 2020 at location 750-SC-003 reported E. Coli and Faecal Coliforms at <1 cfu/100mL and 6 cfu/100mL."*	
5	Table 2-3	Provide clarification in the 17 Jun 2021 sample exceedance for TN. It is not discussed. It appears it is from a sample that was taken investigating the BOD exceedance, which would have similar root causes	The following text was included in Table 2-3: *'Periodic monthly sampling occurred at location 750-SC-003 on 8 June 2021, this identified a BOD exceedance event, which was reported on 17 June 2021. Additional sampling was undertaken on 17 June 2021, to investigate the initial exceedance, which identified an exceedance of TN. Due to the follow up sampling detecting an additional analyte exceedance, the two exceedances were combined into one investigation.'*	Agreed / Accepted
6	Appendix D	Bold exceedances	Appendix D updated with the exceedances in bold.	Agreed / Accepted

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2020/2021

No.	Context	Reviewer Comment/Recommendation	INPEX Response	ERM response
			In addition, a sub-section title for the table (and for Appendix F) was included in the text.	
7	Section 2.2.2	Clarify the DO exceedances during Survey 9 sampling included both east and west reference sites. The text only notes the exceedance at Jetty West. That both reference sites had exceedances provides further support of the conclusions.	The DO exceedance did include both east and west reference site. The text in the section was revised to include the following: *'As reference sites Jetty East and Jetty West also exceeded the trigger value'*	Agreed / Accepted
8	Section 2.2.3	Add a clarification that the physio-chemical parameters discuss in Section 2.2.2 exceedance were determined not to related to the jetty outfall	Due to the exceedances not being attributed to discharges from the jetty outfall, the text in the section was revised with the following: *'Physio-chemical parameter trigger exceedances were found not to be attributable to liquid discharges from the jetty outfall, as discussed in Section 2.2.2.'*	Agreed / Accepted
9	Section 2.3.3	We agree the RPD % are less likely to be consistently achieved as results approach laboratory reporting limits. Consider updating the QA/QC triggers in the OEMP to allow for higher	INPEX will review applicable QA/QC criteria to allow for higher RPD% for when results are at or near laboratory reporting limits and	Agreed / Accepted

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2020/2021

No.	Context	Reviewer Comment/Recommendation	INPEX Response	ERM response
		RPD% when concentrations are within an order of magnitude of the laboratory reporting limit.	amend the OEMP in future revisions.	
10	Section 2.3.4	The proposed change in sediment sampling frequency is reasonable based on the results.	Acknowledged.	Agreed / Accepted
Waste (Qualified Professional – Paul Fridell)				
1	Condition 24 - WMP	There is a link between the key elements of the WMP in Condition 24 and the waste section of the AEMR. Comments below suggest that data collected for the WMP did not appear to make it into the AEMR.	Please refer to responses below to address this comment.	Agreed / Accepted
2	Waste stream categories	These waste streams recyclable/non-recyclable and hazardous/non-hazardous. It should be made clear that these 4 categories refer to both liquid and solid wastes. The term non-recyclable could mean any of the other waste reduction measures: reuse, treat or dispose. Reused waste or treated waste is better than disposal so there should be some classification to align with the waste hierarchy.	The following has been updated in the text to refence the classification scheme as outlined in the OEMP, which defaults to the high level main four waste streams. *'Waste streams at the site are categorised into four broad classes (which include both liquid and solid waste, as outlined in section 3.8.3 of the OEMP)'* Consideration will be given in future revisions of the OMEP to further breakdown the waste classification	Agreed / Accepted

INPEX

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2020/2021

No.	Context	Reviewer Comment/Recommendation	INPEX Response	ERM response
			scheme to align with the waste hierarchy.	
3	*"Waste segregation measures involved the placement of various recyclable and non-recyclable waste receptacles around Ichthys LNG"*	Presumably this only refers to the non-hazardous solid waste stream? What about solid hazardous waste? Non-recyclable hazardous wastes could have been reduced, treated or disposed. Any further details that could be provided here?	The text in the paragraph has been amended to reference both solid and liquid waste streams disposed of offsite from the facility. *'Solid 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 following classification by waste contractors.'* The section has been written to align with the waste classification scheme provided in Section 3.8.3 the OEMP. As noted above consideration will be given in future updated of the OEMP and WMP to further breakdown waste	Agreed / Accepted

INPEX

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2020/2021

No.	Context	Reviewer Comment/Recommendation	INPEX Response	ERM response
			classification to align with the waste hierarchy.	
4	*"The increase in waste in 2020-2021 is attributed to the major shutdown which occurred in May 2021, when significant amounts of both liquid and solid waste were generated through the planned maintenance activities, which involved the change out dehydration and mercury guard beds."*	Based on Table 6-1 three of the four waste streams increased. Were all these increases as a result of the major shut down as implied? What initiative resulted in the reduction of the recyclable/hazardous?	The increase in waste was a direct result of the major shutdown which occurred in May/June 2021, with the main waste generating activities being the change out the dehydration and mercury guard beds on Train 2. The reduction in recyclable hazardous waste is considered likely due to facility generating less of these waste types, during the reporting period. There were no specific waste reduction initiatives implemented to achieve this reduction. The following text has been included in the section: *'There was a decrease in recyclable hazardous waste due to the facility generating less of these waste types during the reporting period from the last, it is not attributed any specific waste initiative.'*.	Agreed / Accepted

INPEX

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2020/2021

No.	Context	Reviewer Comment/Recommendation	INPEX Response	ERM response
			An initiative used during the shutdown to reduce wastewater volumes, was a small water recycling facility that reused treated water for high pressure washing activities. The following text has been included in the section: *'During the May 2021 shutdown a small water recycling plant was brought onsite for the use in high pressure cleaning activities. Waste wash-water was collected, filtered and then reused. This reduced the amount of water being used for high pressure water washing, and the amount of wastewater produced from this activity.'*	
5	*"The main waste reduction measure implemented during the reporting period (i.e. reduce waste being disposed offsite)*	Note that evaporation is still liquid waste disposal. Are the figures disposed on-site 5,273 tonnes and 6118 tonnes don't appear to be captured in Table 6-1. This is not avoidance as implied in the statement *"….which resulted in this liquid waste not being taken offsite for treatment and*	Table 6-1 is specific to the offsite disposal of regulated liquid and solid waste by licenced contractors and excluded the onsite treatment/discharge and disposal of wastewater under EPL228 and the	Agreed / Accepted

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2020/2021

No.	Context	Reviewer Comment/Recommendation	INPEX Response	ERM response
	was through the use of the onsite evaporation basin"	*disposal."* It's still waste being generated and disposed so should be captured in Table 6-1.	OEMP. Where appropriate the preference is to manage wastewater streams onsite if they are suitable. The following text has been included in the section: *'Note the onsite treatment of wastewater and disposal via the onsite evaporation basin are exclude from regulated waste data (refer to Table 6-1), and only records from licenced waste contractors are used for Table 6-1. '*	
6	PFAS foams	Condition 27.1 requires best available practices for disposal of PFAS foams. Include a definitive statement whether PFAS foams are or are not included in the table 6-1.	A small amount of firefighting foam was disposed of by the laboratory following annual testing of the foam systems at the site. Approximately 5.5 kg of foam was disposed of from the site in July 2020, with the waste being classified as non-recyclable hazardous liquid waste, which underwent plasma arc destruction. The following text has been included in the section:	Agreed / Accepted

INPEX

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2020/2021

No.	Context	Reviewer Comment/Recommendation	INPEX Response	ERM response
			'Note PFAS foam is included in Table 6-1 as a non-recyclable hazardous waste stream. In the reporting period a small amount of firefighting foam was disposed of by the laboratory following annual testing of the foam systems at the site. Approximately 5.5 kg of foam was disposed of from the site in July 2020, with the waste being classified as non-recyclable hazardous liquid waste, which underwent plasma arc destruction.'	
7	Energy recovery	Discuss any energy recovery initiatives considering the requirements of the WMP.	From the liquid and solid waste generated at the facility only a minor component was able to be sent to facilities where energy from the waste product could be recovered. Due to the small volume and amount of energy recovered it was not specifically mentioned in this section. The main form of energy recovery at the site is through waste heat	Agreed / Accepted

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2020/2021

No.	Context	Reviewer Comment/Recommendation	INPEX Response	ERM response
			recovery systems. The following text has been included in the section; *'Although not directly related to solid and liquid waste, there was a significant amount energy recovery that occurred at the site through the use of the waste heat recovery systems. Heat recovery units are located on the GE Frame7 gas turbine stacks, which capture the heat of the turbine exhaust and then transfer the energy to the site heating medium system. A similar heat transfer method is also used in the CCPP, where the exhaust heat form the GE Frame 6 turbine stacks are used to generate steam, which is then transferred into energy in the steam turbines. Use of the waste heat recovery systems reduce the overall fuel consumption and air emissions at the site.'*	

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 3, 2 Ord St, West Perth, Western Australia 6005.

(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 on the 22nd day of September 2021.

(3) Signature of the person making the declaration

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

Witnessed by: Rebecca Sarah Neeling

(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

08 6467 1643

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, Paul Steven Fridell 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.

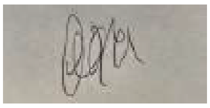
Declared at Melbourne on the 22nd day of September 2021.

(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

Ann Akova

....

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

0419 542 884

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.

ANNEX C: - QUALIFIED PROFESSIONAL PROFILE AND CV

Air Quality

Christopher Thomson (Air Quality Qualified Professional)

Chris is a Principal Environmental Scientist and has gained his 20 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, and participated in the annual statutory audit for the Ichthys LNG facility in October 2019, providing a focus on the air quality components of the site's operating licence. He also undertook the review of the Ichthys AEMR and OEMP for the 2018/2019 and the AEMR review and endorsement for the 2019/2020 period of operations. These opportunities have provided Chris with a deeper understanding of the operations of the plant and an appreciation of the project's performance.

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

Paul Fridell (Waste - Qualified Professional)

Paul is an ERM partner based in Melbourne with approximately 25 years' of experience in the environmental consulting industry and a Victorian EPA appointed Environmental Auditor.

Relevant to this role, Paul's experience includes 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. Paul also acted as the lead auditor and NT EPA Qualified Person on a number of the Ichthys dredging (EPA8) and onshore construction (EPA7) compliance audits from 2012-2019 which included audits of INPEX operations waste records and waste reduction measures.

Christopher Thomson

Principal Environmental Scientist

Chris has 19 years' international experience coordinating Environmental Impact Statements, drafting impact assessments and executing air quality monitoring programs for a range of mining, infrastructure and oil and gas projects.

During his 11 years working in WA, Chris' oil and gas experience is highlighted by be a number of key projects which exemplify his broad capabilities. These include being seconded as the environment advisor to the Chevron's Central Environment team for Wheatstone; successfully managing the execution of 3D Oil's Sauropod EP; undertaking compliance audits for INPEX's Ichthys project in Darwin as well as coordinating a fugitive emissions assessment for Buru Energy in Australia's Kimberly region for its onshore gas operations. This experience allows him to enjoy the advisory aspect to his project management and client-facing role and delivering projects, which meet stakeholder expectation.

Experience: 19 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

Environmental Impact Assessment

HazerGroup: Environmental Approvals strategy and Scoping Study 2019

This study provided an approvals strategy, schedule and risk assessment for a proposed industrial facility within the Perth Metropolitan area. This piece of work identified all relevant approvals for the proponent and allowed the proponent to visualise the development progress allowing decisions to be made at board level.

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.

3D Oil: Sauropod Seismic Environment Plan 2019

Chris was the PM for executing the scopes to produce the offshore seismic environment plan. This involved, coordinating sub-consultant and internal ERM technical expertise to deliver a timely and robust document for public and regulatory review.

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 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
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.

Air Quality Monitoring and Environmental Management

Amazon: Environmental Site Assessment, Obligations Register and Environmental Management Plan, 2019- ongoing
Chris was the lead assessor on this project covering a scope that included a site visit / due diligence audit, preparation of the site's operational EMP including comprehensive risk assessment, preparation of a site audit schedule, monitoring plan.

INPEX Australia: Ichthys LNG Plant compliance audit EPL 228 2019
Chris was part of the ERM site team to execute the annual Compliance Audit of INPEX operating licence 228. Chris' focus included the air quality, greenhouse gas and facility emissions from the plant.

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.

Hastings Technology Metals: Yangibana Rare Earths project, AQMP and plume dispersion review assessment 2019
Chris provided project management and technical review of the outgoing deliverables. Purpose of the reporting was to meet approval conditions and present options for process stack heights to feed back into the design and ultimately the works approval for the project.

Woodside LCA comparative assessment – 2019/20
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.

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.

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.

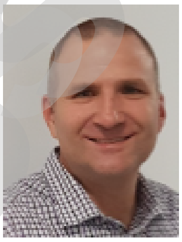
Yorke Environmental Consultants – Perth, WA. Environmental Assistant, May 1997/Sept 1997
Carried out air emissions monitoring and inline sampling for particulates, sulphurous and nitrous oxides from mining operations and industrial sites around WA. The work required the use of an Andersen GS 80 Stack 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.

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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

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.

- 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.

- 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.

Paul Fridell

ERM Partner
Victorian EPA Appointed Environmental Auditor
South Australian EPA accredited Site Contamination Auditor

Paul Fridell is a Partner within ERM based in Melbourne with more than 20 years' experience in environmental consulting including waste management, environmental management, landfill cell design assessments/approvals and landfill impact assessments.

Paul's experience in the waste strategy and planning area includes preparation of strategic waste management plans for Regional Waste Management Groups, municipal councils and private site managers (e.g. airports, ports, markets), technology reviews for government or private waste operators, obtaining environmental approvals for waste technologies and expert witness / technical support services.

Experience: 20+ years' experience, including providing compliance and approvals advice to waste, power, Defence and oil and gas sectors.

Email: paul.fridell@erm.com

LinkedIn: https://www.linkedin.com/in/paul-fridell-8708b75/

Education

- Master Environmental Science (Hydrogeology & Waste Management), University of Melbourne (2002)
- Bachelor Science (Geology & Geography), University of Melbourne (1996)

Professional Affiliations and Registrations

- Waste Management Association of Australia (WMAA)
- Member Australian Land and Groundwater Association (ALGA)

Languages

- English, native speaker

Fields of Competence

- Strategic waste management;
- Contaminated site assessment and remediation
- Hydrogeology (contaminant fate and transport)
- Contaminated site auditing
- Major infrastructure development environmental management;
- Waste classification and management;
- Landfill cell / containment cell design and construction.

Key Industry Sectors

- Upstream and Downstream Oil & Gas;
- Power Sector;
- Land Development;
- Local & State Government;
- Defence;
- Infrastructure Operators (airports, ports, markets);
- International Aid Organisations.

Appointments

- Victorian EPA Environmental Auditor (appointed pursuant to the Environmental Protection Act 1970)
- South Australian EPA accredited Site Contamination Auditor

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Paul Fridell

Key Projects

Mercury and Naturally Occurring Radioactive Material (NORM) Waste Management Review – Australia (2016).

Technical lead for a mercury and **Naturally Occurring Radioactive Material (NORMs)** waste management study for the operations phase of a major liquefied natural gas (LNG) project in Northern Australia. Works included disposal options market review (nationally and internationally) and legislative review.

Abardi Floating FLNG, Development of Waste Management Study, INPEX Masela Ltd, Jakarta (2015).

Technical specialist responsible for the technical delivery of the Waste Management Study for the proposed floating liquefied natural gas (FLNG) (7.5 mtpa) located in the 3,221 km2 Masela block in the Arafura Sea about 350 km from east of Timor Island. The aim of the waste management study was to detail the logistical plan for the transportation and disposal, including collection, segregation, manifesting and storage, of waste materials (including hazardous wastes and **NORMS**) from the proposed Abadi FLNG facility for final disposal as part of the proposed FLNG development.

Confidential O&G Client, Strategic Waste Advice for Decommissioning of Off-shore Platforms.

Technical lead and partner in charge of an initial, high-level desk top assessment of established waste/ decommissioning facilities in Australia and the Asia Pacific Region. The overall objective of the study was to assess the waste management capacity of facilities (either current or potential) to receive, decommission, recycle, reuse and dispose of steel jackets, topsides and associated wastes (both hazardous and non-hazardous, **NORMS**) relating to retirement of the client's offshore platforms.

Thevenard Island Facility, WA – Waste Management Plans for Cessation and Retirement, Chevron Australia (2013).

Technical specialist responsible for the technical delivery 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 considering mercury impregnated wastes and **NORMS**.

Gippsland Water, NORM landfill cell construction audit.

Formal audit of construction of a NORMS landfill cell for the disposal of waste from the Bass Strait off-shore LNG platforms. The landfill cell audit included an audit of the construction of the design and construction of the basal liner and capping system.

Development of District Waste Management Plans, Tsunami Relief – Aceh and Nias, Indonesia (2007-2009), United Nations Development Programme (UNDP).

Project Manager of the project which involved the re-establishment of waste infrastructure in the Districts most impacted by the December 2004 Tsunami and earthquake and development of district strategic waste management plans for 11 Tsunami affected districts. The Waste Management Strategy for each district covered the long-term vision for sustainable waste management over the following 15 years with the aim of improving public health, environmental protection, economic development and maximising employment in waste management within the districts.

The strategy included a review and made recommendations related to waste collection, transport and disposal together with human resources/capacity, finances/ cost recovery and associated facilities such as any existing workshops, collection vehicles, and heavy equipment.

Victorian Advanced Resource Recovery Initiative (VARRI), Department of Sustainability and Environment & the Metropolitan Waste Management Group (2010).
Key environmental advisor within the Engineering Advisory Services team to assist in developing the business case for the establishment of up to eight Advanced Waste Treatment (AWT) facilities in Melbourne by 2014. The business case was driven by the Towards Zero Waste Strategy of the Victorian State Government to achieve the target of 65% resource recovery from Municipal Solid Waste (MSW). Engineering and environmental screening and evaluation criteria were developed to allow the assessment over 50 AWT technologies for their applicability to the Melbourne waste market including likely community acceptance, technical proof /track record of the technologies and ability to meet EPA and other state environmental and planning policies and legislation.

Preparation of a Municipal Waste Management Plan for Mildura Rural City Council (2010).
Project director for the development of a five year – 2010 to 2015 – Municipal Waste Management Plan with the aim of providing long term direction for waste management activities in the municipality in line with state waste management policies and strategies, such as the Towards Zero Waste Strategy (Sustainability Victoria, 2005). The plan had to deal specifically with C&I and C&D wastes being taken across the border into NSW as result of landfill pricing, a cost benefit analysis of implementing recycling collection in some remote parts of the municipality and green waste collection processing options in response to community demand.

Preparation of Barwon Regional Waste Management Plan 2006 – 2016, Barwon Regional Waste Management Group (2005).
Paul was technical reviewer for the project involving the development of a framework for strategic regional waste management planning for the short term (5 year) and long term (20 year). The BRWMG included 4 council areas and covered an area of almost 7,000 km² supporting a population of approximately 220,000. Preparing the plan included: development of a waste minimisation recovery program; development of a program for existing and future waste management facilities; quantification of waste collected in public place litter bins and identification of options for litter management; identification of options for the management of organics; evaluation of the impact of tourism on waste generation and existing and future waste management systems; analysis of commercial and industrial wastes received at landfill and future management options. A comprehensive community consultation process was conducted throughout the development of the Plan.

Preparation of a Waste Management Strategy for Port of Melbourne Corporation (2008).
Project manager for the development of a waste management plan to deal specifically with wastes generated by ships docking at Melbourne Port Corporation Facilities. The plan was required to consider maximising resource recovery and handling of quarantined wastes.

Preparation of a Municipal Waste Management Plan for Mount Alexander Shire Council (2010).
Project director for the development of a Municipal Waste Management Plan for the council with the aim of providing long term direction for waste management activities in the municipality in line with state waste management policies and strategies, such as the Towards Zero Waste Strategy (Sustainability Victoria, 2005). Specifically, works involved a critical review of existing waste collection contract and how the contract structure was influencing the waste tonnage statistics, waste infrastructure review (landfill and transfer station operations), and management of a number of legacy landfill sites and development of a funding model to rehabilitate and close such sites.

SITA Alternative Waste Treatment (SAWT) facility, Works Approval Application.
Project manager of the preparation of an EPA Works Approval for the development of SITA's Advanced Waste Treatment (SAWT) facility at the Hallam Road landfill in Hampton Park, Melbourne. The SAWT facility was designed to recover resources (predominantly organics) from the incoming putrescible waste stream.

Preparation of a Regional Waste Management Plan, Gippsland Regional Waste Management Group (2007). Paul was the project manager for the project involving the development of a framework for strategic regional waste management planning to achieve the objectives of the Gippsland Regional Waste Management Group. the project involved: assessment of current waste management systems; identifying where improvements to waste collection practices could be made; development of a waste avoidance and minimisation strategy with associated actions to achieve specified objectives; development of a program for existing and future waste management facilities; development of a litter prevention and management strategy which specified actions to reduce litter in the region; and analysis of commercial and industrial and construction and demolition wastes received at landfill and development of strategies for management of these waste types.

Preparation of a Municipal Waste Management Plan, East Gippsland Shire Council (2010).
Paul was the project manager for the project involving the development strategic municipal waste management plan to ultimately improve the council's waste budget. The project required a full assessment of facility operational costs (subcontracted), collection costs and disposal gate fee costs. A thorough review of waste management contracts and gate fees revealed a sufficient short fall in revenue compared to costs and recommendations were made to reduce costs and improve efficiencies in waste collection and management across the municipality. A large number of legacy sites and regulatory pressure to rehabilitate the sites also required a critical review of risk of a number of legacy landfill sites and development of a funding model to rehabilitate and close such sites.

Waste Management Plan and Waste Audits, Essendon Airport Pty Ltd (2002 - 2010).
Paul was the project manager and principal technical advisor to Essendon Airport on all environmental matters from 2002 – 2010 including contaminated land, water sensitive urban design, stormwater quality, flora and fauna wand waste management. During this time Paul was involved in undertaking waste audits of airport tenants (land and air side), preparing a waste management plan for Essendon Airport Operations, commercial waste audit of Essendon Airport offices and reviewing environmental management plans for developers and civil contractors undertaking works within the Airport boundary.

Waste Management Services Contract Review, Wellington Shire Council (2009).
Paul was the project manager of a project for Wellington Shire Council to review the waste management services contract, which covered the delivery of kerbside collections and the management of rural and regional landfills (3) and transfer stations (8) for a ten-year period. The previous contract was reviewed in light of Council's updated requirements, significant policy and structural changes in the waste management industry over the preceding years, and consolidations amongst commercial waste management companies. Council's ambition was to maximise resource recovery and increase diversion of waste from landfill across the Shire. The project team worked with Council to review operations of all sites and the business model of outsourced management of the landfill and transfer stations. As a result, a number of recommendations were made on potential upgrades to the contract structure. Following this review Paul was technical reviewer in the Expression of Interest phase of the new contract and select a shortlist of tenderers.

Preparation of a Municipal Waste Management Plan, East Gippsland Shire Council (2010).
Paul was the project manager for the project involving the development strategic municipal waste management plan to ultimately improve the council's waste budget. The project required a full assessment of facility operational costs (subcontracted), collection costs and disposal gate fee costs. A thorough review of waste management contracts and gate fees revealed a sufficient short fall in revenue compared to costs and recommendations were made to reduce costs and improve efficiencies in waste collection and management across the municipality. A large number of legacy sites and regulatory pressure to rehabilitate the sites also required a critical review of risk of a number of legacy landfill sites and development of a funding model to rehabilitate and close such sites.

Preparation of a Greenwaste Compost Market Analysis in Christchurch, SITA Environmental Solutions (2008).

Paul was the project manager for the project involving a strategic analysis of the compost/greenwaste organics market in Christchurch, New Zealand. The review involved identifying the existing greenwaste compost producers within the region, retail prices of product and various retail outlets, identification of any markets for bulk greenwaste compost and market barriers to be overcome.

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

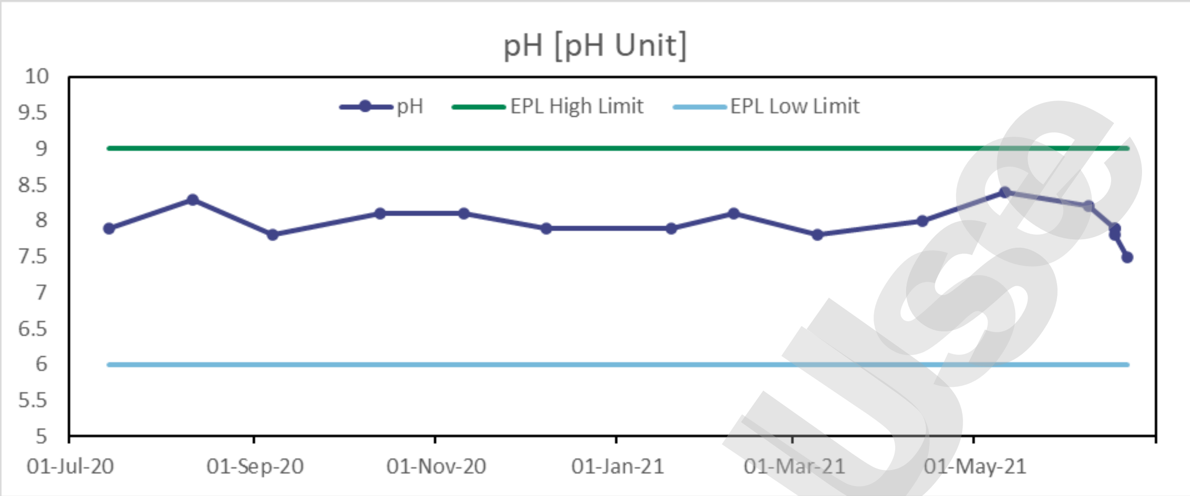
C.1 Weekly/monthly sampling results for 750-SC-003

Shaded cells indicate trigger exceedances described in Table 2-3.

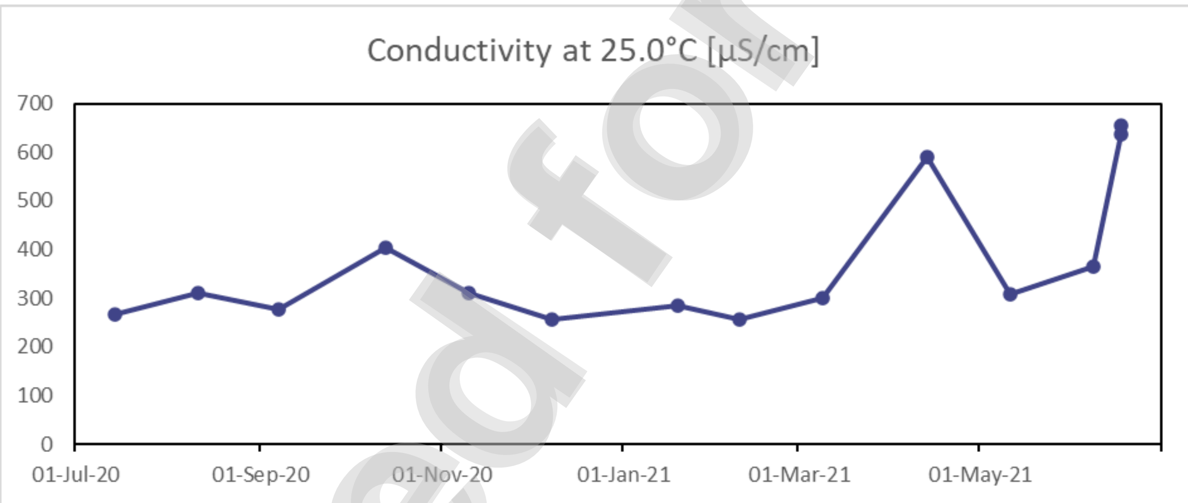
Date	TIME	LIMS Sample ID	pH	Electrical conductivity	Temperature	Turbidity	Dissolved oxygen	TPH as oil & grease	TRH (C6-C10)	TRH (C10-C40)	TSS	BOD	COD	Free Chlorine	Ammonia	Total nitrogen	Total phosphorus	Filterable Reactive Phosphorus	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc	Enterococci	E coli	Faecal coliforms	Anionic surfactants	aMDEA	Glycol (MEG)	Glycol (TEG)
Unit			pH units	µS/cm	°C	NTU	%	mg/L	µg/L	µg/L	mg/L	mg/L	mg/L	mg/L	µg N/L	µg N/L	µg P/L	µg P/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	cfu/ 100mL	cfu/ 100mL	cfu/ 100mL	mg/L	mg/L	mg/L	mg/L
Discharge limit			6 to 9	n/a	35	n/a	n/a	6	n/a	n/a	10	20	125	2	n/a	10000	2000	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
02-Jul-20	10:45 AM	L2003169001	-	-	-	-	-	-	-	-	-	-	-	-	3000	4000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
05-Jul-20	8:20 AM	L2003221001	-	-	-	-	-	-	-	-	-	-	-	-	16000	**17000**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07-Jul-20	9:30 AM	L2003263001	-	-	-	-	-	-	-	-	-	-	-	-	10000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
08-Jul-20	12:23 PM	L2003279001	-	-	-	-	-	-	-	-	-	-	-	-	4000	5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11-Jul-20	8:35 AM	L2003348001	-	-	-	-	-	-	-	-	-	-	-	-	8000	9000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14-Jul-20	6:55 AM	L2003397001	7.9	266	24.4	1.0	80	<1	<20	<100	<5	<2	12	<0.02	<2000	<2000	<500	<500	<0.1	<1	7	<1	<0.1	4	<1	204	<1	<1	<1	<0.1	<5	<5	<5
11-Aug-20	7:57 AM	L2003900001	8.3	311	27.3	1.0	84	<1	<20	<100	<5	2	8	<0.02	<2000	2000	<500	<500	<0.1	<1	4	<1	<0.1	4	<1	148	13	**3800**	**5700**	<0.1	<5	<5	<5
20-Aug-20	8:28 AM	L2004299001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<1	<1	<1	-	-	-	-
01-Sep-20	7:10 AM	L2004299001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<1	6	-	-	-	-
07-Sep-20	8:10 AM	L2004410001	7.8	277	29.6	1.0	82	<1	<20	<100	<5	5	12	0.02	<2000	3000	<500	<500	<0.1	<1	3	<1	<0.1	<1	<1	73	85	10	10	<0.1	<5	<5	<5
15-Sep-20	7:46 AM	L2004523001	-	-	-	-	-	<1	-	-	<5	-	12	<0.02	7000	7000	<500	<500	-	-	-	-	-	-	-	-	-	-	-	-	<5	<5	<5
13-Oct-20	10:20 AM	L2005058001	8.1	404	32.7	0.5	90	<1	<20	<100	<5	2	-	<0.02	5000	6000	<500	<500	<0.1	<1	5	<1	<0.1	<1	<1	28	<1	<1	<1	0.3	<5	<5	<5
10-Nov-20	09:02 AM	L2005539001	8.1	310	32.5	2.0	83	<1	<20	<100	<5	13	17	0.02	4000	5000	<500	<500	<0.1	<1	4	<1	<0.1	<1	<1	116	<1	1	1	<0.1	<5	<5	<5
08-Dec-20	08:00 AM	L2006055001	7.9	257	31.0	1.0	83	<1	<20	<100	<5	2	12	<0.02	<2000	3000	<500	<500	<0.1	<1	2	<1	<0.1	2	<1	368	11	5	5	<0.1	<5	<5	<5
19-Jan-21	09:20 AM	L2100186001	7.9	286	27.9	5.0	87	<1	<20	<100	<5	<2	11	<0.02	<2000	9000	<500	<500	<0.1	<1	2	<1	<0.1	1	<1	140	3	<1	<1	<0.1	<5	<5	<5
9-Feb-21	09:13 AM	L2100662001	8.1	257	27.8	1.0	94	<1	<20	<100	<5	<2	7	0.025	<2000	<2000	<500	<500	<0.1	<1	1	<1	<0.1	<1	<1	122	3	2	2	<0.1	<5	<5	<5
9-Mar-21	09:25 AM	L2101075001	7.8	301	30.0	1.0	92	<1	<20	<100	<5	<2	13	<0.02	<2000	2000	<500	<500	<0.1	<1	<1	<1	<0.1	<1	<1	116	17	<1	<1	<0.1	<5	<5	<5

Date	TIME	LIMS Sample ID	pH	Electrical conductivity	Temperature	Turbidity	Dissolved oxygen	TPH as oil & grease	TRH (C6-C10)	TRH (C10-C40)	TSS	BOD	COD	Free Chlorine	Ammonia	Total nitrogen	Total phosphorus	Filterable Reactive Phosphorus	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc	Enterococci	E coli	Faecal coliforms	Anionic surfactants	aMDEA	Glycol (MEG)	Glycol (TEG)
13-Apr-21	08:15 AM	L2101588001	8.0	590	31.3	0.5	78	<1	<20	<100	<5	<2	11	<0.02	3000	5000	<500	<500	<0.1	<1	2	<1	<0.1	<1	<1	52	1	2	2	<0.1	<5	<5	<5
22-Apr-21	11:54 AM	L2101743001	-	-	-	-	-	-	-	-	-	-	-	-	2000	3000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25-Apr-21	12:07 PM	L2101776001	-	-	-	-	-	-	-	-	-	-	-	-	2000	6000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28-Apr-21	08:05 AM	L2101861001	-	-	-	-	-	-	-	-	-	-	-	-	<2000	3000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30-Apr-21	08:15 AM	L2101884001	-	-	-	-	-	-	-	-	-	-	-	-	<2000	2000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
05-May-21	10:58 AM	L2101949001	-	-	-	-	-	-	-	-	-	-	-	-	2000	3000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
08-May-21	08:23 AM	L2101974001	-	-	-	-	-	-	-	-	-	-	-	-	<2000	2000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11-May-21	09:45 AM	L2102049001	8.4	307	32.7	1.0	99	<1	<20	<100	<5	<2	15	<0.02	4000	4000	<500	<500	<0.1	<1	2	<1	<0.1	1	<1	302	190	2	2	<0.1	<5	<5	<5
08-Jun-21	08:35 AM	L2102440001	8.2	366	28.6	1.0	97	<1	<20	<100	<5	**23**	21	<0.02	<2000	4000	1400	1400	<0.1	<1	5	<1	<0.1	<1	<1	62	1	<1	<1	<0.1	<5	<5	<5
17-Jun-21	01:00 PM	L2102581001	7.9	637	32.0	3.0	96	<1	<20	<100	<5	<2	11	-	3000	10000	2000	2000	<0.1	<1	9	<1	<0.1	2	<1	54	13	<1	<1	<0.1	<5	<5	<5
17-Jun-21	01:00 PM	L2102582001	7.9	655	32.8	2.0	95	<1	<20	<100	<5	<2	12	-	<2000	10000	2000	2100	<0.1	<1	8	<1	<0.1	1	<1	53	3	<1	<1	<0.1	<5	<5	<5
17-Jun-21	01:15 PM	L2102583001	-	-	-	-	-	<1	-	-	-	-	-	-	2000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17-Jun-21	01:00 PM	L2102603001	7.8	-	32.7	-	95	<1	-	-	-	<2	11	-	-	**11000**	2000	2400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21-Jun-21	09:10 AM	L2102622001	7.5	-	26.5	-	84	-	-	-	-	-	< 3	-	-	3000	<500	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-

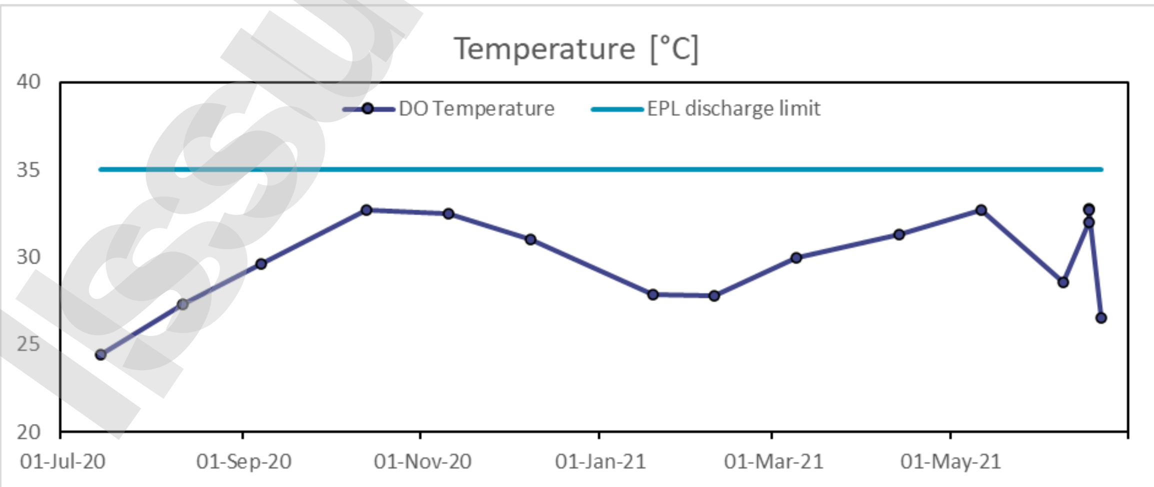
C.2 pH



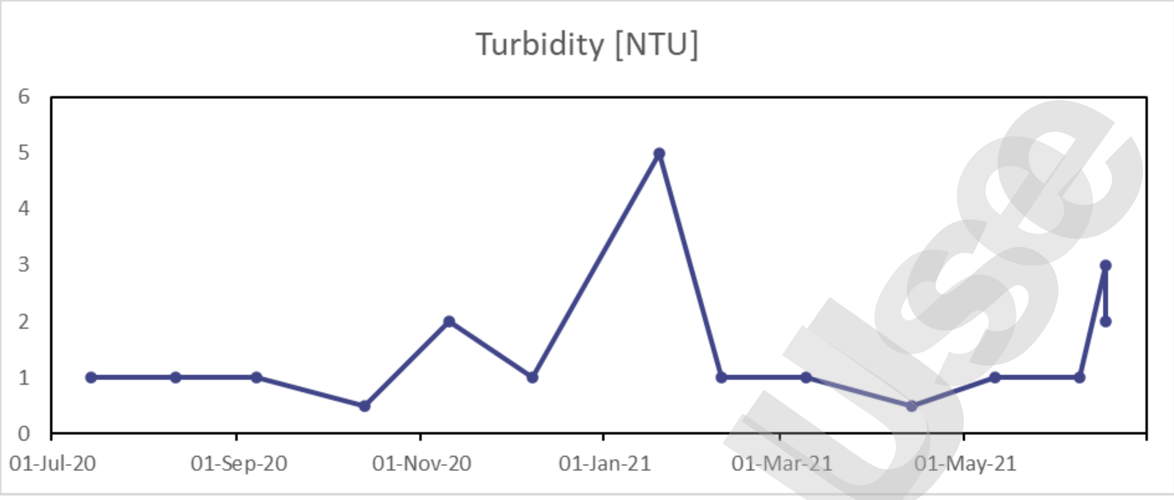
C.3 Conductivity



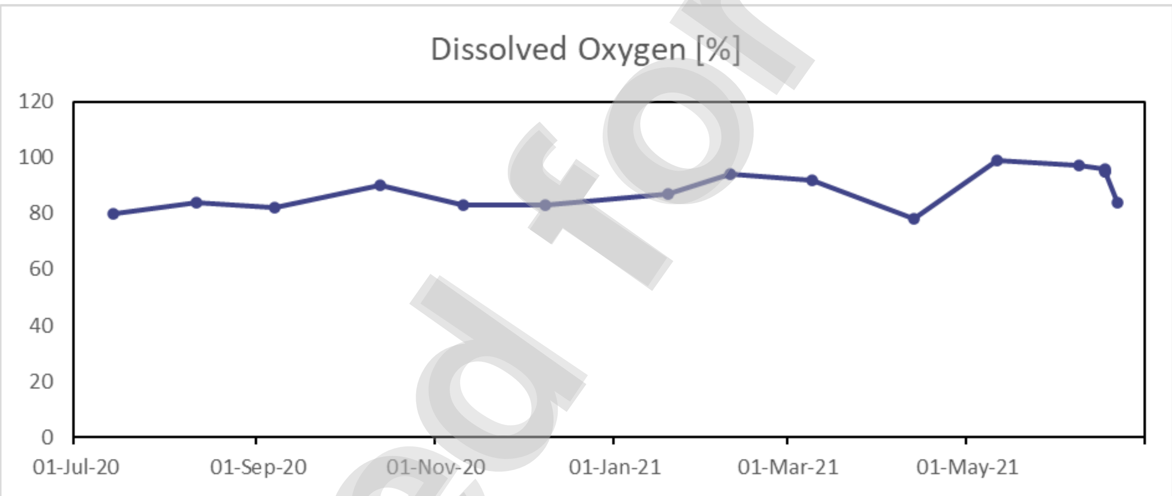
C.4 Temperature



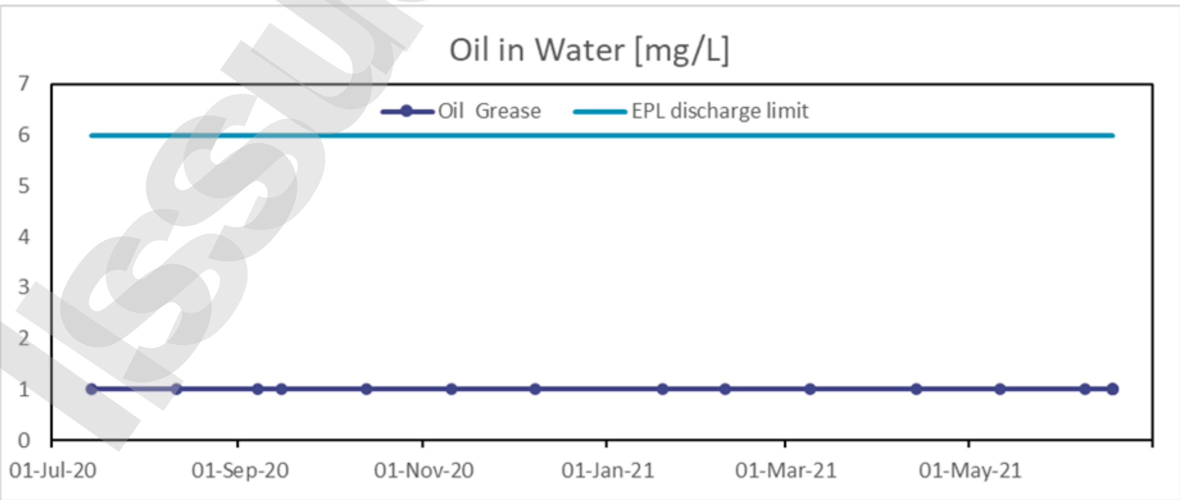
C.5 Turbidity



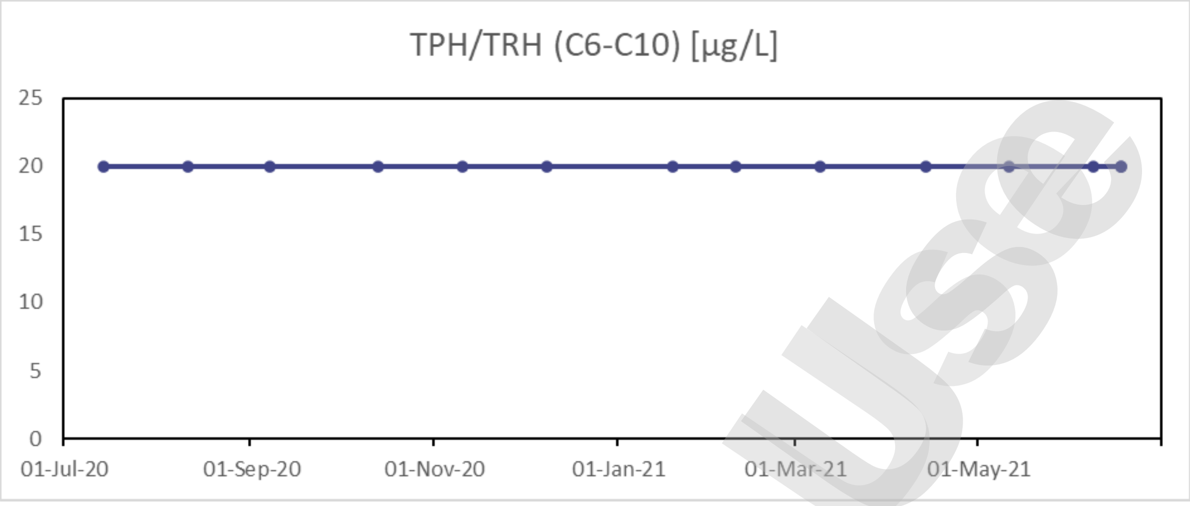
C.6 Dissolved oxygen



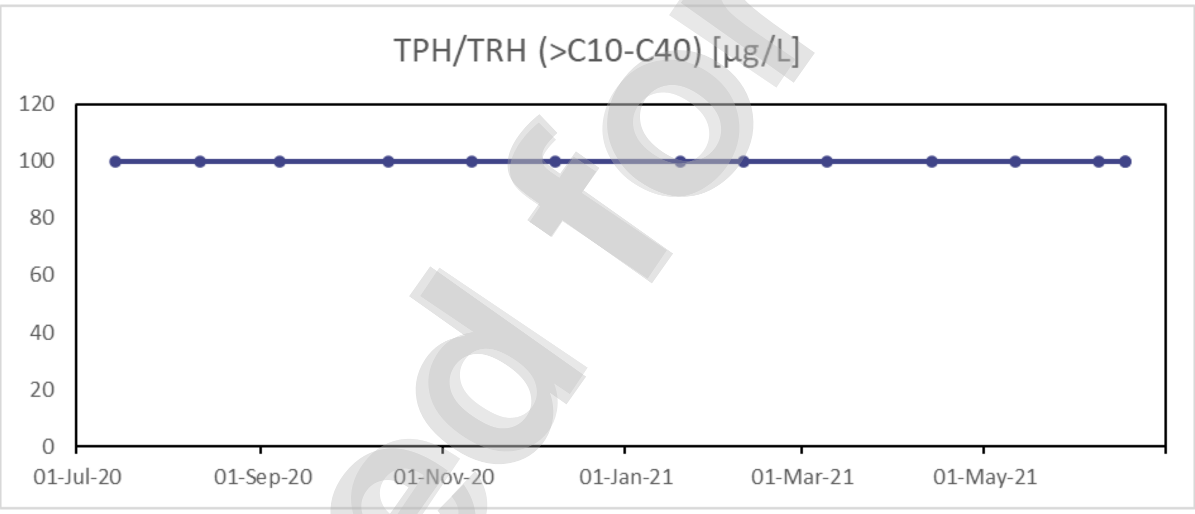
C.7 Oil in water



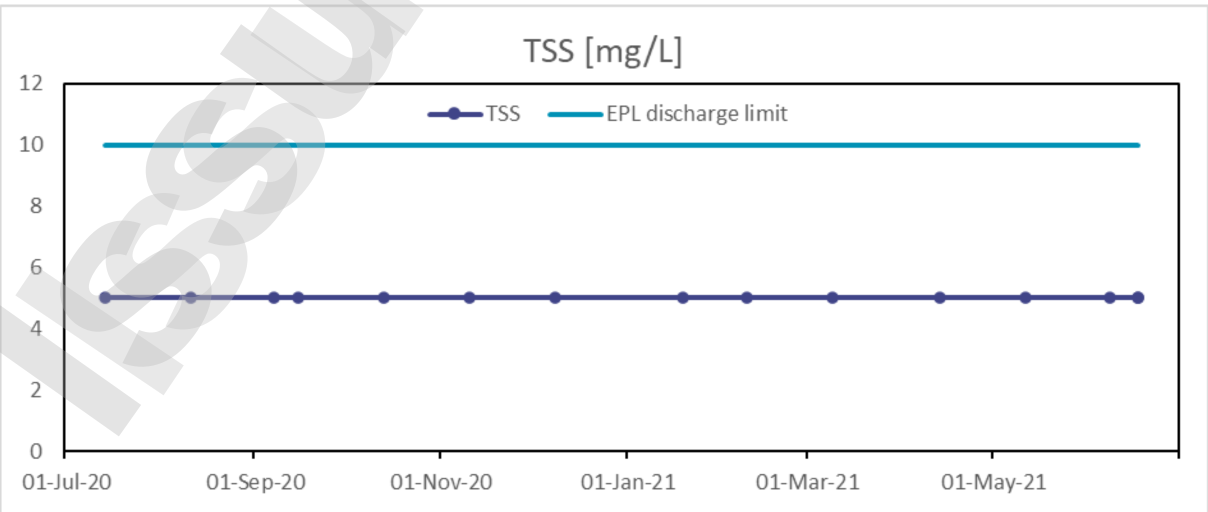
C.8 Total Recoverable Hydrocarbons (C6-C10)



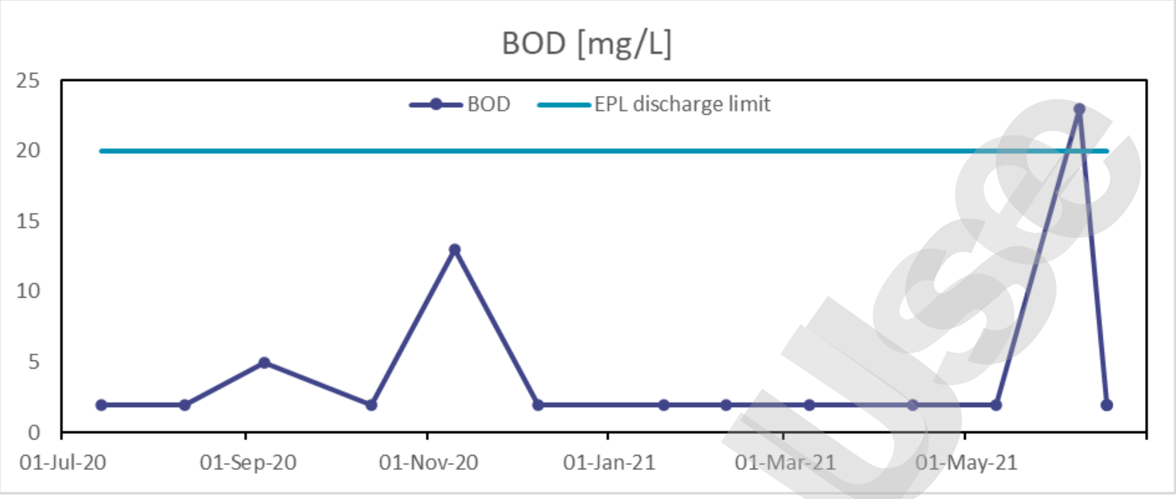
C.9 Total Recoverable Hydrocarbons (C10-C40)



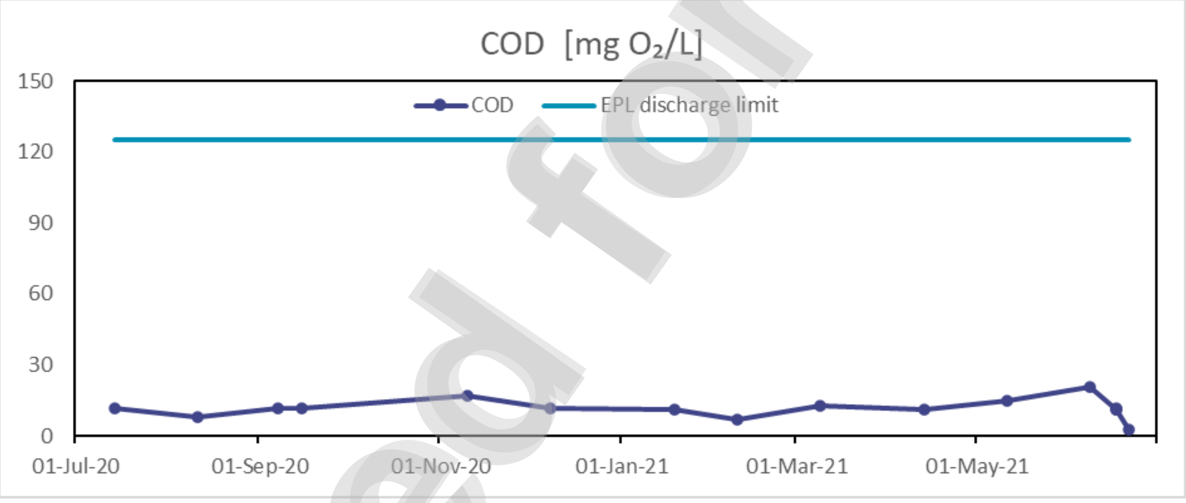
C.10 Total suspended solids



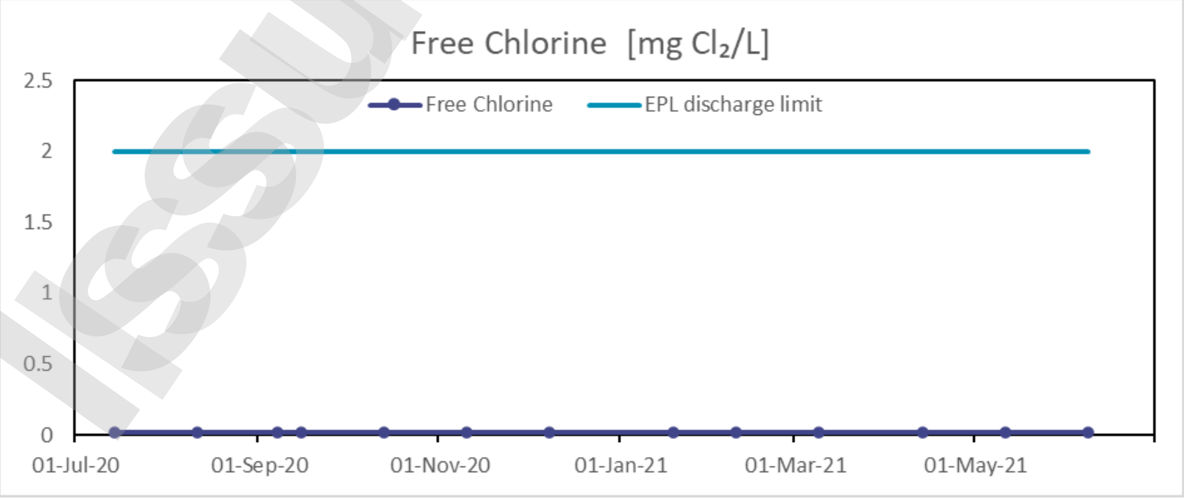
C.11 Biological oxygen demand



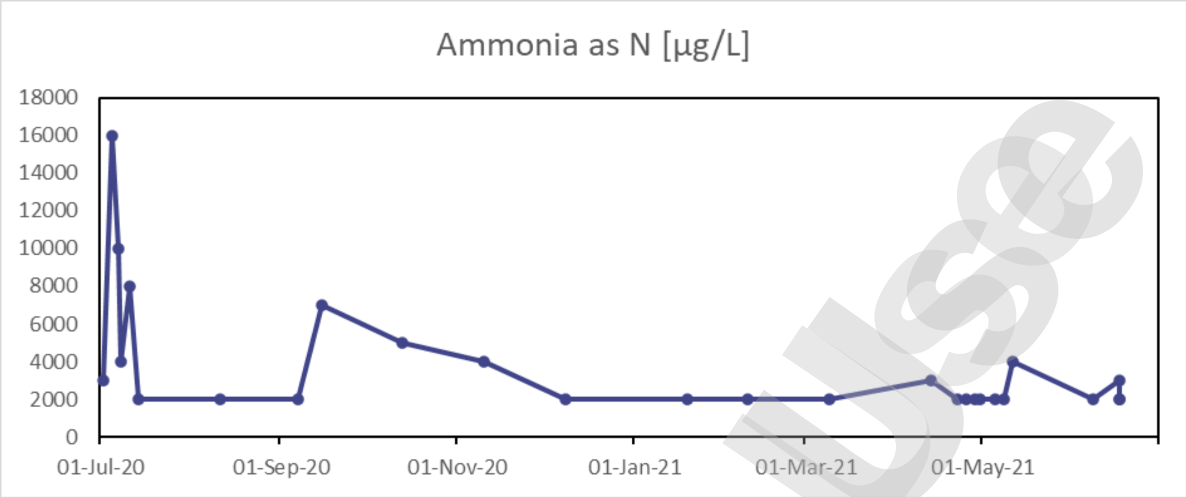
C.12 Chemical oxygen demand



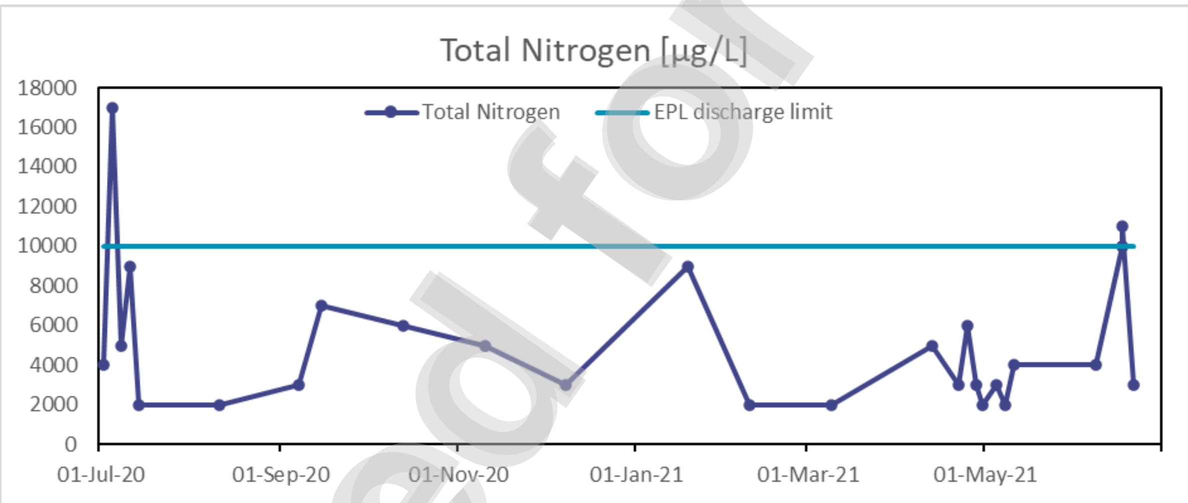
C.13 Free chlorine



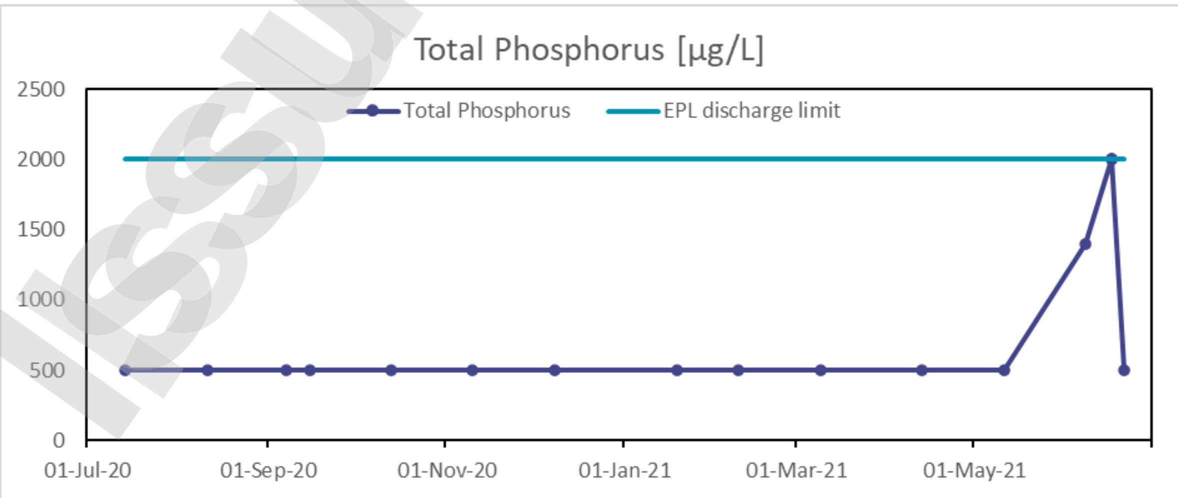
C.14 Ammonia



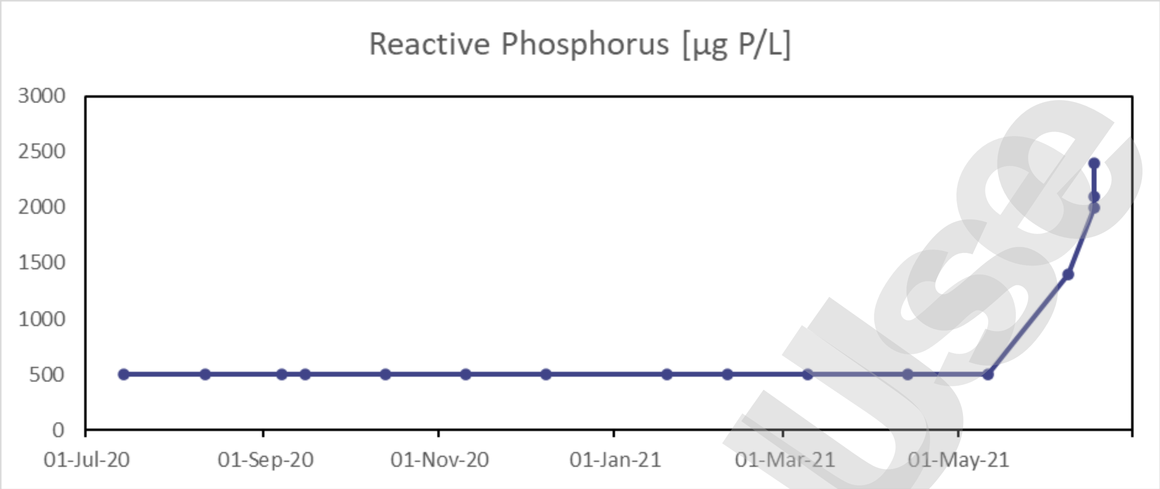
C.15 Total nitrogen



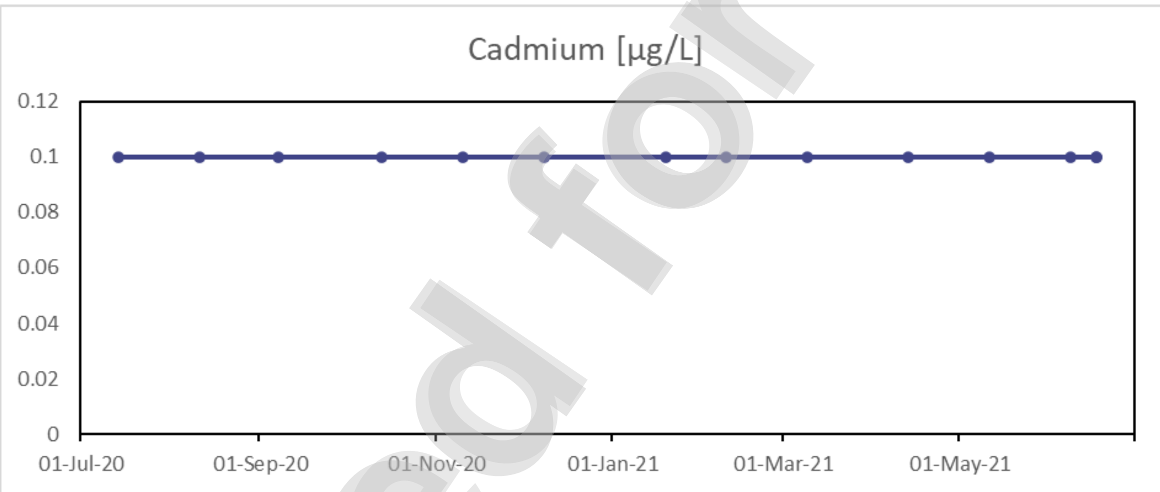
C.16 Total phosphorus



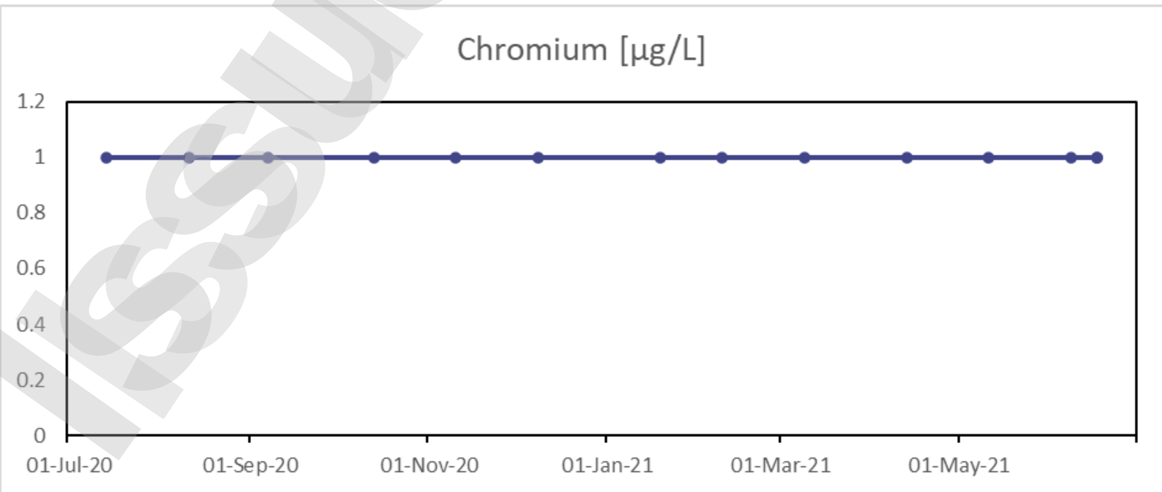
C.17 Filterable Reactive Phosphorus



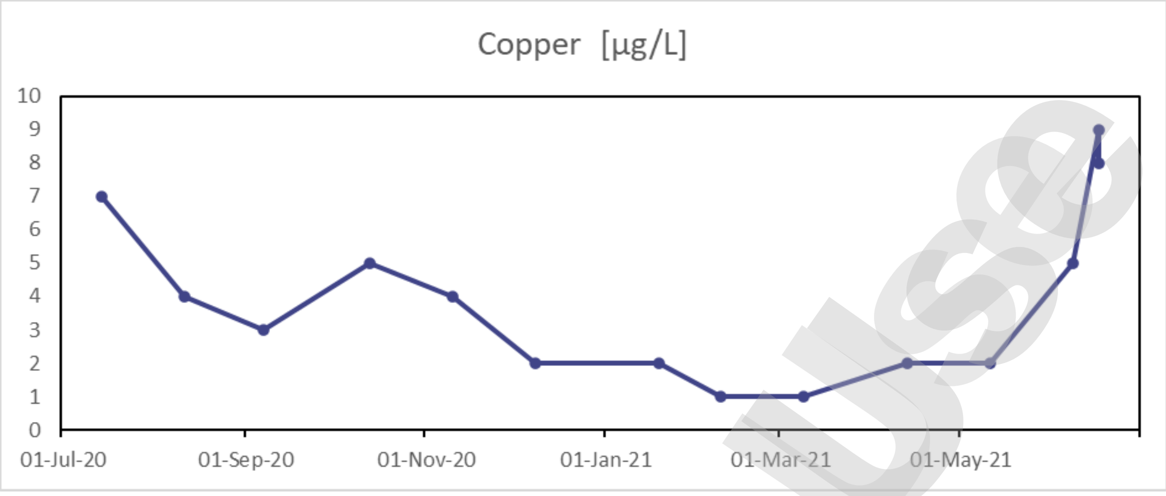
C.18 Cadmium



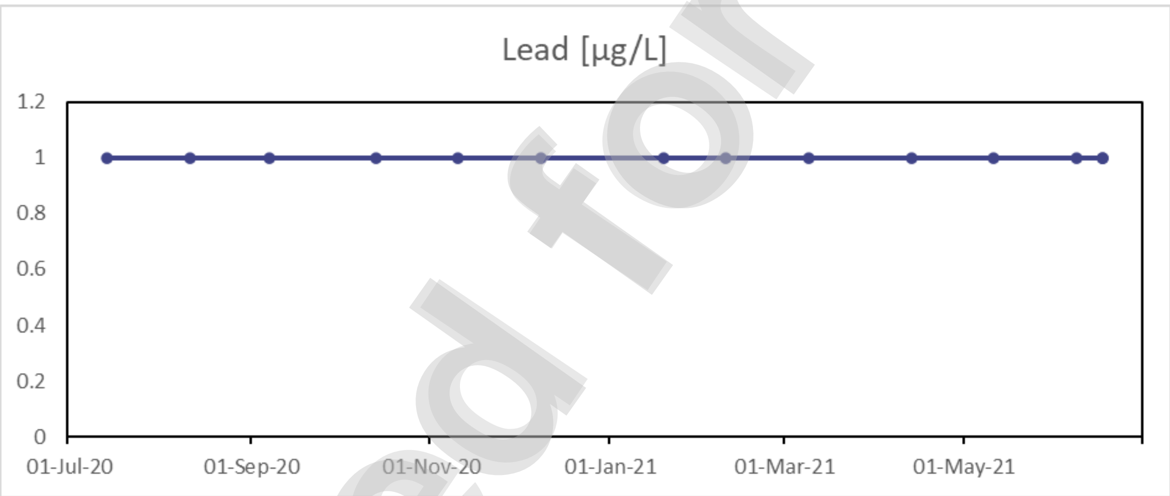
C.19 Chromium



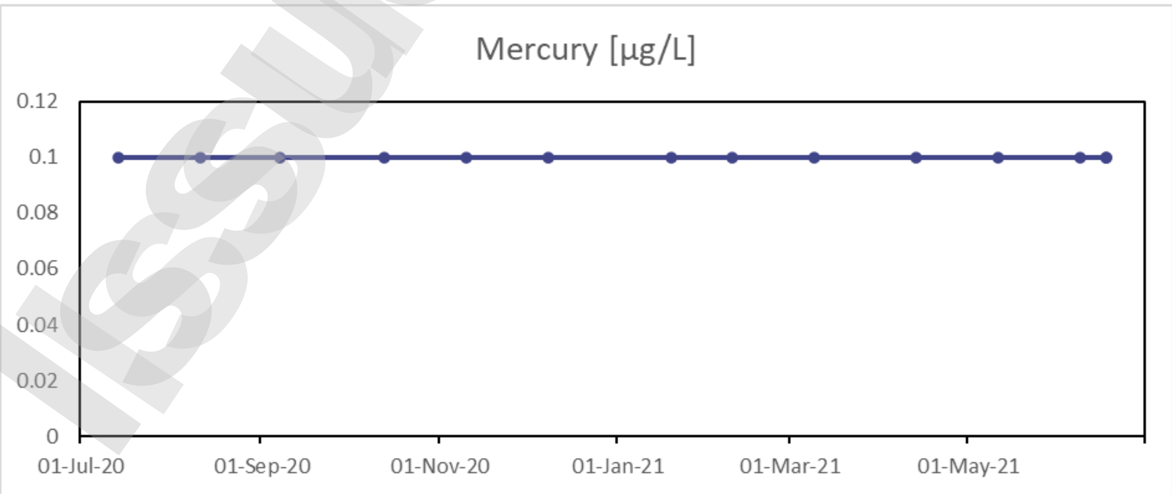
C.20 Copper



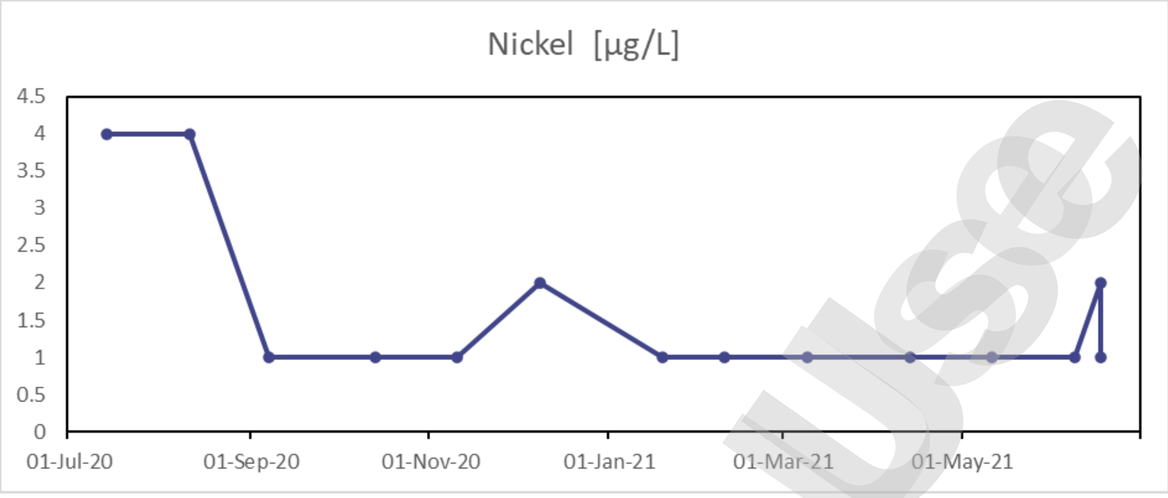
C.21 Lead



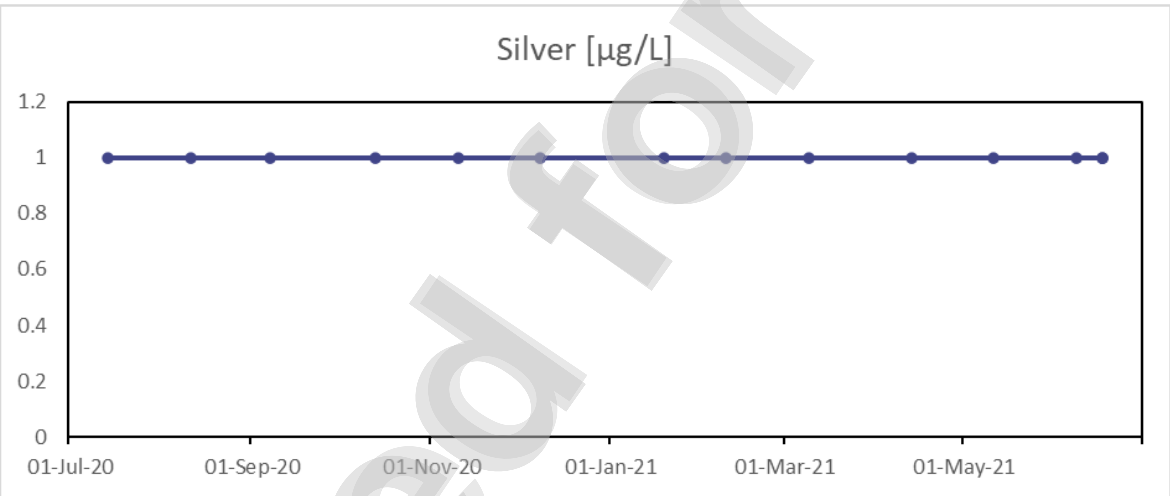
C.22 Mercury



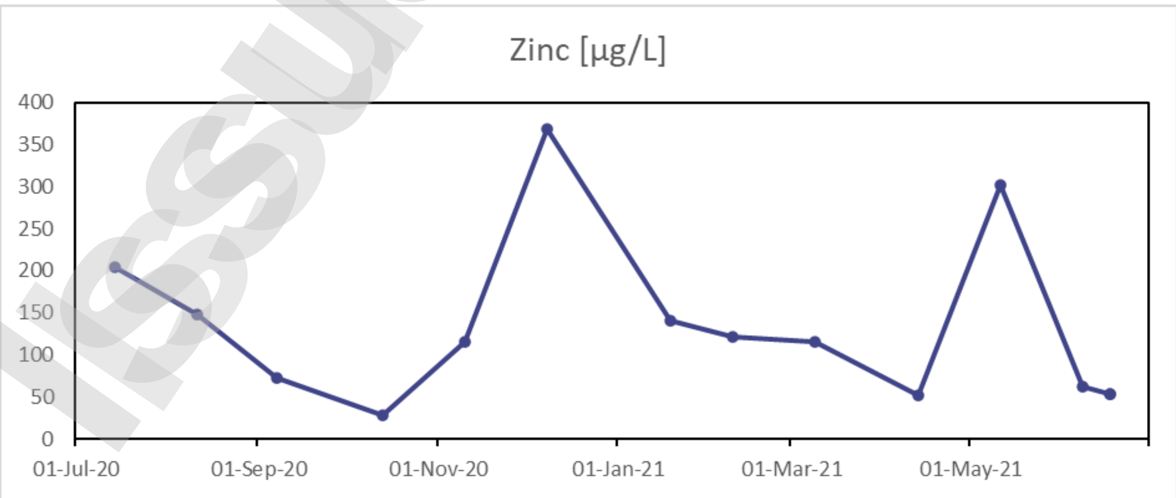
C.23 Nickel



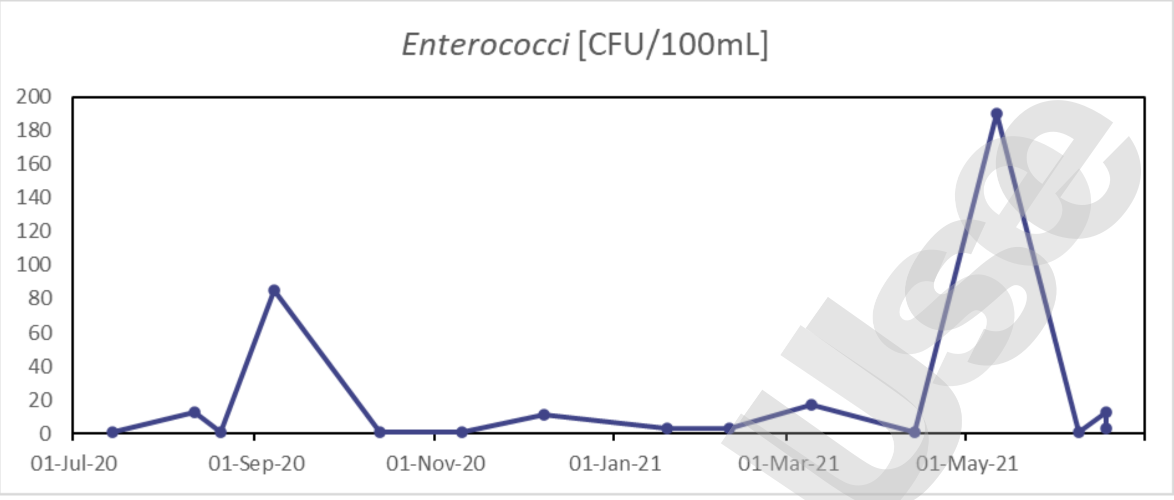
C.24 Silver



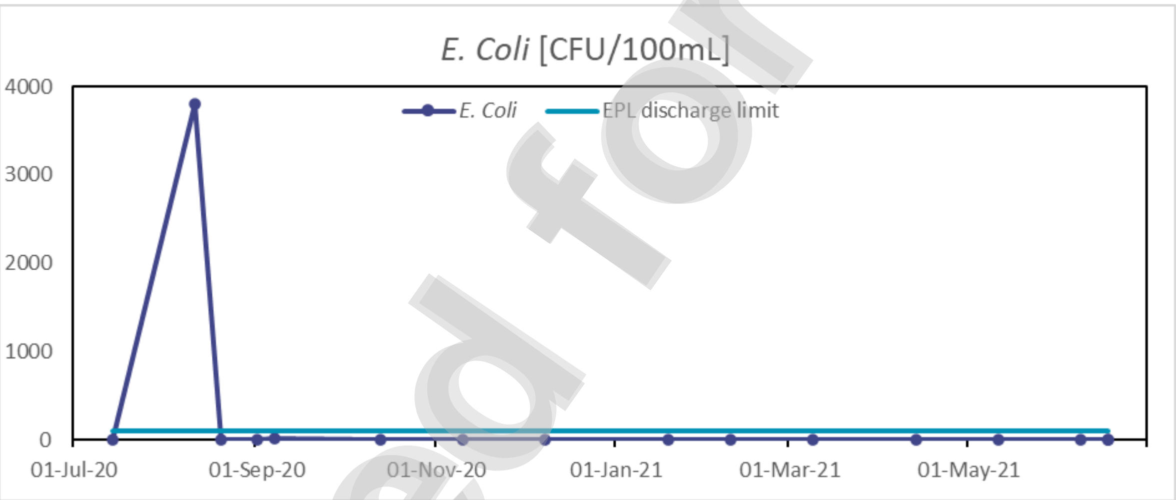
C.25 Zinc



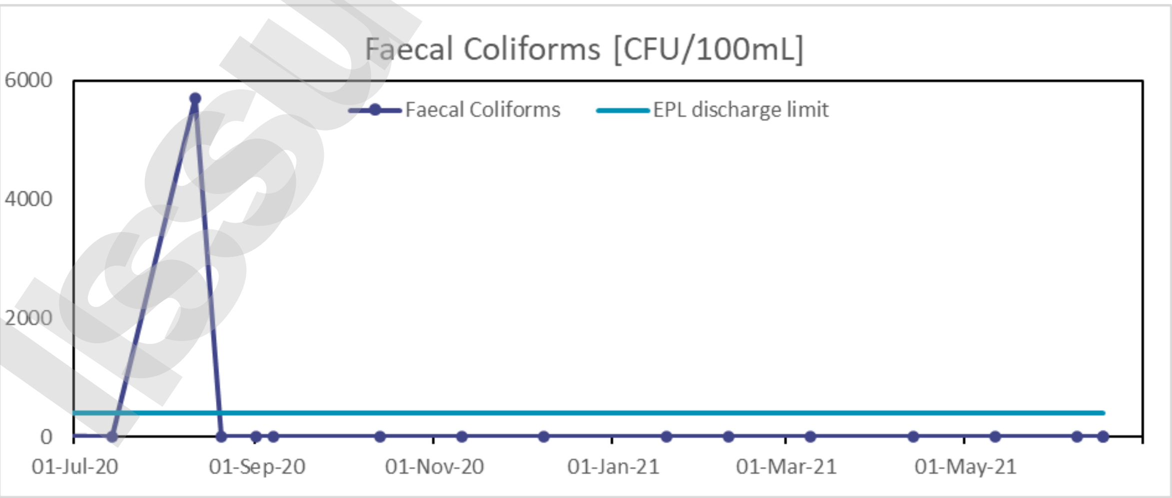
C.26 Enterococci



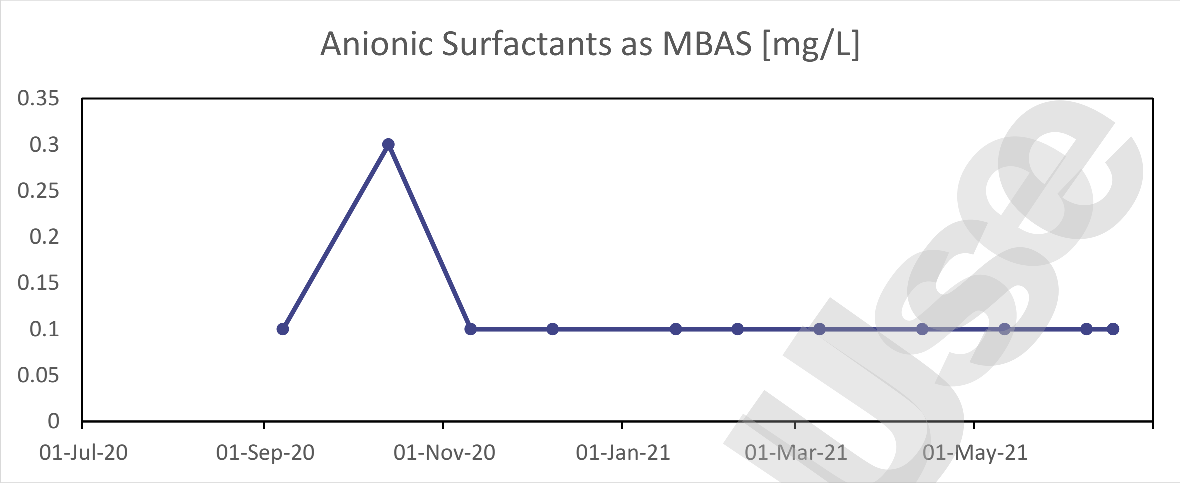
C.27 Escherichia coli



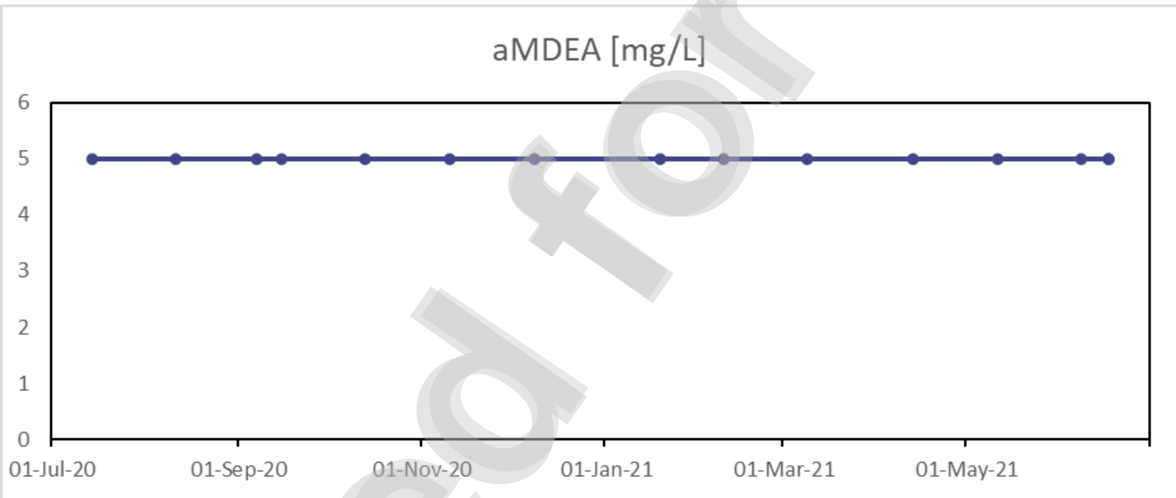
C.28 Faecal Coliforms



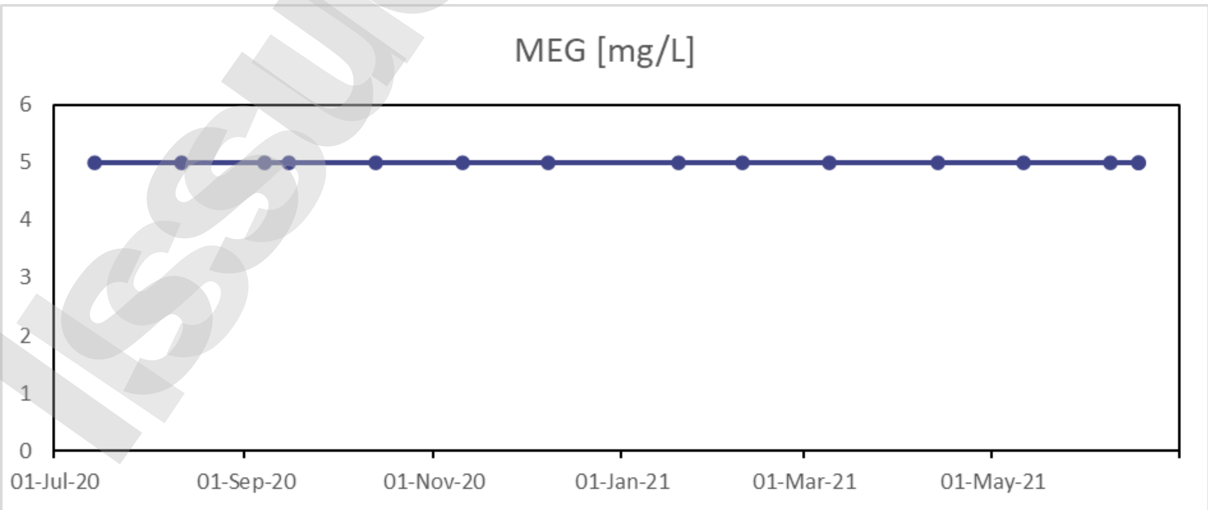
C.29 Anionic Surfactants



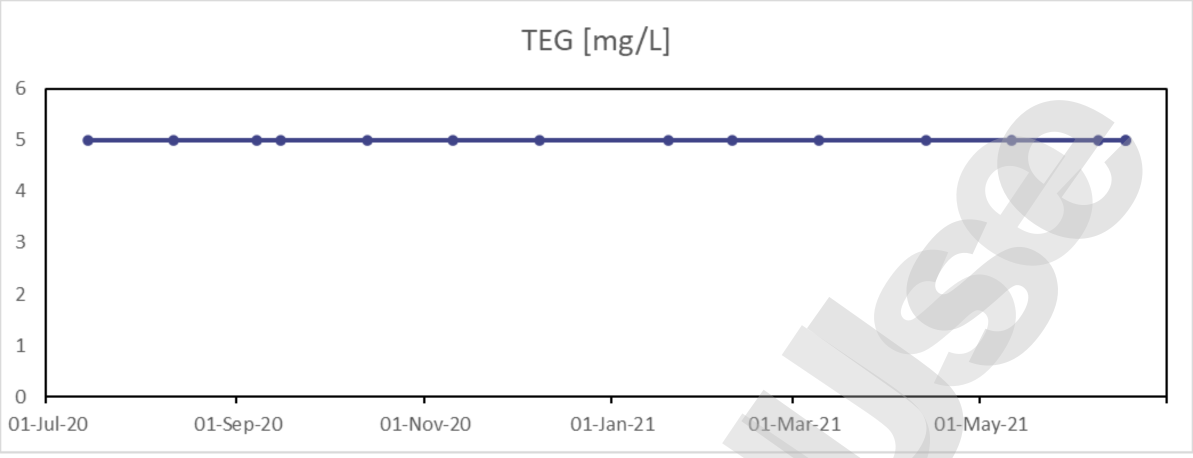
C.30 Activated Methyl Diethanolamine (aMDEA)



C.31 Glycol – MEG



C.32 Glycol – TEG



APPENDIX D: JETTY OUTFALL DATA

D.1 Jetty outfall results for the reporting period

Exceedances are in bold (as described in Section 2.2.3).

Parameter				Free Chlorine	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 (C6 – C36)	Enterococci
Trigger value				0.2	Outside 6 to 8.5	-	±3 ambient	±10 ambient	Outside the range of 80 to 100	No change from background	None observed	1.4	0.7	4.4	1.3	0.1	7	4.4	15	20	10	30	300	10	No visible sheen or emulsion, no odour	-	<LOR	50
Location	Date	Survey	Function	mg/L	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	-	mg/L	µg/L	MPN/
Jetty 01	15/07/20	8	Impact	0.08 (0.02)	7.89	54590.0	25.57	*	97.5	No change	**Yes**	<0.1	<0.1	<0.2	0.4	<0.1	0.4	<0.1	2	<3	7	17	140	<1	None	<5	<50	<10
Jetty 02	15/07/20	8	Impact	0.02 (0.02)	7.83	54090.0	25.41	1.0	97.5	No change	None	<0.1	<0.1	<0.2	0.4	<0.1	<0.3	0.1	2	<3	7	16	110	<1	None	<5	<50	<10
Jetty 03	15/07/20	8	Impact	0.04 (<0.02)	7.93	54720.0	25.73	*	98.7	No change	**Yes**	<0.1	<0.1	<0.2	0.4	<0.1	0.4	<0.1	1	<3	6	17	110	1	None	<5	<50	<10
Jetty west	15/07/20	8	Reference	0.03 (<0.02)	7.88	54050.0	25.37	1.0	96.9	No change	None	<0.1	<0.1	<0.2	0.4	<0.1	<0.3	<0.1	1	<3	7	15	90	1	None	<5	<50	<10
Jetty east	15/07/20	8	Reference	0.02 (0.02)	7.93	54600.0	25.83	*	*	No change	**Yes**	<0.1	<0.1	<0.2	0.3	<0.1	<0.3	<0.1	1	<3	6	29	210	5	None	<5	<50	<10
Jetty 01	15/07/20	8	Duplicate									<0.1	<0.1	<0.2	0.4	<0.1	0.4	<0.1	3	<3	7	16	100	<1	None	<5	<50	<10
Jetty 01	12/10/2020	9	Impact	0.00 (<0.02)	8.04	54390.0	31.18	0.9	**114.0**	No change	None	<0.1	<0.1	<0.2	0.5	<0.1	0.4	<0.1	2	<3	4	16	120	2	None	7	<50	<10
Jetty 02	12/10/2020	9	Impact	0.01 (<0.02)	8.02	54430.0	31.31	0.8	**115.0**	No change	None	<0.1	<0.1	<0.2	0.5	<0.1	0.4	<0.1	1	<3	4	13	100	<1	None	<5	<50	<10
Jetty 03	12/10/2020	9	Impact	0.01 (<0.02)	8.07	54360.0	31.17	1.1	**113.0**	No change	None	<0.1	<0.1	<0.2	0.5	<0.1	0.3	<0.1	1	<3	6	16	120	1	None	<5	<50	<10
Jetty west	12/10/2020	9	Reference	0.03 (<0.02)	7.98	54480.0	31.38	1.1	**116.0**	No change	None	<0.1	<0.1	<0.2	0.5	<0.1	<0.3	0.4	2	<3	4	14	120	<1	None	<5	<50	<10
Jetty east	12/10/2020	9	Reference	0.01 (<0.02)	8.05	54390.0	31.08	1.0	**116.0**	No change	None	<0.1	<0.1	<0.2	0.5	<0.1	<0.3	0.1	2	<3	3	16	120	1	None	<5	<50	<10
Jetty 01	12/10/2020	9	Duplicate									<0.1	<0.1	<0.2	0.5	<0.1	<0.3	<0.1	3	<3	4	16	110	1	None	<5	<50	<10

Parameter				Free Chlorine	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 (C6 – C36)	Enterococci
Jetty 01	20/01/2021	10	Impact	<0.02	7.98	54870.0	30.63	1.5	96.3	No change	None	<0.1	<0.1	<0.2	0.7	<0.1	<0.3	0.1	3	8	6	18	150	3	None	<5	<50	<10
Jetty 02	20/01/2021	10	Impact	<0.02	7.99	55190.0	30.64	1.9	96.9	No change	None	<0.1	<0.1	<0.2	0.4	<0.1	<0.3	<0.1	<1	6	6	17	140	2	None	<5	<50	<10
Jetty 03	20/01/2021	10	Impact	<0.02	7.99	551130.0	30.60	2.0	97.3	No change	None	<0.1	<0.1	<0.2	0.7	<0.1	<0.3	<0.1	2	7	5	18	140	3	None	<5	<50	<10
Jetty west	20/01/2021	10	Reference	<0.02	8.00	55640.0	30.66	2.1	94.3	No change	None	<0.1	<0.1	<0.2	0.6	<0.1	<0.3	<0.1	1	7	6	18	130	3	None	<5	<50	<10
Jetty east	20/01/2021	10	Reference	<0.02	7.99	55130.0	30.64	1.6	97.3	No change	None	<0.1	<0.1	<0.2	0.5	<0.1	<0.3	<0.1	1	6	5	17	130	2	None	<5	<50	<10
Jetty 01	20/01/2021	10	Duplicate									<0.1	<0.1	<0.2	0.7	<0.1	<0.3	0.1	3	7	6	18	150	3	None	<5	<50	<10
Jetty 01	20/01/2021	10	Impact	<0.02	7.98	54870.0	30.63	1.5	96.3	No change	None	<0.1	<0.1	<0.2	0.7	<0.1	<0.3	0.1	3	8	6	18	150	3	None	<5	<50	<10
Jetty 01	07/04/2021	11	Impact	<0.02	6.9	52960.0	30.28	1.1	99	No change	None	<0.1	0.1	<0.2	0.7	<0.1	0.4	0.1	2	<3	4	16	140	2	None	<5	<50	<10
Jetty 02	07/04/2021	11	Impact	<0.02	7.1	52740.0	30.39	1.1	100	No change	None	<0.1	<0.1	<0.2	0.4	<0.1	0.3	<0.1	2	<3	4	14	120	2	None	<5	<50	<10
Jetty 03	07/04/2021	11	Impact	<0.02	8.1	53070.0	30.15	1.3	99	No change	None	<0.1	<0.1	<0.2	0.3	<0.1	<0.3	<0.1	2	4	4	16	130	1	None	<5	<50	<10
Jetty west	07/04/2021	11	Reference	<0.02	8.1	52510.0	30.28	2.5	99	No change	None	<0.1	<0.1	<0.2	0.4	<0.1	<0.3	<0.1	<1	<3	4	16	120	5	None	<5	<50	<10
Jetty east	07/04/2021	11	Reference	<0.02	7.62	53150.0	30.18	1.1	99	No change	None	<0.1	<0.1	<0.2	0.3	<0.1	<0.3	<0.1	1	4	4	15	120	2	None	<5	<50	<10
Jetty 01	07/04/2021	11	Duplicate									<0.1	0.1	<0.2	0.7	<0.1	0.4	0.1	2	<3	4	15	130	3	None	<5	<50	<10

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APPENDIX E: AUTHORISED STATIONARY SOURCE EMISSION RELEASE RESULTS

E.1 Stationary Source Emission Test results by Ektimo

Sampling Point Number	Sampling Location Number	Date	LIMS Number	NO_x as NO_2 - Concentration Target		NO_x as NO_2 - Concentration Limit		N_2O		Hg - un spiked method USEPA 30B	$PM_{2.5}$	PM_{10}	CO		temperature	efflux velocity	volumetric flow rate
				mg/Nm³	ppm	mg/Nm³	ppm	mg/Nm³	ppm	mg/Nm³	mg/m³	mg/m³	mg/m³	ppm	°C	m/s	m³/min
LNG Refrigerant Compressor Driver Gas Turbines (GE Frame 7s)				**50 @ 15%O2**	**25 @ 15%O2**	**70 @ 15%O2**	**35 @ 15%O2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**23**	**-**
A1	L-641-A-001	07/08/2020	L2003721001	16	7.9	16	7.9	<1	<0.5	<0.00017	<0.4	<0.4	<1	<1	181	26	17000
		19/09/2020	L2004327001	20	9.7	20	9.7	<1	<0.5	<0.0004	<0.4	<0.4	<1	<1	177	27	17000
		08/12/2020	L2005364001	19	9.5	19	9.5	<1	<0.5	<0.0001	<0.2	<0.2	<1	<1	172	23	14000
A2	L-642-A-001	10/08/2020	L2003724001	13	6.5	13	6.5	<1	<0.5	<0.0008	<0.4	<0.4	<1	<1	177	28	17000
		22/09/2020	L2004329001	9.7	4.7	9.7	4.7	<1	<0.5	<0.0004	<0.4	<0.4	2.2	1.7	178	25	15000
		09/12/2020	L2005366001	16	8	16	8	<1	<0.5	<0.0002	<0.2	<0.2	<1	3.4	174	23	14000
A3	L-641-A-002	06/08/2020	L2003722001	13	6.5	13	6.5	<1	<0.5	<0.0001	<0.4	<0.4	2.4	1.9	174	24	15000
		17/09/2020	L2004328001	11	5.3	11	5.3	<1	<0.5	<0.0004	<0.4	<0.4	2.5	2	173	27	17000
		13/12/2020	L2005365001	11	5.2	11	5.2	<1	<0.5	<0.001	<0.4	<0.4	1.2	4.1	177	26	16000
A4	L-642-A-002	08/08/2020	L2003725001	23	11	23	11	<1	<0.5	<0.0001	<0.4	<0.4	2	1.6	172	25	16000
		23/09/2020	L2004330001	12	6	12	6	<1	<0.5	<0.00036	<0.4	<0.4	2.5	2	176	27	17000
		10/12/2020	L2005367001	21	10	21	10	<1	<0.5	<0.0022	<0.2	<0.2	2.3	1.9	182	26	16000
CCPP Gas Turbine Generators (GE Frame 6s, 38MW) - HRSG stack				**150 @ 15%O2**	**75 @ 15%O2**	**350 @ 15%O2**	**175 @ 15%O2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**19**	**-**
A5-2	L-630-F-001	09/08/2020	L2003878001	8.6	4.2	8.6	4.2	<1	<0.5	<0.0001	<0.4	<0.4	15	3.9	208	22	6900
		24/09/2020	L2004335001	12	5.6	12	5.6	<1	<0.5	<0.0004	<0.4	<0.4	32	25	169	19	6500
		14/12/2020	L2005372001	7	3.4	7	3.4	<1	<0.5	<0.0002	<0.5	<0.5	64	51	193	20	6300
A6-2	L-630-F-002	12/08/2020	L2003879001	7.5	3.5	7.5	3.5	<1	<0.5	<0.0001	<0.4	<0.4	38	31	215	24	7400
		26/09/2020	L2004336001	8.3	4.1	8.3	4.1	<1	<0.5	<0.0003	<0.4	<0.4	15	12	170	19	6400
		Q4 2020 - Unit offline at the time of sampling, no results available.															
A7-2	L-630-F-003	13/08/2020	L2003880001	13	6.5	13	6.5	<1	<0.5	<0.0001	<0.4	<0.4	32	26	210	23	7000
		27/09/2020	L2004337001	10	5.1	10	5.1	<1	<0.5	<0.0043	<0.4	<0.4	6.4	5.1	172	19	6200
		14/12/2020	L2005373001	7.9	3.9	7.9	3.9	<1	<0.5	<0.0001	<0.5	<0.5	54	43	201	20	6200
A8-2	L-630-F-004	13/08/2020	L2003881001	15	7.3	15	7.3	<1	<0.5	<0.0001	<0.4	<0.4	20	16	216	22	6700
		Q3 2020 - Unit offline at the time of sampling, no results available.															
		15/12/2020	L2005374001	9.3	4.5	9.3	4.5	<1	<0.5	<0.0001	<0.5	<0.5	10	8.4	221	20	6100
A9-2	L-630-F-005	Q2 2020 - Unit offline at the time of sampling, no results available.															

Sampling Point Number	Sampling Location Number	Date	LIMS Number	NO_x as NO_2 - Concentration Target		NO_x as NO_2 - Concentration Limit		N_2O		Hg - un spiked method USEPA 30B	$PM_{2.5}$	PM_{10}	CO		temperature	efflux velocity	volumetric flow rate
				mg/Nm³	ppm	mg/Nm³	ppm	mg/Nm³	ppm	mg/Nm³	mg/m³	mg/m³	mg/m³	ppm	°C	m/s	m³/min
		27/09/2020	L2004338001	18	8.5	18	8.5	<1	<0.5	<0.00046	<0.5	<0.5	29	23	220	19	5900
		15/12/2020	L2005375001	6.9	3.3	6.9	3.3	<1	<0.5	≤0.0045	<0.5	<0.5	41	32	228	21	6200
AGRU Incinerators				**320 @3%O2**	**160 @3%O2**	**350@3%O2**	**175 @15%O2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**19**	**-**
A13-1	L-551-FT-031	17/08/2020	L2003723001	41	20	41	20	71	36	<0.00015	<0.6	<0.6	300	240	483	20	2900
		18/09/2020	L2004331001	43	21	45	6.9	83	42	<0.0004	<0.6	<0.6	280	230	483	20	2800
		11/12/2020	L2005370001	39	19	39	6.1	61	31	<0.0001	<0.5	<0.5	250	200	482	19	2500
A14-1	L-552-FT-031	Unit offline at the time of sampling, no results available.															
Heating medium furnaces				**160 @3%O2**	**80 @3%O2**	**350@3%O2**	**175 @3%O2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
A15	L-640-A-001-A	11/08/2020	L2003727001	160	76	160	76	<1	<0.5	<0.0001	<0.7	<0.7	210	170	185	3.4	530
		20/09/2020	L2004333001	**200**	**97**	200	98	<1	<0.5	<0.0004	<0.7	<0.7	370	300	100	3	590
		12/12/2020	L2005368001	140	69	140	69	<1	<0.5	<0.0002	<0.9	<0.9	170	130	190	2.9	450
A16	L-640-A-001-B	11/08/2020	L2003728001	150	73	150	73	<1	<0.5	<0.0001	<0.7	<0.7	270	210	190	4	620
		21/09/2020	L2004334001	**200**	**98**	200	98	<1	<0.5	<0.0004	<0.7	<0.7	440	350	172	3.4	550
		12/12/2020	L2005369001	130	66	130	66	<1	<0.5	<0.000054	<0.8	<0.8	250	200	172	1.9	930

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E.2 Gas Sampling Test Results Reported by the INPEX Laboratory

Date	LIMS number	Hydrogen Sulfide (H_2S)	Benzene	Toluene	Ethylbenzene	m/p-Xylene	o-Xylene	Mercury
	Unit	ppmV	ppmV	ppmV	ppmV	ppmV	ppmV	µg/Nm³
A13-2 (L-551-SC-003) AGRU Hot Vent - LNG Train1, prior to release at A3								
09/07/2020	L2003276001	160	120	< 30	< 30	< 30	< 30	-
22/07/2020	L2003555001	150	140	< 30	< 30	< 30	< 30	-
11/08/2020	L2003859001	140	130	90	<30	<30	<30	-
15/08/2020	L2003968001	150	50	<30	<30	<30	<30	-
15/09/2020	L2004529001	160	<30	<30	<30	<30	<30	-
11/10/2020	L2005004001	160	<30	<30	<30	<30	<30	-
05/11/2020	L2005442001	160	<30	<30	<30	<30	<30	-
02/12/2020	L2005951001	140	<30	<30	<30	<30	<30	-
20/12/2020	L2006234001	160	<30	<30	<30	<30	<30	-
12/01/2021	L2100155001	150	<30	<30	<30	<30	<30	-
18/01/2021	L2100212001	150	60	<30	<30	<30	<30	-
11/02/2021	L2100629001	140	<30	<30	<30	<30	<30	-
05/03/2021	L2100992001	150	<30	<30	<30	<30	<30	-
11/04/2021	L2101545001	150	30	<30	<30	<30	<30	-
10/05/2021	L2101936001	160	40	<30	<30	<30	<30	-
27/06/2021	L2102533001	160	<30	<30	<30	<30	<30	-
A13-3 (L-541-SC-001) Feed gas to AGRU – LNG Train 1 – prior to release at A3								
24/07/2020	L2003525001	-	-	-	-	-	-	<0.005
15/08/2020	L2003969001	-	-	-	-	-	-	<0.005
04/10/2020	L2004682001	-	-	-	-	-	-	<0.005
05/11/2020	L2005443001	-	-	-	-	-	-	<0.005
02/12/2020	L2005928001	-	-	-	-	-	-	<0.005
19/12/2020	L2006235001	-	-	-	-	-	-	<0.005
19/01/2021	L2100211001	-	-	-	-	-	-	<0.005
01/03/2021	L2100739001	-	-	-	-	-	-	<0.005
12/03/2021	L2101182001	-	-	-	-	-	-	<0.005

Date	LIMS number	Hydrogen Sulfide (H_2S)	Benzene	Toluene	Ethylbenzene	m/p-Xylene	o-Xylene	Mercury
	Unit	ppmV	ppmV	ppmV	ppmV	ppmV	ppmV	µg/Nm³
18/04/2021	L2101694001	-	-	-	-	-	-	<0.005
05/05/2021	L2101935001	-	-	-	-	-	-	<0.005
08/05/2021	L2102064001	-	-	-	-	-	-	<0.005
21/06/2021	L2102173001	-	-	-	-	-	-	<0.005
A14-2 (L-552-SC-003) AGRU hot Vent Train2, prior to release at A4								
09/07/2020	L2003277001	160	150	40	<30	<30	<30	-
11/08/2020	L2003858001	160	130	140	<30	<30	<30	-
15/09/2020	L2004528001	150	<30	<30	<30	<30	<30	-
11/10/2020	L2005005001	150	<30	<30	<30	<30	<30	-
12/11/2020	L2005510001	140	<30	<30	<30	<30	<30	-
13/12/2020	L2005952001	160	<30	<30	<30	<30	<30	-
25/12/2020	L2006375001	140	<30	<30	<30	<30	<30	-
12/01/2021	L2100154001	140	<30	<30	<30	<30	<30	-
11/02/2021	L2100628001	140	<30	<30	<30	<30	<30	-
05/03/2021	L2100993001	150	<30	<30	<30	<30	<30	-
28/03/2021	L2101368001	140	<30	<30	<30	<30	<30	-
11/04/2021	L2101546001	180	<30	<30	<30	<30	<30	-
10/05/2021	L2102014001	150	60	<30	<30	<30	<30	-
A14-3 (L-542-SC-001) Feed gas to AGRU – LNG Train 2 – prior to release at A4								
24/07/2020	L2003630001	-	-	-	-	-	-	< 0.005
28/08/2020	L2004111001	-	-	-	-	-	-	< 0.005
04/10/2020	L2004795001	-	-	-	-	-	-	< 0.005
25/10/2020	L2005290001	-	-	-	-	-	-	< 0.005
20/11/2020	L2005785001	-	-	-	-	-	-	< 0.005
25/12/2020	L2006374001	-	-	-	-	-	-	< 0.005
19/01/2021	L2100371001	-	-	-	-	-	-	< 0.005
27/02/2021	L2100862001	-	-	-	-	-	-	< 0.005
22/03/2021	L2101299001	-	-	-	-	-	-	< 0.005
26/04/2021	L2101814001	-	-	-	-	-	-	< 0.005

Date	LIMS number	Hydrogen Sulfide (H_2S)	Benzene	Toluene	Ethylbenzene	m/p-Xylene	o-Xylene	Mercury
	Unit	ppmV	ppmV	ppmV	ppmV	ppmV	ppmV	µg/Nm³
24/07/2020	L2003630001	-	-	-	-	-	-	< 0.005
28/08/2020	L2004111001	-	-	-	-	-	-	< 0.005
04/10/2020	L2004795001	-	-	-	-	-	-	< 0.005
25/10/2020	L2005290001	-	-	-	-	-	-	< 0.005
20/11/2020	L2005785001	-	-	-	-	-	-	< 0.005
25/12/2020	L2006374001	-	-	-	-	-	-	< 0.005
19/01/2021	L2100371001	-	-	-	-	-	-	< 0.005
27/02/2021	L2100862001	-	-	-	-	-	-	< 0.005
22/03/2021	L2101299001	-	-	-	-	-	-	< 0.005
26/04/2021	L2101814001	-	-	-	-	-	-	< 0.005
30/06/2021	L2102174001	-	-	-	-	-	-	< 0.005

APPENDIX F: GROUNDWATER QUALITY DATA

F.1 Groundwater monitoring results for the reporting period

Shaded cells indicate trigger exceedances (i.e. exceed both background levels and trigger values), as described in Section 4.1.2.

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	mg/L (Survey 6) % (Survey 7)	Unit	µg/L	µg/L	µg/L	µg/L
		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
6	BPGW01	03/11/2020	270	330	60	20	<10	<1	70	20	1.2	<0.5	<0.5	38	<0.2	1.7	1700	<0.1	18	<0.1	<5	110	<1	<1	<1	<3	<100	0.10	4181	4.86	4181	32.6	4.82
	BPGW07	03/11/2020	660	1000	<50	30	<10	20	>10	18	0.3	<0.5	1	27	<0.2	2	1300	<0.1	28	<0.1	<5	52	<1	<1	<1	<3	<100	0.02	96583	5.54	96583	32.4	0.74
	BPGW08A	19/10/2020	140	<200	<50	40	<10	4.6	330	2	0.8	<0.5	<1	53	2	8	4700	<0.1	33	<5*	<5	65	<1	<1	<1	<3	<100	-	19746	7.08	19746	31.5	4.10
	BPGW09	28/10/2020	570	570	<50	2100	<10	92	<10	5	<0.2	<0.5	1.1	1.1	2.8	0.6	180	<0.1	1	<0.1	<5	5	<1	<1	<1	<3	<100	1.00	106722	6.14	106722	32.3	0.74
	BPGW13A	20/10/2020	1200	1200	<50	60	60	100	<10	5	<0.2	<0.5	<0.5	10	<0.2	0.9	1100	<0.1	4	<0.1	<5	31	<1	<1	<1	<3	<100	0.29	45956	5.75	45956	33.3	2.62
	BPGW14A	20/10/2020	140	<200	<50	<10	70	12	<10	2	0.4	<0.5	<0.5	5.8	5.8	0.4	3600	<0.1	3	<0.1	<5	40	<1	<1	<1	<3	<100	0.00	231457	4.42	231457	32.9	3.16
	BPGW18	22/10/2020	290	600	<50	60	<10	92	<10	15	<0.2	<0.5	<0.5	<0.2	0.6	0.9	78	<0.1	<1	<0.1	<5	6	<1	<1	<1	<3	<100	-	89570	8.68	89570	30.4	2.21
	BPGW19A	26/10/2020	1600	1600	<50	40	<10	26	20	9	<0.2	<0.5	<0.5	<0.2	0.8	1.4	100	<0.1	<1	<0.1	<5	8	<1	<1	<1	<3	<100	0.01	66429	6.03	66429	32.4	1.60
	BPGW20	21/10/2020	1400	500	<50	<10	<10	<1	<10	2	<0.2	<0.5	<0.5	1.9	0.3	<0.2	36	<0.1	1	<0.1	<5	<5	<1	<1	<1	<3	<100	-	1534	7.03	1534	33.0	3.50
	BPGW23	29/10/2020	20	340	340	5300	<10	<1	310	2	1	<0.5	<0.5	37	5.3	3	5400	<0.1	19	3.4	<5	37	<1	<1	<1	<3	<100	4.50	69545	4.49	69545	31.2	2.45
	BPGW24	28/10/2020	790	790	<50	1600	<10	51	<10	<1	<0.2	<0.5	<0.5	48	0.3	<0.2	420	<0.1	10	<0.1	<5	26	<1	<1	<1	<3	<100	0.04	19016	5.49	19016	30.1	2.22
	BPGW25	27/10/2020	230	230	<50	10	<10	89	<10	12	0.2	<0.5	<0.5	56	0.5	0.2	2700	<0.1	32	<0.1	<5	67	<1	<1	<1	<3	<100	0.01	37736	5.53	37736	30.3	2.09
	BPGW26	26/10/2020	360	500	<50	<10	<10	15	<10	6	<0.2	<0.5	<0.5	8.8	<0.2	0.7	3000	<0.1	2	<0.1	<5	18	<1	<1	<1	<3	<100	-	14484	5.85	14484	32.0	3.64
	BPGW27A	26/10/2020	260	3000	<50	<10	<10	<1	<10	1	<0.2	<0.5	<0.5	1.6	<0.2	<0.2	24	<0.1	<1	<0.1	<5	<5	<1	<1	<1	<3	<100	-	3272	5.57	3272	33.6	3.82
	BPGW28	29/10/2020	510	900	<50	1800	<10	75	<10	4	<0.2	<0.5	<0.5	<0.2	6.6	0.5	150	<0.1	<1	<0.1	<5	5	<1	<1	<1	<3	<100	0.07	94572	6.44	94572	30.9	3.04
	BPGW38A	27/10/2020	160	200	<50	<10	<10	6	<10	<1	13	<0.5	<0.5	1.5	0.5	<0.2	65	<0.1	2	<0.1	<5	7	<1	<1	<1	<3	<100	-	5996	6.16	5996	32.4	3.19
	BPGW40	22/10/2020	380	380	<50	<10	<10	44	<10	<1	1.2	<0.5	0.6	0.4	0.2	<0.2	140	<0.1	<1	<0.1	<5	<5	<1	<1	<1	<3	<100	0.04	7321	6.15	7321	31.1	2.17
	BPGW41	21/10/2020	570	800	<50	<10	<10	29	<10	5	0.3	<0.5	0.6	<0.2	<0.2	<0.2	14	<0.1	<1	<0.1	<5	<5	<1	<1	<1	<3	<100	0.01	23333	6.53	23333	30.9	2.40
	VWP328	20/10/2020	340	340	<50	50	<10	110	<10	440	0.8	<0.5	17	11	0.7	2.6	530	<0.1	3	<0.1	<5	11	<1	<1	<1	<3	<100	1.82	101951	5.94	101951	34.3	2.66
	VWP341	20/10/2020	780	780	<50	<10	<10	32	<10	7	<0.2	<0.5	<0.5	100	<0.2	0.2	1500	<0.1	14	<0.1	<5	73	<1	<1	<1	<3	<100	0.07	5546	5.42	5546	33.2	4.06
7	BPGW01	12/04/2021	86	<50	35	<5	4	140	20	11	<0.20	<5.0	<5.0	7	<1.0	<0.20	500	<0.1	2.7	<0.1	<0.5	12	<1	<1	<1	<3	<100	0.12	350	5.12	48.8	30.9	1.35

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	mg/L (Survey 6) % (Survey 7)	Unit	µg/L	µg/L	µg/L	µg/L
		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
	BPGW07	12/04/2021	400	414	14	70	75	72000	<250	11	<0.10	1.8	<5.0	24	<5.0	<5.0	1100	<0.5	25	<25	<25	60	<1	<1	<1	<3	<100	2.10	110298	5.64	86.1	31.3	0.73
	BPGW08A	12/04/2021	57	64	64	510	11	1500	20	28	<0.20	1.9	<5.0	52	5	<0.20	1900	<0.5	17	<0.1	<0.5	12	<1	<1	<1	<3	<100	3.50	3529	5.50	2.1	31.0	2.53
	BPGW09	12/04/2021	240	575	35	<5	<1	100000	<10	68	<0.10	1.4	<5.0	5.1	<5.0	<5.0	610	<0.1	<5.0	<25	<25	<25	<1	<1	<1	<3	<100	0.10	149178	5.90	-31.2	30.7	0.61
	BPGW18	14/04/2021	300	300	<5	<5	<1	53000	<10	<10	<0.20	-	<5.0	<0.20	<1.0	<0.20	91	<0.1	<0.5	<0.1	<0.5	<5	<1	<1	<1	<3	<100	2.20	91947	6.07	-54.6	31.8	2.11
	BPGW19A	14/04/2021	1400	1400	6	<5	<1	49000	<10	4.7	<0.20	-	-	<0.20	<1.0	<0.20	88	<0.1	<0.5	<0.1	0.05	<5	<1	<1	<1	<3	<100	1.80	81578	6.08	-56.9	30.6	1.26
	BPGW20	14/04/2021	100	<200	13	40	49	660	<10	2.1	<0.20	-	-	1.4	12	<0.20	37	<0.1	0.8	<0.1	2.6	7	<1	<1	<1	<3	<100	4.30	1608	5.49	55.3	32.6	2.29
	BPGW26	13/04/2021	230	<50	46	40	43	4700	<10	1.5	<0.20	2	-	4.1	<1.0	<0.20	1300	<0.1	<0.5	<0.1	<0.5	<5	<1	<1	<1	<3	<100	5.60	10478	5.48	73.8	31.7	3.15
	BPGW27A	13/04/2021	250	<500	52	8	8	1400	<10	0.7	<0.20	1	-	1.4	<1.0	<0.20	24	<0.1	<0.5	0.1	<0.5	<5	<1	<1	<1	<3	<100	6.30	3234	5.23	74.9	33.5	3.37
	BPGW28	14/04/2021	890	890	<5	<5	<1	79000	<10	2.5	<0.20	-	-	<0.2	<1.0	0.3	200	<0.1	<0.5	<0.1	<0.5	<5	<1	<1	<1	<3	<100	6.90	116395	6.44	-75.5	30.5	2.53
	BPGW38A	13/04/2021	8	1000	370	90	92	240	<10	<0.20	<0.20	2.2	-	<0.2	<1.0	<0.20	<1.0	<0.1	<0.5	<0.1	<0.5	<5	<1	<1	<1	<3	<100	14.40	650	6.06	116.2	31.5	2.69
	BPGW40	13/04/2021	380	59	59	<5	3	3000	<10	5.3	<0.20	<0.5	-	1.5	<1.0	<0.20	150	<0.1	<0.5	<0.1	<0.5	<5	<1	<1	<1	<3	<100	1.50	6010	6.01	-47.9	30.7	1.71
	BPGW41	13/04/2021	560	<50	19	610	5	11000	10	3.2	<0.20	2	-	<0.2	<1.0	<0.20	18	<0.1	<0.5	<0.1	<0.5	6	<1	<1	<1	<3	<100	1.50	26767	6.45	-82.5	30.7	2.05
	VWP328	14/04/2021	300	300	19	<5	160	64000	<10	510	<0.20	-	-	13	<1.0	0.3	650	<0.1	4	<0.1	<0.5	9	<1	<1	<1	<3	<100	2.10	107326	5.91	-32.8	31.1	2.15
	VWP341	13/04/2021	520	124	64	20	22	1900	20	2.5	<0.20	1.7	-	64	<1.0	<0.20	920	<0.1	7.4	<0.1	<0.5	85	<1	<1	<1	<3	<100	2.70	3775	5.28	58.6	32.2	3.61

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