EPL228 Annual Environmental Monitoring Report 2023-2024

Report

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Revision	Section	Amendment

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NOTICE

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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
AGI	acid gas incinerator
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
COA	certificate of analysis
COC	continuously oily contaminated
COD	chemical oxygen demand
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
GTG	gas turbine generator

Abbreviation	Description
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
m^3/h	cubic metres per hour
MPN	most probable number
NATA	National Association of Testing Authorities, Australia
NCW	non-contaminated water
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

Abbreviation	Description
NT DITT	Northern Territory Department of Industry, Tourism and Trade
NT EPA	Northern Territory Environment Protection Authority
O_2	oxygen
OEMP	Onshore Operations Environmental Management Plan (L060-AH-PLN-60005)
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
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
SQGV	sediment quality guideline value
SWL	standing water level
TC	tidal creek
TF	tidal flat
TKN	total Kjeldahl nitrogen
TN	total nitrogen
TOC	total organic carbon
TP	total phosphorus
TPH	total petroleum hydrocarbons
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 (as amended from time to time) on 13 December 2017 (EPL228). Activation of EPL228 occurred on 14 September 2018 triggering several EPL228 monitoring conditions and Onshore Operations Environmental Management Plan (OEMP) monitoring commitments.

Condition 76 of EPL228-05[1] requires an Annual Environmental Monitoring Report (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) from 1 July to 30 June. For this AEMR, the reporting period is defined as 1 July 2023 to 30 June 2024. This AEMR has been developed to meet the requirements of Condition 77 of EPL228-05.

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, 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.

The point source emission monitoring 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] EPL228-05 came into effect on 13 December 2022.

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) 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 12.89 million tonnes per annum of hydrocarbons[2], being up to:

- *9.64 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 the AEMR is to satisfy Condition 76 of EPL228-05 for the Licensed Premises (hereafter Ichthys LNG)[3]. The reporting period for this AEMR is 1 July 2023 to 30 June 2024.

1.2 AEMR Condition requirements

Table 1-1 provides details of Condition 77 of EPL228-05 as they relate to the AEMR requirements and the relevant section for where the conditions have been addressed within this report.

Table 1-1: Annual environmental monitoring report condition requirements

EPL288 Condition #	Condition detail	Section
77	The Annual Environmental Monitoring Report must:	-
77.1	report on monitoring required under this licence;	This AEMR
77.2	include a tabulation in Microsoft ® Excel ® format, of all monitoring data required to be collected in accordance with this licence;	Provided to NT EPA separately
77.3	summarise performance of the authorised discharge to water, compared to the discharge limits specified in Table 3 in Appendix 2;	2.1

[2] As defined in EPL228-05

[3] Condition 76 reads: *The licensee must submit an Annual Environmental Monitoring Report to the NT EPA by 30 September for each year of this licence unless otherwise authorised, for the Scheduled Activity conducted during the preceding 12 month period from 1 July to 30 June.*

EPL288 Condition #	Condition detail	Section
77.4	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
77.5	summarise operating conditions of each emission source and the resulting air emission quality;	3.2
77.6	provide total emissions to air in tonnes per year for the air quality parameters listed in Table 6 in Appendix 3;	3.1
77.7	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;	3.3
77.8	report on outcomes of the REMP monitoring and assessment;	This AEMR
77.9	summarise measures taken to reduce waste;	6
77.10	consider the NT EPA Guideline for Reporting on Environmental Monitoring;	APPENDIX A:
77.11	be reviewed by Qualified Professional(s); and	APPENDIX B:
77.12	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. Monitoring was undertaken in accordance with the Onshore Operations Environmental Management Plan (OEMP) and EPL228 requirements.

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
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.	2.2
Point source emissions to air	To determine if air emissions from stationary point sources are within acceptable limits	3.2
Dark-smoke events	To determine if air emissions from the flare systems are within acceptable limits.	3.4
Groundwater quality	To detect changes in groundwater quality and determine if these changes are attributable to Ichthys LNG operations.	4.1
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

Program	Objective	Section
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
July 2023	Unplanned outage on train 1 & 2 for 9 days due to high level alarm in ILNG inlet liquid level
July 2023	Non-Statutory audit of *Liquid Discharge Management Plan* L060-AH-PLN-60050 Rev 4
October 2023	NTEPA Site Inspection at ILNG facility
October -November 2023	Changeover of major ILNG maintenance contractor
November 2023	External RINA audit and site inspection at ILNG

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.

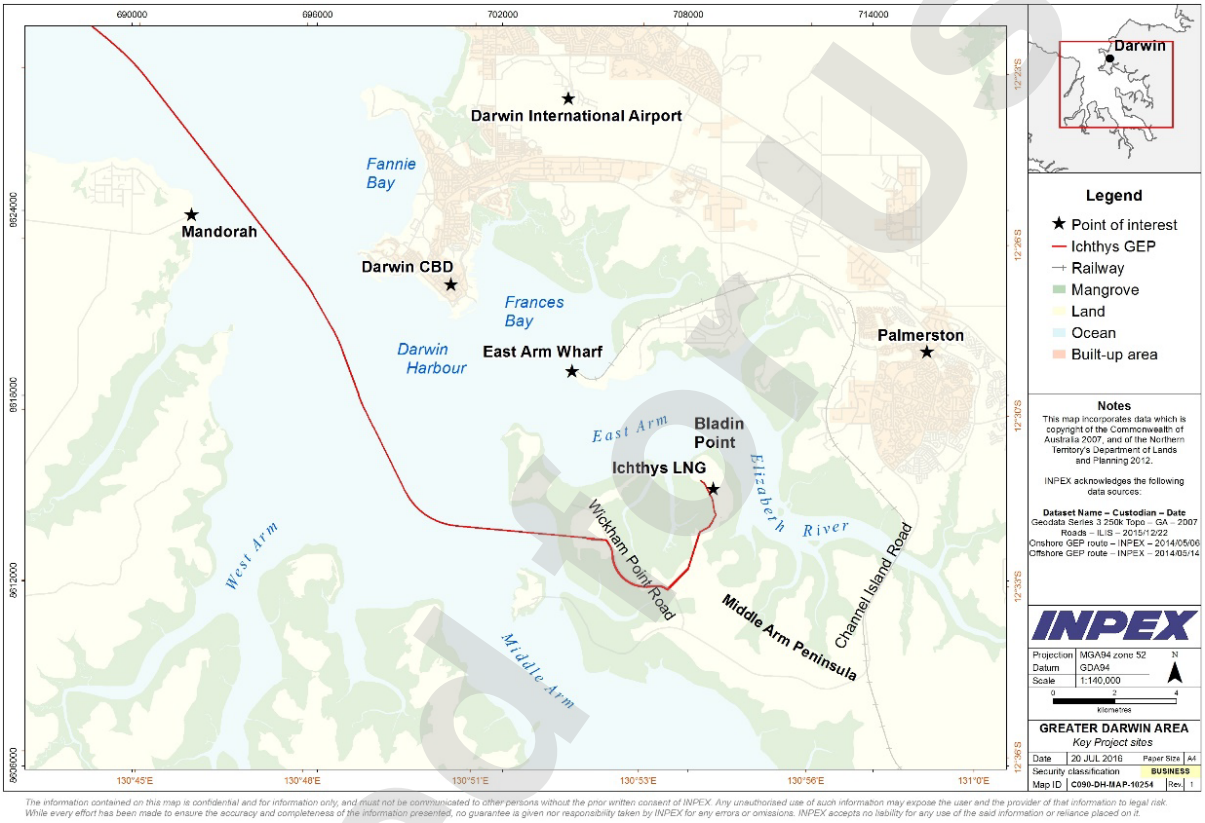

Figure 1-2: Location of Ichthys LNG

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 ~1,643 mm, the majority of which occurs during the wet season. The 2023/2024 wet season recorded 1153.4 mm of rainfall (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**	**1,610.1**
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
2021/2022	67.9	131.9	282.0	357.0	222.2	121.2	89.6	1,271.7
2022/2023	155.9	177.9	341.3	196.2	228.2	207.8	92.1	1,399.4
2023/2024	9.0	52.0	111.3	476.1	289.5	203.7	11.8	1153.4

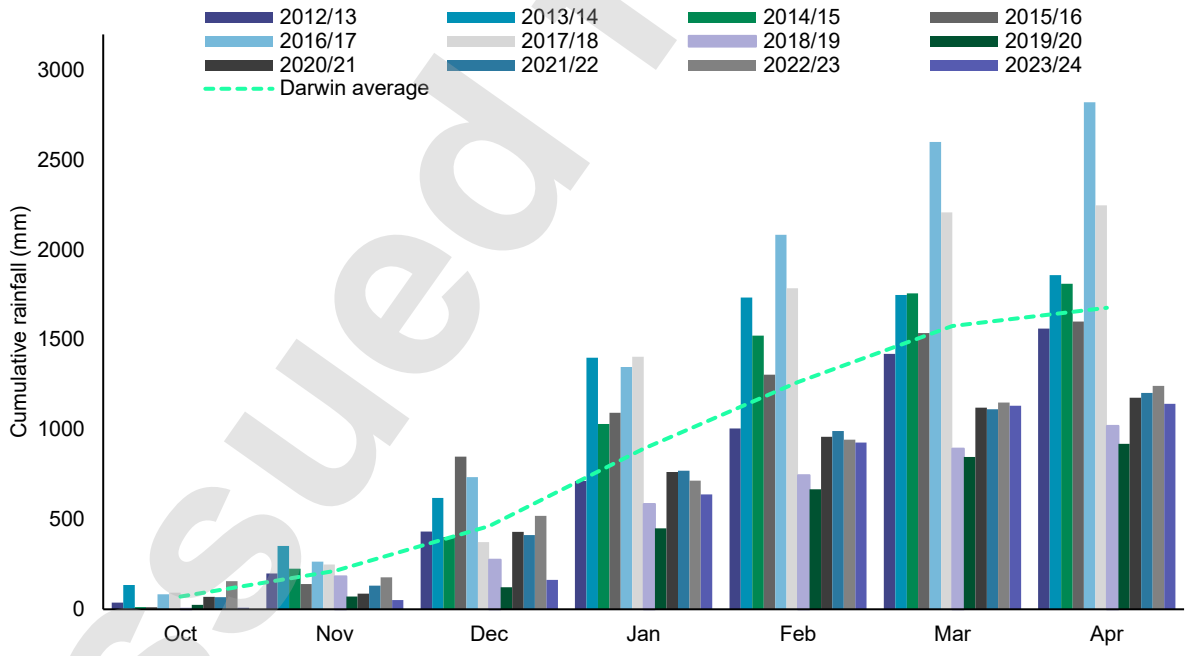

Figure 1-3: Bladin Point cumulative wet seasons

2 DISCHARGES TO WATER

This section describes the outcomes of the comingled treated effluent wastewater monitoring program.

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 is 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).

Table 2-1: Commingled treated effluent sampling dates

Sample month	Sample collection date(s)
Jul-2023	18
Aug-2023	8
Sep-2023	5
Oct-2023	17
Nov-2023	14
Dec-2023	12
Jan-2024	8, 19*
Feb-2024	13, 16**
Mar-2024	12, 14**
Apr-2024	15
May-2024	15
Jun-2024	11

* Additional sampling following an exceedance at location 750-SC-003.

** Subsequent sampling from initial monthly sampling event

2.1.1 Method overview

All samples for the monitoring of the comingled effluent were taken from the nominated sampling point 750-SC-003 in accordance with INPEX's sample schedule (document number L290-A1-LIS-60006). All testing equipment passed QC requirements during the 2023-2024 audit period with all calibration records maintained by INPEX's NATA certified onsite laboratory. Records of calibration are referenced on the Certificate of Authenticity issued by the onsite laboratory for each sample. Applicable calibration records are verified during the statutory audit conducted every two years. 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 jetty outfall discharge is visually inspected daily by Inpex operations staff for any visible sheen caused by hydrocarbons. Sightings are recorded only by exception in the J5 logbook for reference. No visible hydrocarbon sheen observed during this reporting period. 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: Commingled treated effluent discharge monitoring, methods, and discharge limits

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: Commingled treated effluent discharge monitoring, methods, and discharge limits) have been entered 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. The external laboratory responsible for the micro analysis updated the reporting name for Faecal Coliforms in May 2024. These are now presented as Thermotolerant Coliforms as part of NATA accreditation requirements with testing, LOR and discharge limits remaining the same.

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

Parameter	Sampling method*	Unit	LOR	Discharge limit
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	INPEX Lab	mg/L	0.02	2
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 (Thermotolerant 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.

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:.

During the reporting period, there were two occurrences where wastewater quality was above discharge limits, these are further discussed in Section 2.1.3. Note, following an initial exceedance, further sampling at 750-SC-003 was 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 little variability of the wastewater quality during the 2023/2024 reporting period in comparison to previous reporting timeframes. There was a significant reduction in overall EPL228 exceedances associated with wastewater discharges with the total exceedance events reducing from ten in the 2022-2023 period, to two in the 2023/2024 period. The main sampling considerations for this reporting period were Total Nitrogen exceedances (one event) and Total Suspended Solids exceedances (one event). These will be discussed further in Table 2-4.

The total number of discharge exceedances experienced in the 2023/2024 reporting period (two) varies significantly from the ten discharge exceedance events during the 2022/2023 reporting period (Table 2-3). Although this may be considered significant between these reporting periods, the 2022/2023 reporting period total events (ten) is an anomaly in comparison to reporting periods to date which are summarised in Table 2-3: Yearly discharge exceedance comparison at 750-SC-003 below. The 2023/2024 reporting period saw a return to a total number of events to be "as expected" for a 12-month reporting period.

Table 2-3: Yearly discharge exceedance comparison at 750-SC-003

Reporting Period	Total Number of Exceedances at 750-SC-003
2018-2019	4
2019-2020	4
2020-2021	2
2021-2022	3
2022-2023	10
2023-2024	2

In general, INPEX's main wastewater discharge exceedances during the 2023/2024 reporting period were related to Total Nitrogen and Total Suspended Solids at the Jetty Outfall discharge location 750-SC-003. Due to the year-on-year trend of TN exceedances at ILNG, a more in-depth investigation was undertaken in Q1 and Q2, 2024 to obtain a better understanding of this issue. The TN exceedance in January 2024 was investigated in detail with a report presented to the NT EPA in Q2 2024. The report investigated all incoming waste streams originating with nitrogen and/or ammonia and the cumulative impacts each source impacts along the process to the eventual final level of nitrogen obtained at the 750-SC-003 sample point. The investigation report identified the increasing nitrogen trend during the wet season since 2018; however, the cause of the trend is still unknown. A New Environmental Impact Risk Assessment (NEIRA) was proposed to be completed by 31 December 2024 to further evaluate the wet season trend.

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

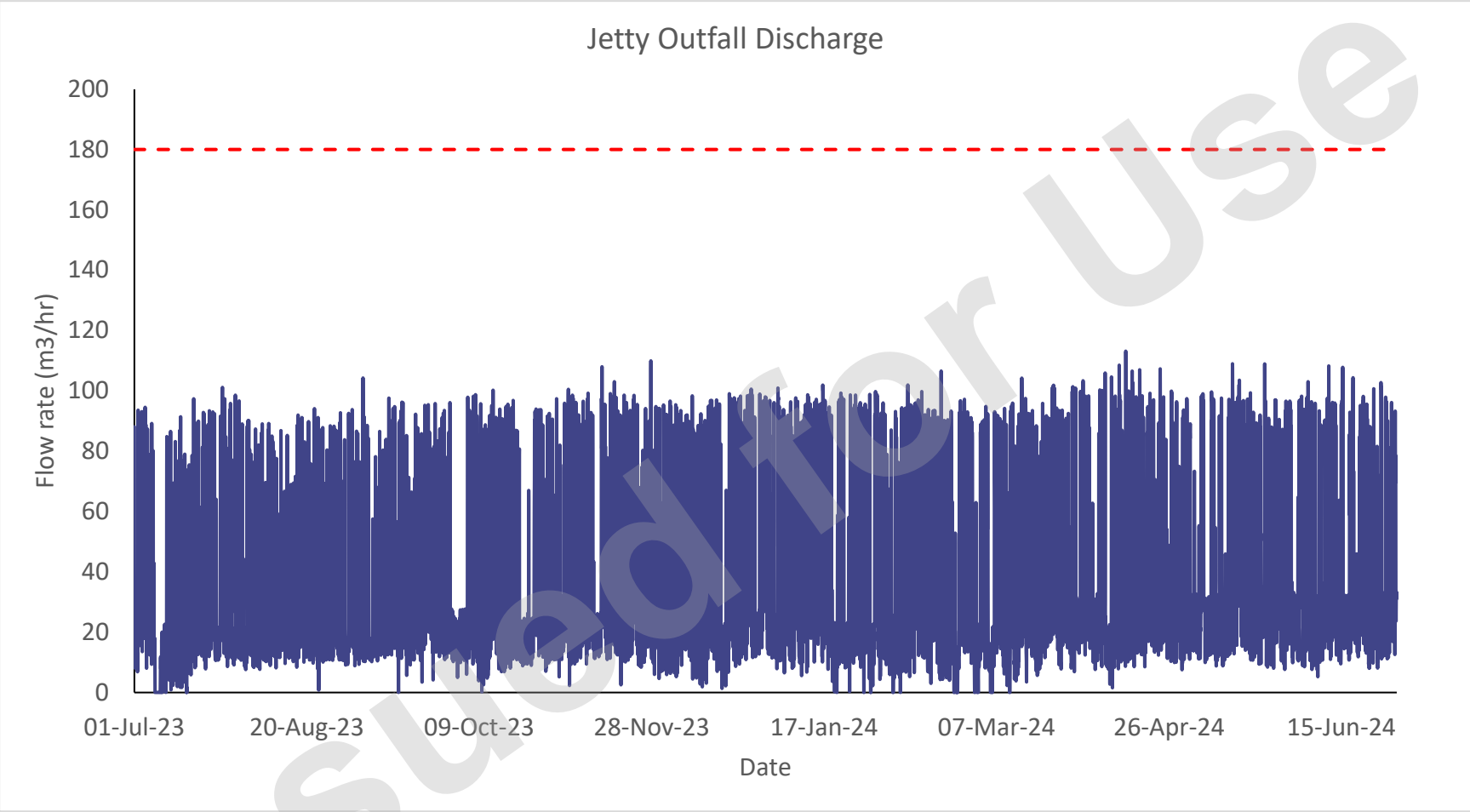

Figure 2-1: Flow rate measured at L-750-FI-0002 flow meter

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
- laboratory designated sample holding times met
- chain of custody forms was completed and accompanied the samples
- INPEX laboratory QA/QC procedures were completed as follows:
  - 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 Assessment off limit exceedances and investigation outcomes

Throughout the reporting period, and displayed on the Certificates of Authority (COA), there were two discharge limit exceedances (refer to APPENDIX C:). A summary table of all discharge limit exceedances, including contributing factors and corrective actions is provided in Table 2-4.

Table 2-4: Summary of commingled treated effluent sample point exceedance events

Date sampled	Exceedance reported	Parameter	Result	Limit	Contributing factors	Corrective actions
8th January 2024	9th January 2024	TN	TN 12 mg/L	TN 10 mg/L	As part of the incident investigation, a detailed report was provided to the NT EPA (L060-AH-REP-70059) detailing the following: During the routine monthly sampling event on 08 January 2024, the following three wastewater streams were flowing into the combined jetty discharge outfall line: • Combined Cycle Power Plant (CCPP) Neutralisation Package • Observation Basin Pump • Irrigation Tank (treated sewage) Following the exceedance, an investigation into the cause of the exceedance was conducted. Non-routine sampling was undertaken across all eight sources contributing to Total Nitrogen at sample point L750-SC-003. Samples were taken from the following points: • Filter Package L750-SC-002 • Demin Package L720-SC-016 • CCPP L630-MV-6880 • Sewage Treatment Package L750-SC-009 • Liquid Rim Vacuum Pump (LRVP) Seal Water L630-MV-99381 • Observation Basin L750-SU-404 • Irrigation Tank L750-SC-004 • Sea Loading Jetty Outfall L750-SC-003 1 0F The investigation concluded that wastewater contributions (volume) from each source can vary. This is dependent on packages being online (i.e. filter package), operational requirements (i.e. maintaining levels in tanks and sumps) and other factors (i.e. wet season, Persons on site etc). The main source of Nitrogen was confirmed to be from within the CCPP Neutralisation Package. This source is the most stable and continuous source of Nitrogen. Within the CCPP Neutralisation Package, Nitrogen was initially identified from within the Liquid Ring Vacuum Pump (LRVP) seal water system. This sample was collected and tested which showed Ammonia as N concentrations at 0.8% (8,000 mg/L). Further investigation was undertaken into the operation and performance of the CCPP system to understand the root cause. The investigation revealed that an MOC 200006566 was raised in 2019 relating to Thermal Power Cycle (TPC)-line from LRVP tank to Steam Tank (ST) flash tank, which was superseded by MOC 200007253 in 2020. • There were various attempts to deal with the condensed steam following original issues with the AOC system's inability to handle high pH liquids. • Initially the condensed steam containing high pH was directed into Intermediate Bulk Carrier (IBC), collected by a licensed waste contractor to be taken offsite. • However, this process was amended to send the condensed steam to the condensate tanks; which subsequently resulted in issues with Concentrated Acid Condensate Extract (CACE) at Condensate/Saturated Steam/Superheated Steam. Currently, the condensed steam is sent to STG flash tanks with intent to warm and vaporise dissolved ammonia to atmosphere. The flash tanks drain into the CCPP sumps and flow into the neutralisation package.	In conclusion, the main source of the elevated TN in the combine Jetty Outfall was identified in the LRVP seal water within the CCPP Neutralisation Package. Contributing factors to the increased TN levels appear to be related to lower operating temperatures of the Steam Turbine Generator (STG) Flash Separator. Routine monthly sampling of the Jetty Outfall L-750-SC-003 on 12 February 2024 confirmed that the TN concentration was back below the EPL228-05 limit (4 mg/L). Average TN concentrations during the wet season appear to have been increasing since Q4 2018. The cause for this gradual increase in TN is unknown and will be evaluated through a NEIRA. The NEIRA process will internally evaluate these increasing TN trends and consider if there are any operational implications; consider whether additional engineering controls or laboratory testing are necessary. ACTIONS TO PREVENT REOCCURANCE Confirmation of the effectiveness of operational procedures to manage TN confirmed by routine monthly sampling of the Jetty Outfall L-750-SC-003 on 12 February 2024 which returned a result of 4 mg/L. Through the incident investigation process, the following actions were identified to understand the issue and prevent reoccurrence: • Review operational procedure for dealing with condensed steam water from the LRVP seal by increasing temperature of STG flash tank to vaporise ammonia. Temperatures in the ST Flash Tanks were increased to 130°C with the objective to improve ammonia volatilisation, thereby reducing the Nitrogen contributions originating from the CCPP Neutralisation Package. (Completed) • Fortnightly monitoring of TN at the following locations, for a period of three months, to determine contributions of all streams and variations: o L750-SC-004 o L750-SU-404 o L750-SC-003 (ensuring that one of the tests falls on the monthly routine testing for Jetty Outfall) • Complete a NIERA (due Q4 2024) to internally evaluate increasing TN trends and consider if there are any operational implications; consider whether additional engineering controls or laboratory testing are necessary.

Date sampled	Exceedance reported	Parameter	Result	Limit	Contributing factors	Corrective actions
					The root cause of the TN, following the Non-Routine Request (NRR). Sampling was still not clear, so further investigations of all the sumps in the CCPP and one of the Heat Recovery Steam Generator (HRSG) Drums (Blowdown Water) was undertaken to understand the influence of temperature on TN levels, and to verify whether the LRVP seal water was the root cause. This is summarised in the corrective actions listed in this table.	
12th March 2024	14th March 2024	Total Suspended Solids	60mg/L	10mg/L	A sample was taken from the combined jetty outfall discharge line, sampling location 750-SC-003 at 8:50am (CST) Tuesday 12 March 2024. The NATA accredited interim testing results issued on Thursday 14 March 2024 reported a Total Suspended Solid (TSS) concentration of 60 mg/L, which exceeds the discharge limit of 10 mg/L. As standard practise, the INPEX laboratory collect a duplicate sample when undertaking the required monthly sampling from location 750-SC-003. The duplicate was collected approximately at 9:15am on Tuesday 12 March after the primary TSS sample (following the sample collection protocol) and reported a TSS value of <5 mg/L, which is below the discharge limit of 10 mg/L.	The follow up sample came back within specification, therefore there was no actual or potential cause for harm. No further investigation was undertaken.

2.1.4 Program rationalisation

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

2.2 Harbour sediment

In accordance with the OEMP (L60-AH-PLN-60005), harbour sediment monitoring occurs biennially (every two years). Harbour sediment monitoring were monitored last in July 2022, and therefore were not monitored in the 2023/2024 reporting period.

The key objective of the harbour sediment quality program is to:

- detect changes in surficial sediment quality in the vicinity of the jetty outfall and determine if changes are attributable to Ichthys LNG operations.

2.2.1 Program rationalisation

No program rationalisation was proposed for harbour sediment monitoring from the previously conducted 2022 harbour sediment monitoring. The next proposed survey was undertaken in July 2024 and will be included in the next reporting period.

3 EMISSIONS TO AIR

This section includes the outcomes of the following monitoring programs:

- point source emissions (Section 3.2)
- dark smoke events (Section 3.4).

This section also summarises the operating condition of each emission source and the resulting air emission quality (Section 3.3) 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 77.6 of EPL228-05 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 the reporting period

Parameter	Emissions (t/yr)
NOx as nitrogen dioxide (NO_2)	1,941.326
Mercury (Hg)	0.000
Benzene	3.397
Toluene	4.540
Ethylbenzene	0.828
Xylenes	3.754
Hydrogen sulphide (H_2S)	270.166
Carbon monoxide	2,823.742
Total hydrocarbons flared	Refer Table 3-5

INPEX is currently transitioning to a new emissions reporting management system, which includes a review of current NPI calculation methods for flaring and venting. This review will consider replacing the industry averaged NPI emission factors for flaring and venting with plant specific factors derived from stack testing data, which will more accurately reflect the performance of the ILNG Plant and its associated emissions.

3.2 Point source emissions to air

The key objective of point source emission monitoring (commonly referred to as stack sampling) is to ensure air emissions do not exceed the concentration limit criteria specified in Table 5, Appendix 3 of EPL228. The frequency of monitoring is outlined in EPL228, which requires annual monitoring of most emission points, monthly monitoring of hot venting, and hydrocarbons monitoring for all flare events.

Annual monitoring is undertaken in accordance with the requirements of EPL228.

Table 3-2 provides a summary of the point source emission monitoring conducted for the reporting period.

Table 3-2: Point source emissions survey dates

Survey	Start date	End Date
Survey 9 Q4 2023	October 2023	November 2023

3.2.1 Method overview

Stationary source emissions monitoring was completed at 10 point sources (out of a total of 18 stacks) on the Frame 7 compression turbines (4), CCPP Frame 6 heat recovery system generator (HRSG) stacks (4) and heating medium furnaces (2).

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 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 3-3 and Table 3-4 show the EPL228 air emission target and limits plus the constituents that are required to be monitored at the point source locations as per Appendix 3, Table 5 and Table 6 respectively, of EPL228-05. Figure 3-1 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 benzene, toluene, ethylbenzene and xylene (BTEX), hydrogen sulphide (H_2S) and mercury (Hg) using conventional industry methods which are not NATA accredited. The analysis of these gases is conducted on a monthly basis 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 Positions.

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

- New South Wales (NSW) Environment Protection Authority (formerly the Department of Environment and Conservation) Approved Methods for the Sampling and Analysis of Air Pollutants in NSW; or
- United States Environmental Protection Agency (USEPA) Method 30B (Mercury Sorbent Trap Procedure) 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 3-3: 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@ 15% O_2 dry	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@ 15% O_2 dry	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@ 15% O_2 dry	175 @ 15% O_2 dry
A13-1, A14-1	AGRU Incinerators	NO_x	320 @ 3% O_2 dry	160 @ 3% O_2 dry	350@ 3% O_2 dry	175 @ 3% O_2 dry
A15, A16	Heating Medium Furnaces	NO_x	160 @ 3% O_2 dry	80 @ 3% O_2 dry	350@ 3% O_2 dry	175 @ 3% O_2 dry

Table 3-4: 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)	annual	NO_x as NO_2, 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	annual	NO_x as NO_2, 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	annual	NO_x as NO_2, CO, temperature, efflux velocity, volumetric flow rate
A13-1	L-551-FT-031	AGRU Incinerator – LNG Train 1	annual	NO_x as NO_2, CO, temperature, efflux velocity, volumetric flow rate
A13-2	551-SC-003	AGRU Hot Vent – LNG Train 1, prior to release at A3	monthly	BTEX, H_2S, volumetric flow rate
A13-3	541-SC-001	Feed gas to AGRU – LNG Train 1 – prior to release at A3	monthly	Hg
A14-1	L-552-FT-031	AGRU Incinerator – LNG Train 2	annual	NO_x as NO_2, CO, temperature, efflux velocity, volumetric flow rate
A14-2	552-SC-003	AGRU Hot Vent – LNG Train 2, prior to release at A4	monthly	BTEX, H_2S, volumetric flow rate
A14-3	542-SC-001	Feed gas to AGRU – LNG Train 2 – prior to release at A4	monthly	Hg
A15	L-640-A-001-A	Heating Medium Furnaces	annual	NO_x as NO_2, CO, temperature, efflux velocity, volumetric flow rate
A16	L-640-A-001-B	Heating Medium Furnaces	annual	NO_x as NO_2, 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		

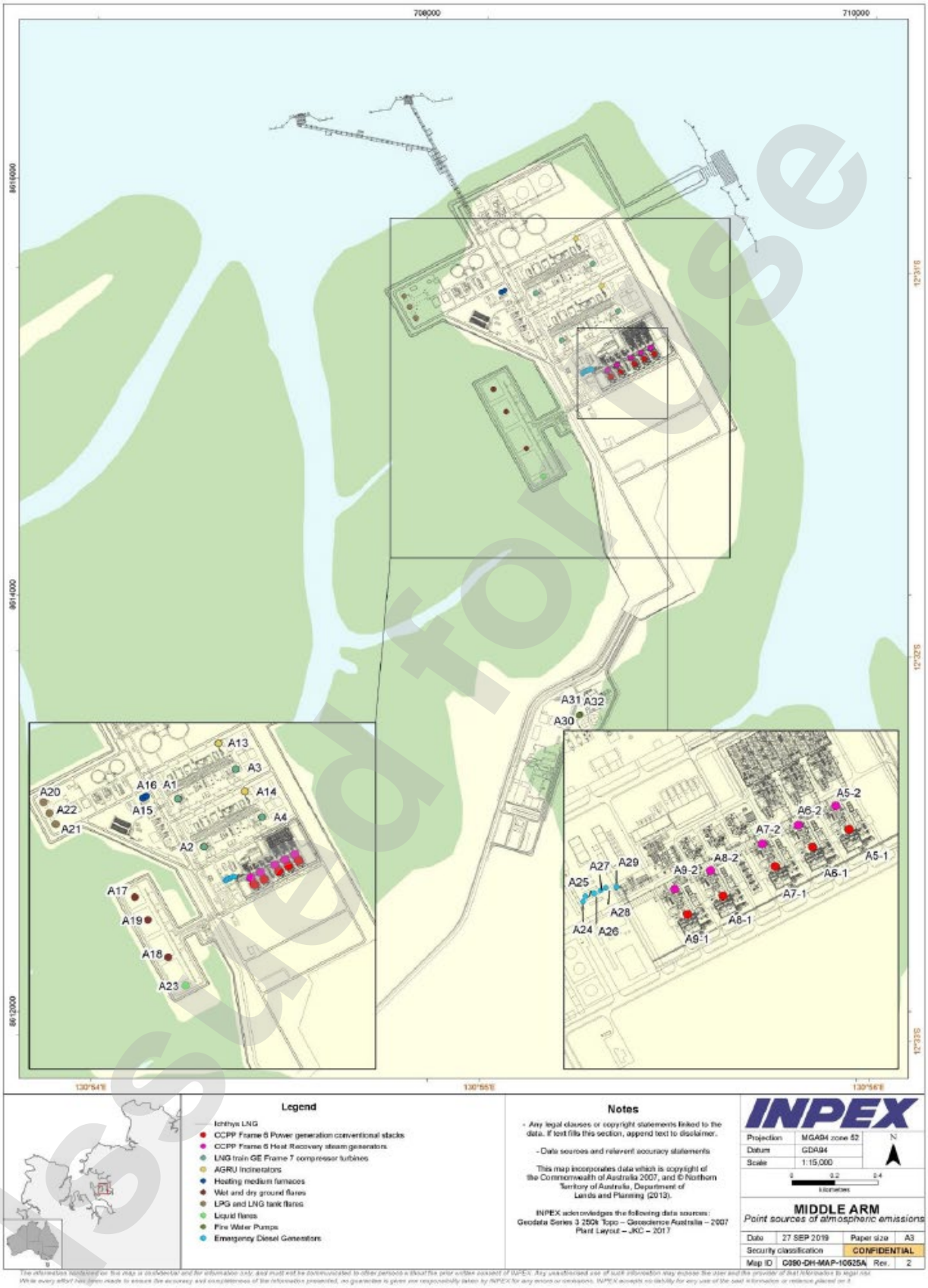

Figure 3-1: Location of authorised stationary emission release points

3.2.2 Quality control assessment

Stationary source emissions testing undertaken in October-November 2023, were carried out as per the nominated test method within EPL228-05 license condition 58.2 following the NSW Department of Environment and Conservation Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales or USEPA Method 30B for mercury emissions. This was completed in conjunction with Appendix 3, Table 6 of EPL228. All samples were collected and sampled as per above conditions. NATA accredited environmental consultants Ektimo were engaged to carry out onsite stationary source testing as INPEX's NATA accreditation is still pending.

3.2.3 Results and discussion

All results for the permanent plant were below limit criteria provided in Appendix 3, Table 6 of EPL228 (Table 3-3). The stationary source emission monitoring results are provided in APPENDIX D:

Due to equipment being offline for planned maintenance and extended unplanned equipment fault outages; release point number A5-1 (L-780-GT-001), A6-1 (L-780-GT-002), A7-1 (L-780-GT-003), A8-1 (L-780-GT-004) and A9-1 (L-780-GT-00 5) were unable to be tested during the Q4 2023 survey. Similarly, A7-2 (L-630-F-003) CCPP Gas Turbine Generator 3 was offline during the survey. As previously mentioned in section 3.2.1, CCPP frame 6 turbines have two stacks with only one of the two stacks running at a time. As such, release port numbers A5-1 to A9-1 (conventional stack series) were not tested in this reporting period as they were not online while the "HRSG stack series" frame 6 sampling locations (A5-2 (L-630-F-001), A6-2 (L-630-F-002), A8-2 (L-630-F-004) and A9-2 (L-630-F-005), were online and utilised in this survey.

The mass of hydrocarbons flared for the reporting period for each flare source is presented in Table 3-5.

Table 3-5: 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	10,010
A18 / A19	L-700-F-001-A/B / L-700-F-003	Ground flare #2 cold / Ground flare #1 spare	21,443
A20	L-700-F-005-A/B	Tank flare #1 LNG	6,902
A21	L-700-F-006-A/B	Tank flare #2 LPG	13,339
A22	L-700-F-007	Tank flare #3 LNG/LPG	0
A23	L-700-F-004	Liquid flare	0

Figure 3-2 and Figure 3-3 show the vented acid gas flow rates in standard cubic metre per hour Sm^3/h for Train 1 and Train 2 respectively. During the time the acid gas incinerators (AGIs) were offline, the acid gas was hot vented when the LNG trains were online. Figure 3-4 and Figure 3-5 provide the flow rate of acid gas to the Train 1 and Train 2 AGIs, while the incinerator was in service.

While the AGIs were offline and venting was occurring, gas sampling was undertaken in accordance with EPL228-05 condition 58.1. Throughout the reporting period, INPEX experienced a number of performance issues with Train 1 and Train 2 AGIs resulting in subsequent trips of both AGIs. They were taken offline for a full review and Management of Change process before being re-implemented. The NT EPA were notified of the AGI performance issues in accordance with EPL228-05 condition 70.

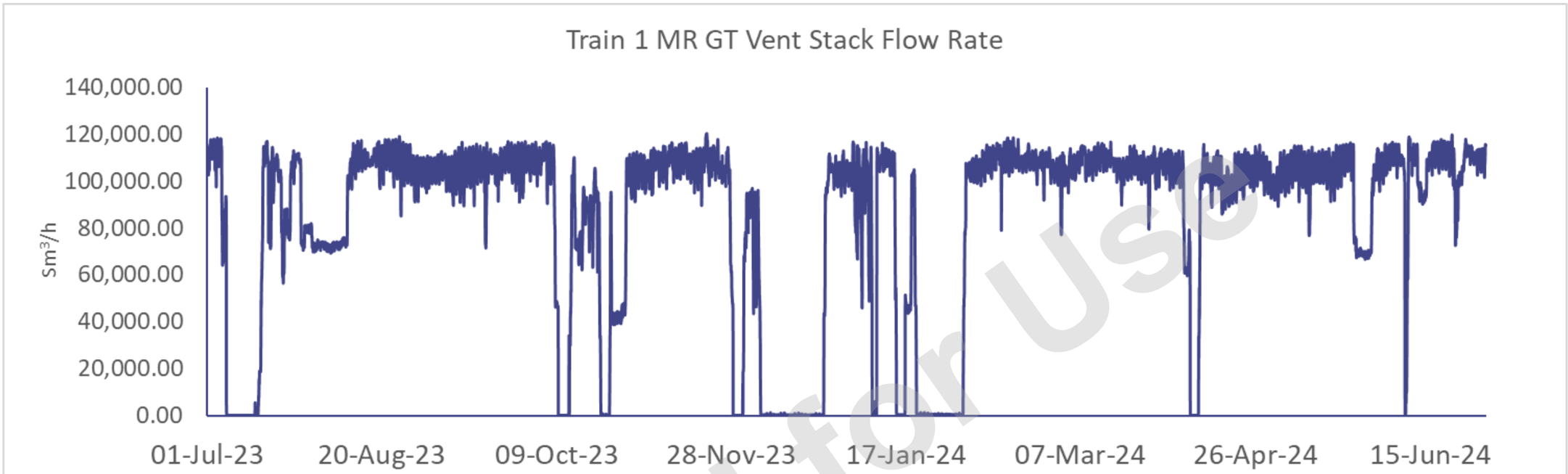

Figure 3-2 Train 1 acid gas venting flow rates

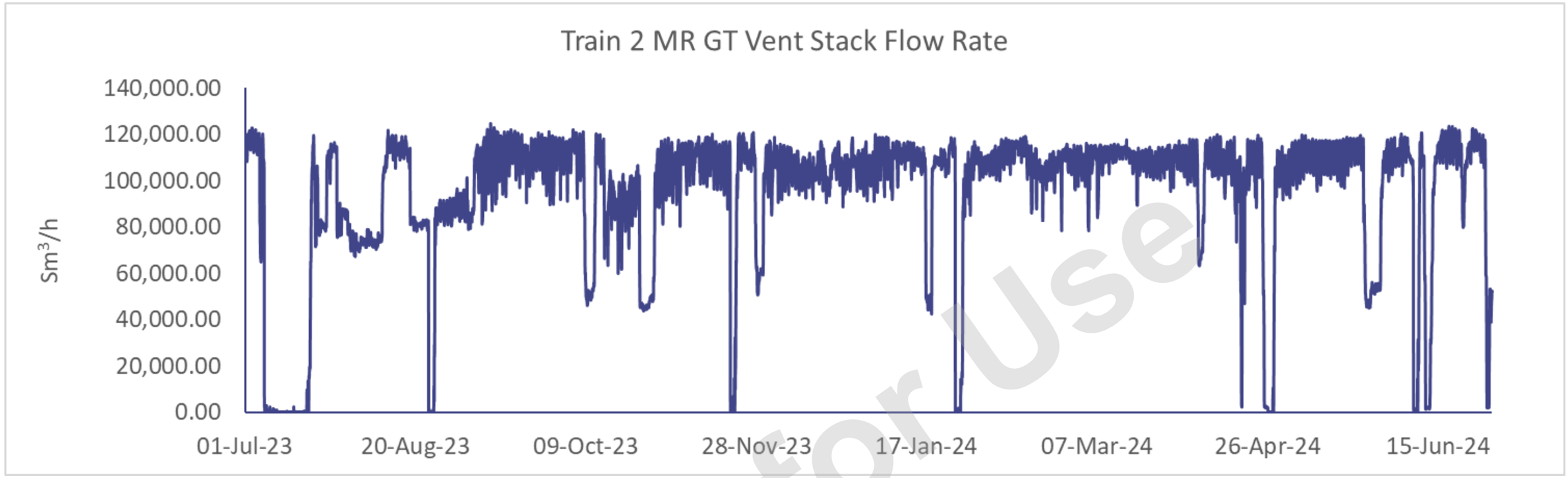

Figure 3-3 Train 2 acid gas venting flow rates

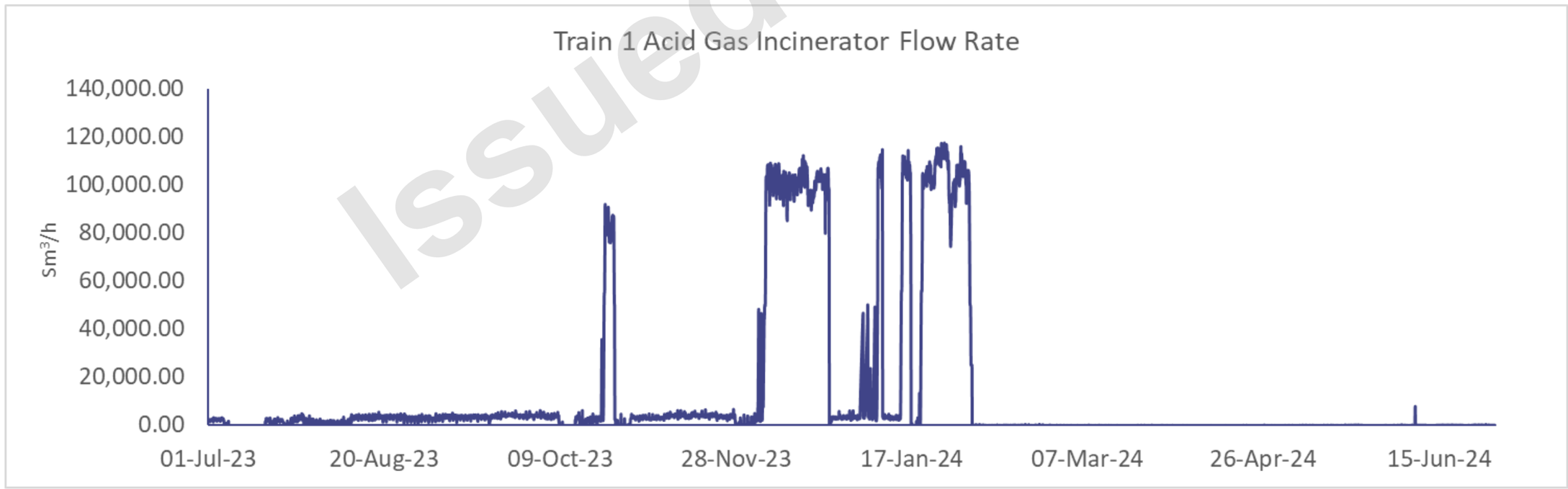

Figure 3-4 Train 1 acid gas incinerator flow rates

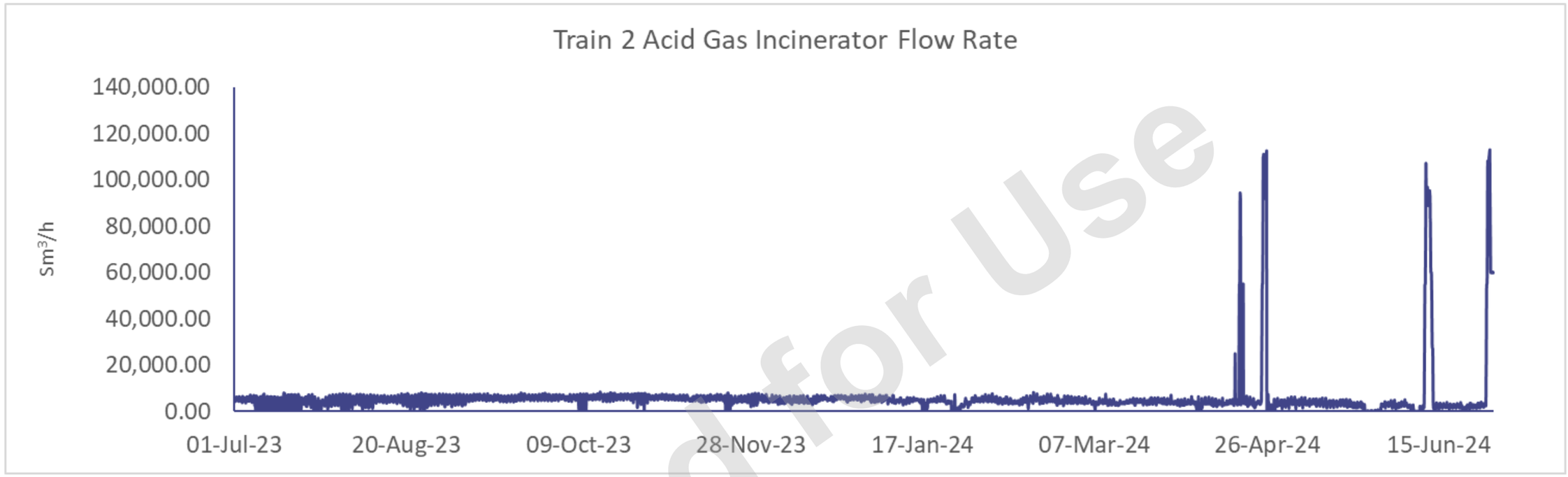

Figure 3-5 Train 2 acid gas incinerator flow rates

3.2.4 Program rationalisation

No rationalisation is currently proposed, and monitoring will be conducted as per the EPL228 requirements.

3.3 Overall summary of performance of stationary emission sources

The status of the stationary point source emissions at Ichthys LNG is provided in Table 3-6 based on information presented in Sections 3.1 and 3.2. As stated above the Train 1 and LNG Train 2 AGIs for both were intermittently offline during the period. While the acid gas incinerators were offline, sampling of the vented gas occurred as per EPL228 condition 58.

Table 3-6: 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
A5-1	Power generation turbine 1 (Frame 6)	Intermittent use, when HRSG offline	Not tested in this survey
A6-1	Power generation turbine 2 (Frame 6)	Intermittent use, when HRSG offline	Not tested in this survey
A7-1	Power generation turbine 3 (Frame 6)	Intermittent use, when HRSG offline	Not tested in this survey
A8-1	Power generation turbine 4 (Frame 6)	Intermittent use, when HRSG offline	Not tested in this survey
A9-1	Power generation turbine 5 (Frame 6)	Intermittent use, when HRSG offline	Not tested in this survey
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)	Off-line during survey	Not tested in this survey
A8-2	Power generation turbine 4 HRSG (Frame 6)	Operational	Acceptable
A9-2	Power generation turbine 5 HRSG (Frame 6)	Operational	Acceptable
A13-1	AGRU Incinerator – LNG Train 1	Off-line during survey	Not tested in this survey

Release point number	Emission source	Status	Air emissions
A13-2	AGRU Hot Vent – LNG Train 1, prior to release at A3	Operational	Acceptable
A14-1	AGRU Incinerator – LNG Train 2	Off-line during survey	Not tested in this survey
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

3.4 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 are considered negligible but may cause visual amenity impact and community concern.

3.4.1 Method overview

Visual monitoring and closed-circuit television monitoring of flares is undertaken to detect possible dark smoke events in accordance with the Onshore LNG Dark Smoke Management Guideline. 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 3-7. Any dark smoke events (above Ringelmann 1) are recorded and investigated as an incident and reported to the NT EPA in the annual record of flaring (Condition 71 of EPL228-05).

Table 3-7: 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 are 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.

3.4.2 Results and discussion

No dark smoke events (above Ringelmann 1) occurred during the 2023/2024 reporting period.

3.4.3 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 biannually (e.g. twice yearly at 15 sites). 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 #
12	10-12 October 2023	Groundwater Quality Monitoring – Trigger Assessment: Report No 12	L290-AH-REP-70054
		Groundwater Quality Interpretive Report No 12	L290-AH-REP-70055
13	02-04 April 2024	Groundwater Quality Interpretive Report No 13	L290-AH-REP-70076

4.1.1 Method overview

The groundwater quality monitoring surveys were undertaken in accordance with the Groundwater Quality Monitoring Plan (L290-AH-PLN-70000). 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). 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 had stabilised over three consecutive readings, groundwater samples were then collected for analysis.

Following collection, groundwater samples were sent to NATA accredited laboratories for analysis of parameters listed in Table 4-2. Results were then compared to benchmark levels to ascertain whether a trigger exceedance had occurred.

Exceedance of a benchmark level is defined as a measured analyte exceeding its relevant trigger value (see Table 4-2) and the same analyte also exceeding the background level for each groundwater well. Specific background level trigger values were calculated using the approach described in ANZG (2018). The 80th and/or 20th percentile value for each parameter was determined using the monthly groundwater data collected during the construction phase of Ichthys LNG between 2013 and 2018.

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

Parameter	Unit	Sampling method*	Trigger value	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	
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	

Parameter	Unit	Sampling method*	Trigger value	Trigger value reference
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 Quality Control Assessment

Laboratory holding times

All samples arrived at the laboratories within the required holding times for all analytes and chemical compounds with trigger values, for both survey 12 and 13.

Blank samples

Analyte concentrations measured in rinsate and field blank samples reported below the laboratory LORs. It is therefore unlikely that the sampling procedure caused a measurable increase in contaminant concentrations during groundwater sampling.

Duplicate and triplicate samples

Analyses of duplicate samples revealed that the relative percentage differences (RPD) achieved the performance criteria of <30 % for most analytes, with the following exceptions:

- Survey 13
  - Total phosphorus (RPD = 52)

Analyses of triplicate samples revealed that the RPD achieved the performance criteria of <30 % for the majority of analytes, with the following exceptions:

- Survey 12
  - Total kjeldahl nitrogen (TKN) (RPD = 67)
  - Total nitrogen (RPD = 67)
- Survey 13
  - Ammonia (as N) (RPD = 61)
  - Total kjeldahl nitrogen (TKN) (RPD = 34)
  - Total nitrogen (RPD = 34)

For survey 12, the nitrogen concentrations in both the primary sample (500 µg/L) and the triplicate sample (1,000 µg/L) were above the trigger level of 300 µg/L and the background level at BPGW26 of 468 µg/L. This elevated RPD therefore places some uncertainty on the accuracy of nitrogen concentrations recorded in the primary sample from BPGW26, this has been treated as an exceedance and investigated in Sections 4.1.3 and 4.1.4.

For survey 13, the ammonia concentrations in both the primary sample (514 µg/L) and the triplicate sample (970 µg/L) were above the trigger level of 200 µg/L and the background level at BPGW40 of 160 µg/L. This elevated RPD therefore places some uncertainty on the accuracy of ammonia concentrations recorded in the primary sample from BPGW40. The nitrogen concentration of both the primary sample (710 µg/L) and the triplicate sample (1,000 µg/L) were above the trigger level of 300 µg/L and the background level at BPGW40 of 270 µg/L. This elevated RPD therefore places some uncertainty on the accuracy of nitrogen concentrations recorded in the primary sample from BPGW40, this has been treated as an exceedance and investigated in Sections 4.1.3 and 4.1.4.

For both survey 12 and 13 there are no trigger values for TKN.

Limit of reporting

The number of raised LORs during the 12th and 13th groundwater monitoring events is less than what was recorded for previous monitoring rounds. This was achieved following discussion with ALS to develop an improved COC that details the laboratory methods required to attain the LORs outlined in the Ichthys LNG Groundwater Monitoring Plan (INPEX 2020b).

Survey 12

The following observations were made regarding the limit of reporting (LOR) for analytes measured at ALS:

- Trivalent chromium was analysed to an LOR of 10 µg/L in five primary samples. This is higher than the LOR of 0.2 µg/L required for the groundwater monitoring program but equal to the trigger value; therefore, this result does not impact the trigger assessment.
- Vanadium was analysed to an LOR of 0.2 µg/L in three primary samples and an LOR of 0.5 µg/L in four primary samples. This is higher than the LOR of 0.1 µg/L required for the groundwater monitoring program, but less than the trigger value of 100 µg/L; therefore, this result does not impact the trigger assessment.
- Total phosphorus was analysed to an LOR of 25 µg/L in one primary sample. This is higher than the LOR of 20 µg/L required for the groundwater monitoring program, but less than the trigger value of 30 µg/L; therefore, this result does not impact the trigger assessment.

None of the raised LORs were higher than the trigger values, therefore the integrity of this round of groundwater monitoring has not been impacted.

Survey 13

The following observations were made regarding the LOR for analytes measured at the primary laboratory (ALS) for Survey 13:

- Nickel was analysed to an LOR of 0.5 µg/L in in five primary samples. This is higher than the LOR of 0.1 µg/L required for the groundwater monitoring program but less than the trigger value of 7 µg/L; therefore, this result does not impact the trigger assessment.
- Vanadium was analysed to an LOR of 0.2 µg/L in three primary samples and an LOR of 0.5 µg/L in two primary samples. This is higher than the LOR of 0.1 µg/L required for the groundwater monitoring program, but less than the trigger value of 100 µg/L; therefore, this result does not impact the trigger assessment.

None of the raised LORs were higher than the trigger values, therefore the integrity of this round of groundwater monitoring has not been impacted.

A review of accredited laboratory (ALS) procedures and sampling equipment was conducted and implemented following the previous reporting period. This involved ensuring the ultra-trace sample containers designated for analytical testing at low concentration levels.

4.1.3 Results and discussion

A high-level summary of groundwater results and trends is provided in the following sections, with detailed results discussion and data collected during the reporting period provided in APPENDIX E:. Note, presentation of groundwater data trends include data collected during the construction phase. Groundwater surveys undertaken during the reporting period are specified in Table 4-1. To date, groundwater monitoring during the operations phase of Ichthys LNG shows that there has been no change in groundwater quality.

Survey 12: October 2023

Thirty-seven exceedances against both the trigger and background concentrations were recorded in the 12th groundwater monitoring event in October 2023. Exceedances include 21 for nutrients and 16 for dissolved metals. No exceedances were recorded for hydrocarbons, mercury, PH or physicochemical parameters. This is more than the 31 exceedances recorded during the tenth groundwater monitoring event undertaken during October 2022.

All exceedances have been compared to data recorded during the dry season months of May to October between May 2016 and May 2023.

Visual assessment of time plotted data indicates that several of the nutrient analyte exceedances represent short-term spikes, potentially related to seasonal environmental variables, rather than increasing trends. Visual assessment of time plotted data has indicated the following trends for nutrient exceedances:

- Ammonia: Increasing trends at BPGW40 and BPGW41.
- Total Nitrogen: Increasing trends, albeit fluctuating at VWP341 and BPGW40.
- Filterable reactive phosphorus (FRP): Increasing trend at BPGW01.

Visual assessment of time plotted data for metal exceedances has indicated the following trends:

- Arsenic: increasing trend at BPGW09
- Cobalt: Increasing trend at VWP341
- Zinc: Increasing trend at VWP341.

The following historical maximum values were recorded during the October 2023 monitoring event:

- Arsenic at BPGW28 (15.2 µg/L)
- FRP at BPGW01 (17 µg/L)
- Oxides of Nitrogen at BPGW20 (310 µg/L) and at BPGW28 (178 µg/L)

Results of the investigation into each of the exceedances are described in Section 4.1.4.

Survey 13: April 2024

Twenty-eight exceedances against both the trigger and background concentrations were recorded in the thirteenth groundwater monitoring event in April 2024. Exceedances include 13 for nutrients and 15 for dissolved metals. No exceedances were recorded for hydrocarbons, mercury, PH or physicochemical parameters.

Exceedances were plotted on time series graph to compare to pre-construction and construction data and discern trends in the data.

No trigger exceedances for pH or hydrocarbons were recorded from the survey.

A review of the 13 nutrient exceedances from April 2024 monitoring event found that seven of the exceedances were consecutive for at least three surveys. Trend analysis completed by the monitoring contractor indicates:

- Ammonia:
  - Increasing trends for ammonia at BPGW40
  - Increasing trends for ammonia has stabilised at BPGW41 and VWP341
  - Fluctuating trends for ammonia at BPGW18, BPGW20, and BPGW28
- Nitrogen: Fluctuating long-term trend for total nitrogen at BPGW40, BPGW41 and VWP341
- Oxides of nitrogen: Consistent fluctuating trend of oxides of nitrogen, with concentrations increasing in the wet season and decreasing in the dry season at BPGW38A.
- Phosphorus: Slightly increasing trend at BPGW07 has stabilised, fluctuating but stable phosphorus concentrations at BPGW08A.

Trend analysis of the 14 metals exceedances completed by the monitoring contractor indicates that:

- Arsenic: Increasing albeit fluctuating long-term trend at BPGW09 and VWP328.
- Cobalt: Stable but fluctuating at BPGW08A; and increasing trend at BPGW09, VWP328, BPGW40 and VWP341.
- Zinc: Increasing trend at VWP341.
- Copper: Fluctuating trend at BPGW07.
- Manganese: Fluctuating and increasing trend at VWP341 and BPGW09.
- Nickel: Stable overall but fluctuating at VWP341.
- Zinc: Fluctuations at BPGW07, fluctuating and increasing VWP341.

The following historical maximum values were recorded during the April 2024 monitoring event:

- Ammonia at VWP341(736 µg/L)
- Cobalt at BPGW40 (1.8 µg/L) and at VWP341 (168 µg/L)
- Zinc at VWP341(173 µg/L)

Results of the investigation into each of the exceedances are described in Section 4.1.4.

4.1.4 Trend analysis and trigger exceedance investigation outcomes

Trend analysis

Increasing trends were determined across groundwater surveys 12 and 13, Ammonia (BPGW40, BPGW41, VWP341), Total Nitrogen (BPGW40), Arsenic (BPGW09 and VWP328), Cobalt (VWP341, VWP328 and BPGW40), Zinc (VWP341). Note analytes that with an increasing trend in survey 12 but not survey 13 have not been included in this analysis. Trend graphs represented below are based on sites experiencing exceedances for at least 3 successive monitoring sampling campaigns.

pH

Analysis of pH at the sampling sites over time indicate that the overall pH trend stabilised across the sites from previous reporting period. This is also reflected by no pH exceedances being observed in either sampling survey.

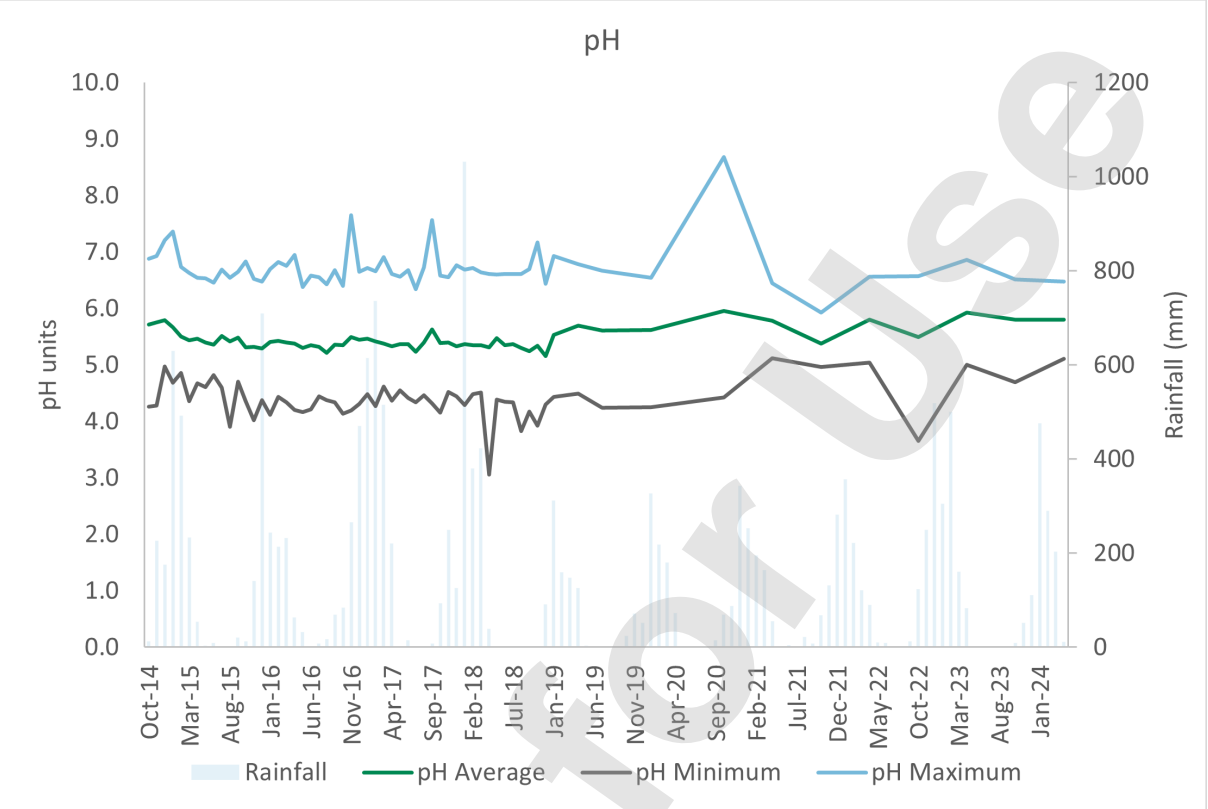

Figure 4-2: average, minimum and maximum pH of all operational monitoring wells from October 2014 to April 2024

Ammonia

Ammonia exceedances were recorded at eight and six monitoring bores respectively during the twelfth and thirteenth groundwater monitoring event (BPGW18, BPGW20, BPGW28, BPGW40, BPGW41 and VWP341 for both surveys and BPGW26, BPGW27A for Survey 12). This is the same number of exceedances that were recorded during the previous dry and wet season monitoring events undertaken in October 2022 and April 2023. The ammonia exceedances recorded at BPGW40 may be representative of a long-term increasing trend, while exceedances at BPGW20 represent stable but fluctuating trends. Recorded ammonia values at BPGW26 and BPGW27A fell below trigger exceedance levels during survey 13.

Trend analysis indicates that ammonia concentrations at BPGW41 and VWP341 have increased since 2018 and have stabilised, while concentrations at BPGW18 and BPGW28 are stable but fluctuating, Figure 4-3. BPGW18 and BPGW28 appear to be responding to changing conditions but fluctuate within a stable range.

It is noted that monitoring during the construction stage of the project (2012-2015) identified that ammonia concentrations were regularly recorded above the trigger value of 20 µg/L across the site (AEC Environmental 2015). Investigations into the ammonia trigger exceedances did not determine any potential sources of ammonia on site, no pathway from sources of ammonia on site to groundwater. Therefore the increasing trends are considered to be as a result of natural variation.

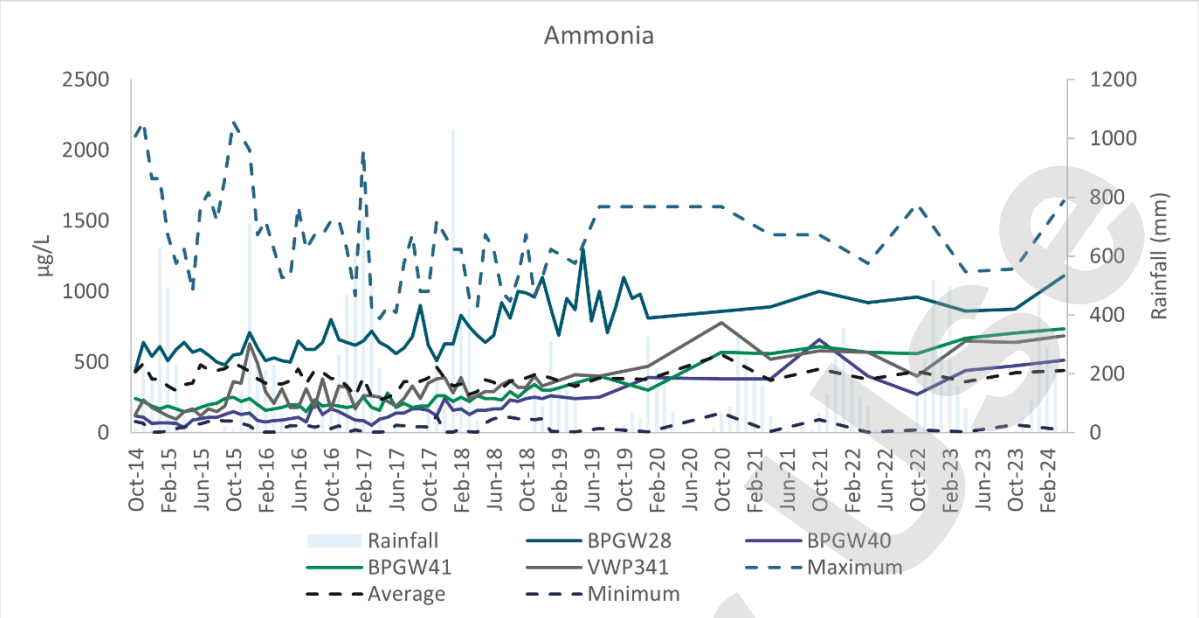

Figure 4-3: Ammonia concentrations at BPGW40, BPGW41 and VWP341, and the average, minimum and maximum pH of all operational monitoring wells from October 2014 to April 2024

Total Nitrogen

Five and three trigger exceedances for total nitrogen were recorded respectively during the twelfth and thirteenth groundwater monitoring events, at bores BPGW26, BPGW27A, BPGW40 and BPGW41 and VWP341.

Trend analysis indicates total nitrogen recorded at BPGW26, BPGW27A, BPGW41 and VWP341 fluctuate each year, and the recent exceedances likely represent stable but fluctuating long-term trends. Nitrogen concentrations at BPGW40 have been elevated since October 2021, Figure 4-4. The April 2024 result at BPGW40 is the sixth consecutive nitrogen exceedance at this site.

A review of Ichthys LNG activities indicates that there have been no activities that may have impacted total nitrogen at these locations. Therefore, total nitrogen trigger exceedances are not considered to be a result of Ichthys LNG operations, however they will continue to be monitored in future surveys.

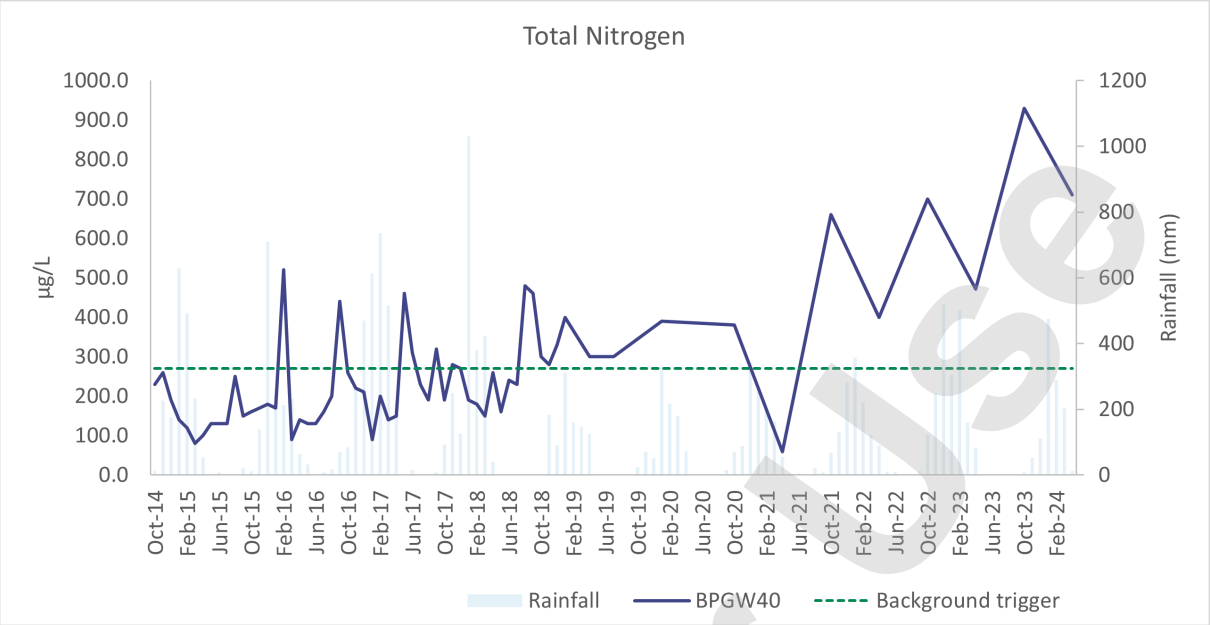

Figure 4-4: Total Nitrogen concentrations recorded at BPGW40 from October 2014 to April 2024

Arsenic

Arsenic concentrations recorded at BPGW09 and VWP328 from October 2014 to April 2024 are displayed below in Figure 4. Arsenic concentrations at BPGW09 and VWP328 fluctuate, with concentration increases correlating with increased rainfall. Arsenic concentrations have increased since the construction period of 2014-2015; however, the long-term trend appears to be stable.

High levels of arsenic are known to occur within the coastal strata of Darwin Harbour and are likely a reflection of local geology rather than anthropogenic sources (Padovan, 2003). The April 2024 exceedance is likely due to seasonal factors.

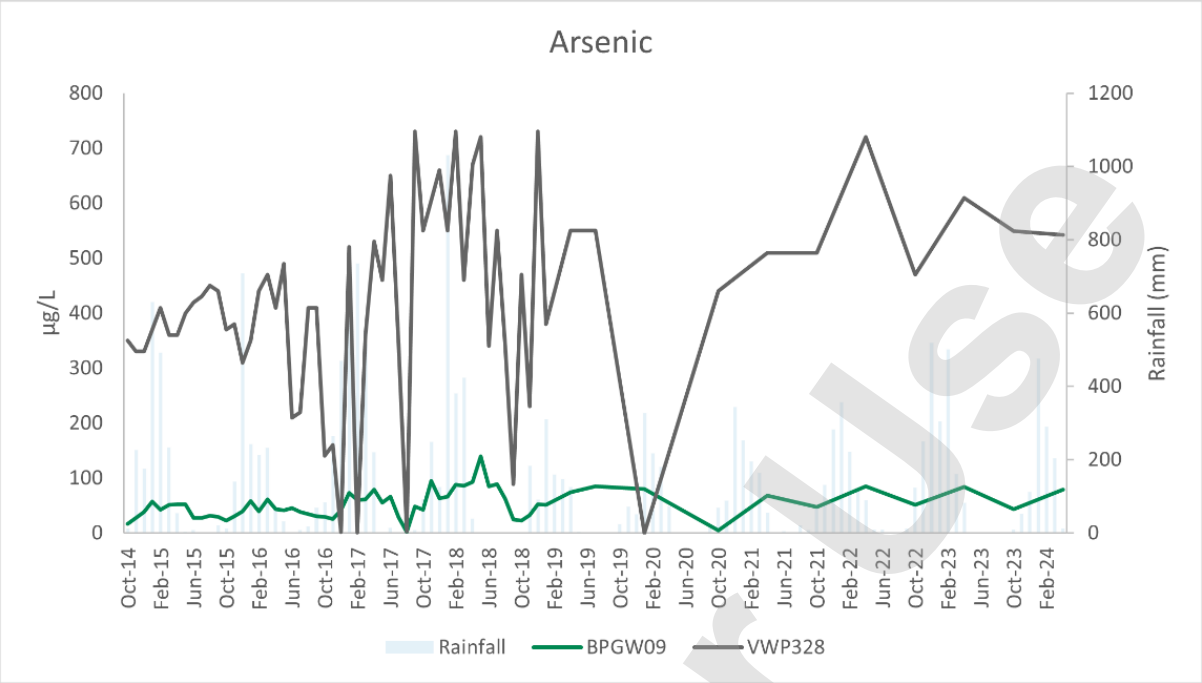

Figure 4-5: Arsenic concentrations recorded at BPGW09 and VWP328 from October 2014 to April 2024

Cobalt

Cobalt concentrations at BPGW40 and VWP341 are increasing, with the April 2024 results representing historical maxima at both bores. Exceedances at BPGW40 appear to be fluctuating seasonally at or just above the trigger value (1 µg/L), with higher trends potentially linked to an increasing rainfall (Figure 4-6), and therefore are likely a result of natural variation. Cobalt concentrations at VWP328 fluctuate but appear to have increased since October 2022.

Figure 4-7 demonstrates that VWP341 cobalt concentrations have consistently trended at the top of cobalt concentrations across operational groundwater bores. Investigations into trigger exceedances did not determine any potential sources of cobalt on site (refer Section 4.1.4), therefore the increasing trends are considered to be likely as a result of natural variation.

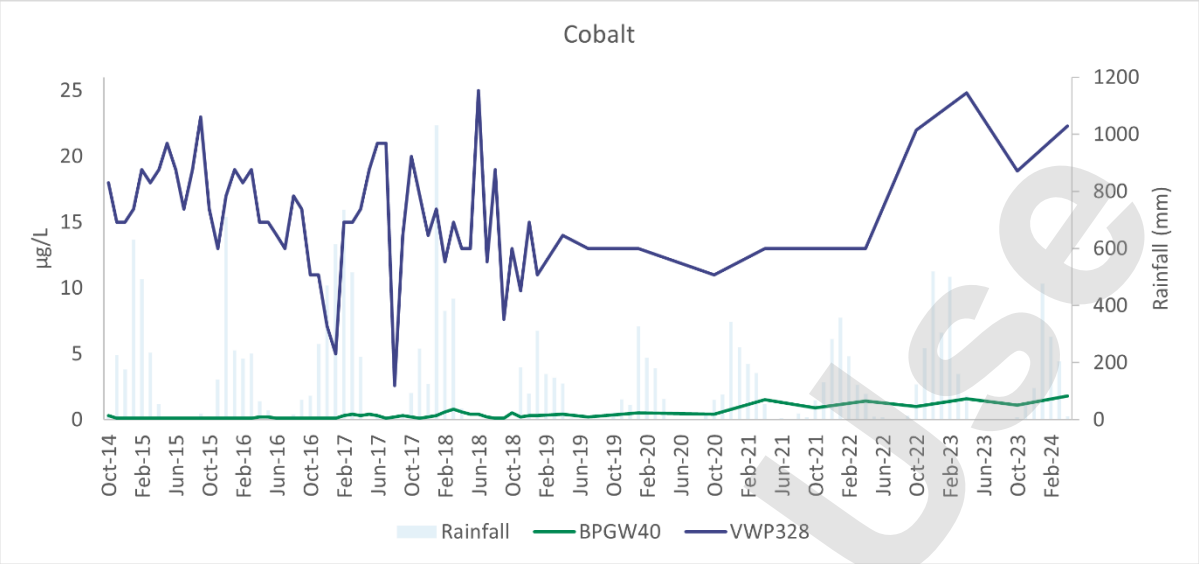

Figure 4-6: Cobalt concentrations recorded at BPGW40 and VWP328 from October 2014 to April 2024

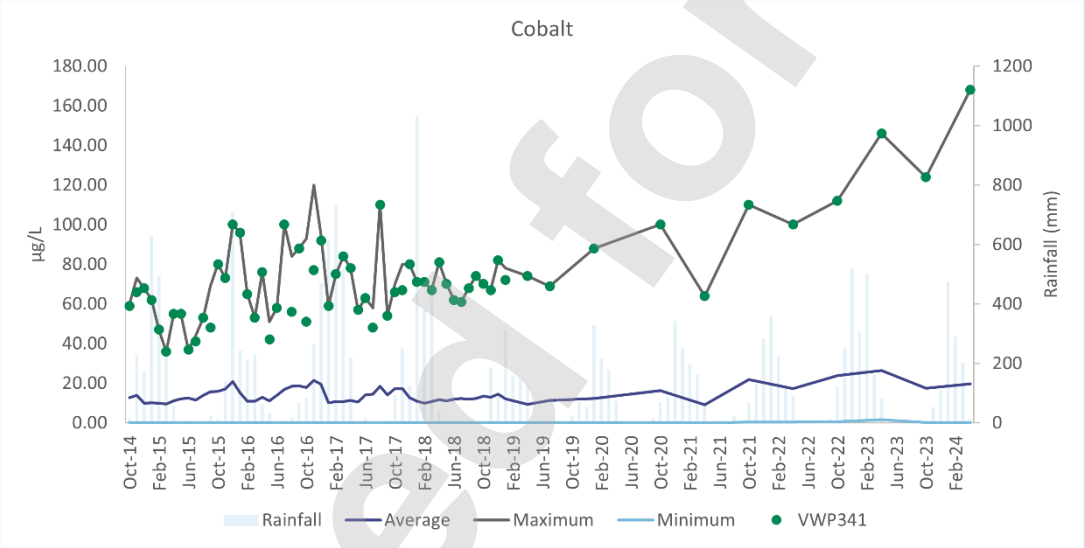

Figure 4-7: Cobalt concentrations recorded at VWP341 and the average, minimum and maximum pH of all operational monitoring wells from October 2014 to April 2024

Zinc

Zinc concentrations frequently fluctuate at VWP341 (Figure 4). These fluctuations do not always appear to be related to seasonal factors, as concentrations peak in both the wet and dry seasons. Zinc concentrations appear to have steadily increased at VWP341 since 2016.

The 173 µg/L of zinc recorded at VWP341 during April 2024 is an historical maximum. Investigations into trigger exceedances did not determine any potential sources of zinc on site (refer Section 4.1.4), therefore the increasing trends are considered to be likely as a result of natural variation.

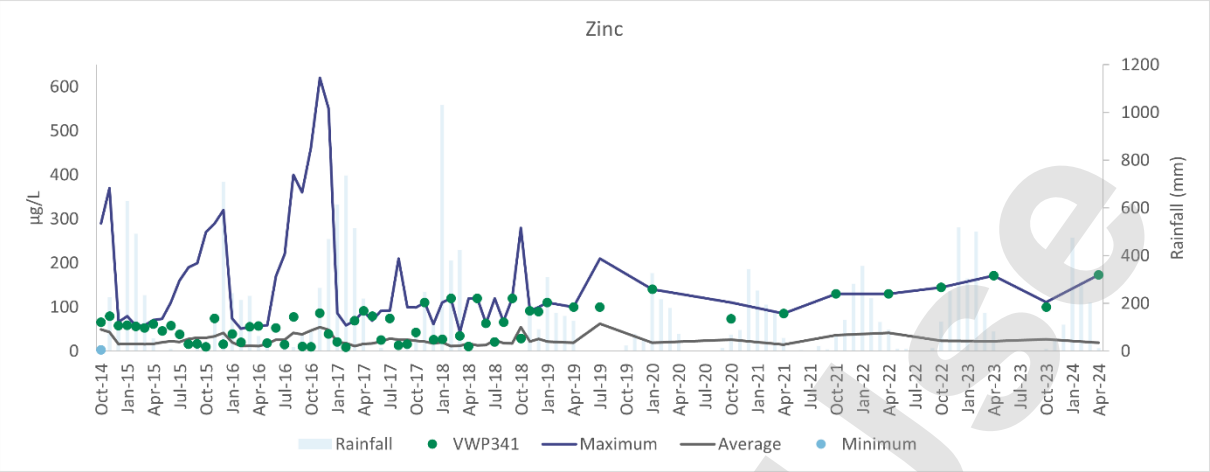

Figure 4-8: Zinc concentrations recorded at VWP341 and the average, minimum and maximum pH of all operational monitoring wells from October 2014 to April 2024

Manganese

Two monitoring bores recorded a trigger exceedance for manganese in the twelfth (BPGW08A and BPGW09) and thirteenth (BPGW09 and VWP341) surveys. Analysis indicates that manganese normally fluctuates over a wide range at BPGW08A and VWP341. Figure 4- shows that manganese concentrations at BPGW09 fluctuate in a similar seasonal pattern, though at much lower concentrations.

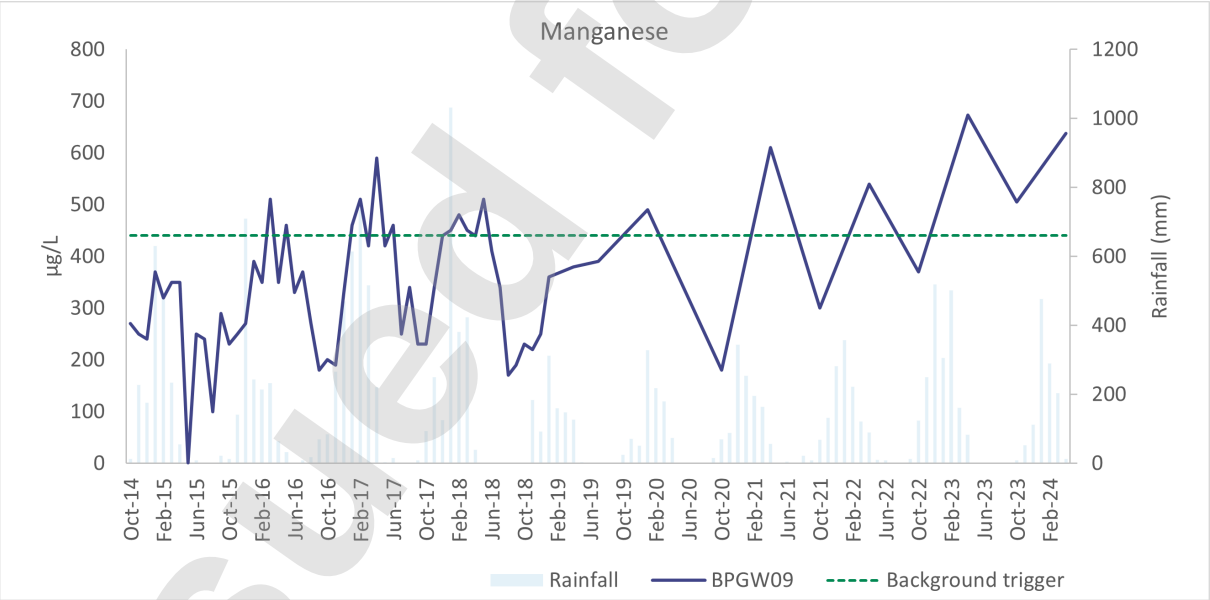

Figure 4-9: Manganese concentrations recorded at BPGW09 from October 2014 to April 2024

Trigger exceedance investigations

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 4-3 with corresponding investigation reports listed below:

- Groundwater Survey 12 – Trigger Investigation Report (L290-AH-REP-70075)

- Groundwater Survey 13 – Trigger Investigation Report (L290-AH-REP-70111).

Investigations were completed for all trigger exceedances. Investigations considered multiple lines of evidence, such as rainfall, seasonal factors, Ichthys LNG operational activities and any spill events, to determine if increasing trends in groundwater analytes were likely to be as a result of Ichthys LNG.

Investigations completed following the October 2023 and April 2024 monitoring events concluded that the reported trigger exceedances were not as a result of Ichthys LNG operations and were likely natural (e.g. represent seasonal trends and natural variability). Therefore, no further evaluation or management response was required.

Table 4-3: Summary of groundwater trigger exceedances

Date	Month	Physio-chemical	Nutrients	Metals
Survey 12	October	0	21	16
Survey 13	April	0	13	15

4.1.5 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 and intertidal sediment

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 biennial mangrove health and intertidal sediment surveys are to:

- informatively monitor mangroves adjacent to Ichthys LNG
- detect changes in intertidal sediment quality attributable to Ichthys LNG.

As per the OEMP (L060-AH-PLN-60005), mangrove health and intertidal sediments are monitored biennially. Mangrove health and intertidal sediments were monitored during April 2024 as part of the fifth mangrove monitoring event. Table 5-1 provides a summary of the mangrove health and intertidal sediments survey completed during the reporting period.

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

Survey	Date	Report	INPEX Doc #
5	17—19, 22 April 2024	Mangrove Health and Intertidal Sediments Monitoring: Report No 5	L290-AH-REP-70079

5.1.1 Method overview

The mangrove health and intertidal sediment survey was completed 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 =100m^2) 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 = 25m^2 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, TRH, ToC, % Moisture, PSD • pH (measured in field) • Redox (measured in field)

Mangrove Health monitoring

Mangrove canopy cover was measured at each site using established fixed quadrats and 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 densiometer was modified to a 17-point densiometer according to the Strickler method (Strickler 1959). The densiometer was placed on the top of a camera tripod and positioned at a height of approximately 1 m above the ground. Measurements were only taken once the bubble level on the densiometer and the tripod were centred.

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. Photos taken during Survey 5 were compared with photos from the early construction phase (2015) to detect changes in mangrove health over time.

Sediment monitoring

To test for potential changes in sediment composition and sediment quality, two surficial sediment sample were taken from the top 2—5 cm, from within each of the 13 monitoring quadrats. Collected sediments were sent to NATA laboratories, accredited for the relevant analytical suite, 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). Quality assurance and quality control (QAQC) procedures for intertidal sediment sampling include collection of field split samples, field triplicate samples, field blanks and transport blanks.

Sediments were also tested in-situ for pH and redox potential using a YSI water quality probe.

5.1.2 Results and discussion

Mangrove health monitoring

Canopy cover

Canopy cover can be defined as the per cent forest area occupied by the vertical projection of tree crowns (Paletto & Tossi, 2009). This parameter is considered a useful indicator of environmental stress as leaf defoliation and leaf growth are sensitive to a wide range of environmental indicators. Canopy cover across all sites has remained relatively stable over time (Figure 5-2). Canopy cover data recorded during Survey 5 was slightly higher at control sites (91.6% ±8.7) than at impact sites (90.6 ±10.7).

Canopy cover values recorded during the Survey 5 were generally slightly higher than baseline values (2012-2013), construction phase (2013-2018) and data recorded during April 2021 (Survey 3). Results were similar to values recorded during Survey 4 undertaken in 2022. Variations in mean canopy density between sampling dates at individual sites are relatively minor and were typically in the 5–18 % range, with canopy cover higher in 2024 than during the baseline and construction phase at all sites. This extent of variation, experienced at both impact and control locations, is expected to reflect natural variability and the precision of the sampling technique.

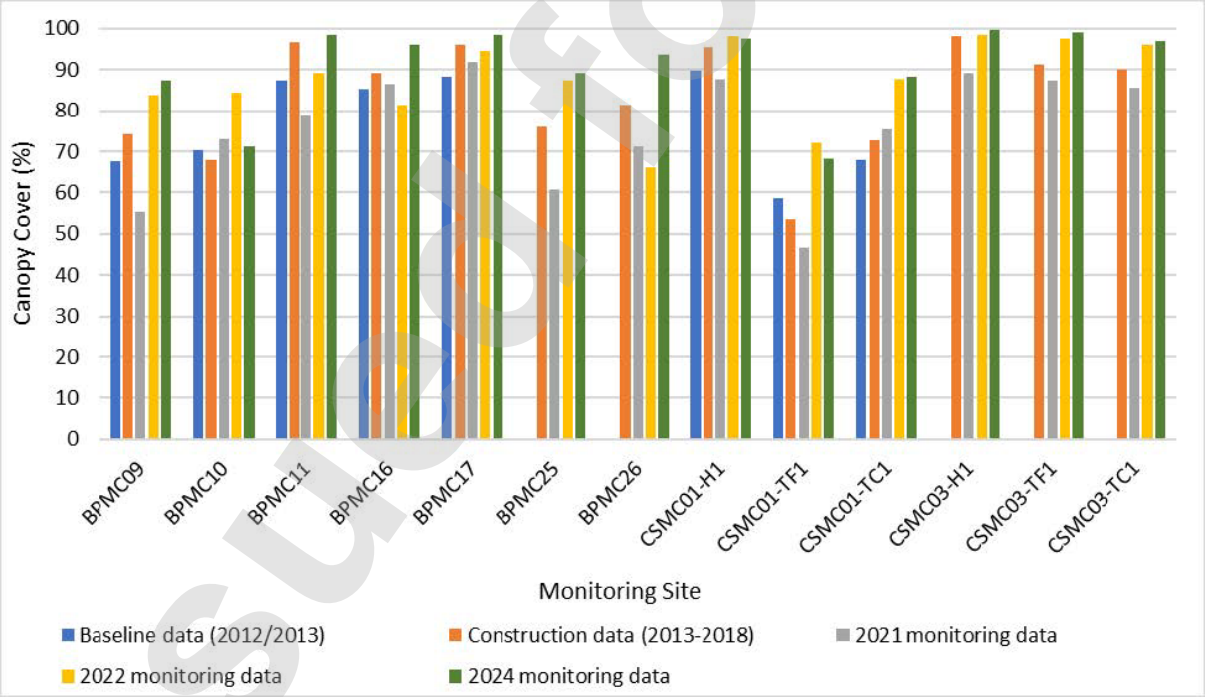

Figure 5-2: Mangrove canopy cover

Table 5-3: Canopy cover results from 2024 and comparison with baseline and construction data

Location	% Canopy cover			Change from baseline data
	Baseline data	Construction data	2024 results (± SD)	
Impact sites				
BPMC09	67.5	74.3	87.3 (21.3)	29.3%
BPMC10	70.3	67.9	71.1 (22.2)	1.1%
BPMC11	87.5	96.7	98.5 (2.6)	12.6%
BPMC16	85.3	89.1	96.1 (6.0)	12.6%
BPMC17	88.3	96.0	98.5 (2.3)	11.6%
BPMC25	NA	75.9	89.2 (13.6)	17.5%
BPMC26	NA	81.5	93.6 (6.6)	14.9%
Mean	**79.8**	**83.1**	**90.6 (10.7)**	**9.0%**
Control sites				
CSMC01 - H	89.8	95.6	97.6 (3.8)	8.6%
CSMC01 -TF	58.5	53.5	68.1 (26.0)	16.5%
CSMC01 -TC	68.0	72.6	88.2 (13.6)	29.8%
CSMC03 - H	NA	98.2	99.5 (1.6)	1.3%
CSMC03 -TF	NA	91.3	99.0 (2.2)	8.5%
CSMC03 -TC	NA	90.1	97.1 (5.1)	7.7%
Mean	**72.1**	**83.6**	**91.6 (8.7)**	**9.5%**

Differences in canopy density between the sites are reflective of different community structures. Typically, the closed forests and woodlands of tidal creek (such as BPMC26) and hinterland margin (BPMC16) assemblages produce relatively high canopy density values (> 95%) compared to the lower and more open canopies within the Ceriops scrubland assemblage which occupies much of the mid-upper tidal flat zone (CSMC01-TF).

Community health

All sites were classified as healthy in 2024 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 measurements of pH and redox are displayed below in Table 5-4. In-situ measurements for pH at impact sites ranged from 6.27 to 7.35, with a mean value of 6.88. Measurements of pH at control sites ranged from 6.13 to 7.38 at control sites, with a mean value of 6.64. The range of pH values recorded reflects the conditions experienced by the surface sediments which are well oxygenated and regularly flushed by tidal waters. The results indicate that that mangrove sediments at both impact and control sites range from being slightly alkaline to slightly acidic. Subsurface mangrove soils are typically anaerobic and microbial decomposition takes place through a series of oxygen-reduction (redox) processes. Most mangrove soils are well buffered, having a pH in the range of 6-7, but some have a pH as low as 5 (English et al., 1997).

In-situ measurements for redox potential at impact sites ranged from -7.7 mV to 141.5 mV, with a mean of 72.0. Redox potential at control sites ranged from 48.7 mV to 112.3 mV, with a mean of 93.43 mV. The predominantly positive ORP values indicate that mangrove sediments at monitoring sites in the top 5 cm are oxidising.

Table 5-4: Mangrove sediment in situ monitoring results

Location	Date	pH	ORP (mV) (redox potential)
Impact sites			
BPMC09	18/04/2024	7.02	100.8
BPMC10	22/04/2024	6.64	141.5
BPMC11	17/04/2024	7.09	79.4
BPMC16	17/04/2024	6.92	109.0
BPMC17	17/04/2024	6.27	-7.7
BPMC25	17/04/2024	6.89	85.2
BPMC26	17/04/2024	7.35	-4.1
Mean		**6.88**	**72.0**
Control sites			
CSMC01 - H	19/04/2024	6.20	48.7
CSMC01 -TF	19/04/2024	6.73	112.3
CSMC01 -TC	19/04/2024	6.53	98.7
CSMC03 - H	18/04/2024	6.89	92.8
CSMC03 -TF	18/04/2024	7.38	96.1
CSMC03 -TC	18/04/2024	6.13	112.0
Mean		**6.64**	**93.43**

Sediment chemistry

A summary of the mangrove sediment chemistry results is provided in Table 5-5 and Table 5-6. Elevated arsenic concentrations are consistent with those recorded from the broader Darwin Harbour region and from previous monitoring undertaken during the baseline and construction phases. Elevated concentrations of arsenic in Darwin Harbour sediments have historically been attributed to local geological influence rather than anthropogenic sources (Padovan, 2003; Fortune, 2006).

One Arsenic exceedance was recorded at a control site, with the next highest recording also at a control site. Therefore, the exceedance is unlikely to be due to Ichthys LNG operations, and further investigation was not warranted.

Organic results were below the limit of reporting for all sites but CSMC01-TC (Table 5-6). Given this result (55 mg/kg) was still below the trigger level (280mg/kg) and the result was from a control site, further investigation was not warranted.

Limits of reporting (LOR) in sediment samples were sufficiently low in all samples to capture trigger value exceedances, with the following exception:

- Antimony in BPMC10, which was analysed to a LOR of 10 mg/kg. This is higher than the trigger value of 2 mg/kg required for the mangrove sediment monitoring program.

This raised LOR marginally impacts the integrity for this parameter at the site for this round of intertidal sediment monitoring.

Table 5-5: Summary of inorganic mangrove sediment chemistry

Analyte	Aluminium	Antimony	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc	Moisture Content	Total Organic Carbon
Unit	**mg/kg**										**%**	**mg/kg**
LOR	**10**	**1**	**2***	**0.1**	**1**	**1**	**1**	**0.02**	**1**	**5**	**1**	**1000**
Trigger Value	**-**	**2**	**20**	**1.5**	**80**	**65**	**50**	**0.15**	**21**	**200**	**-**	**-**
BPMC09	1,400	<1	5.1	<0.1	6.2	1.7	2.7	<0.02	1.5	9.3	25	33,000
BPMC10	12,000	<10	9.5	<0.4	27	6.4	8.1	<0.1	8.4	65	33	20,000
BPMC11	440	<1	<2	<0.1	3.1	<1	<1	<0.02	<1	<5	15	5,000
BPMC16	1,900	<1	7.9	<0.1	32	1.6	2.7	<0.02	2.9	17	16	5,000
BPMC17	2,200	<1	4.1	<0.1	40	2.1	3.9	<0.02	<1	7.1	24	15,000
BPMC25	3,600	<1	15	<0.1	15	4.6	6.6	<0.02	4.4	34	57	140,000
BPMC26	3,000	<1	13	<0.1	23	3.6	5.6	<0.02	3.5	22	35	76,000
CSMC01-TC	<20	<1	<2	<0.1	<1	<1	<1	<0.02	<1	<5	26	13,000
CSMC01-H	710	<1	4	<0.1	6.5	<1	2.2	<0.02	<1	6.9	18	12,000
CSMC01-TF	<20	<1	<2	<0.1	<1	<1	<1	<0.02	<1	<5	56	78,000
CSMC03-TC	3,900	<1	4.3	<0.1	46	7.5	22	0.02	4.7	17	25	7,000
CSMC03-H	6,200	<1	**33**	<0.1	26	3.4	13	0.02	6.1	20	49	130,000

Analyte	Aluminium	Antimony	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc	Moisture Content	Total Organic Carbon
CSMC03-TF	3,900	<1	20	<0.1	15	3.3	7	<0.02	4.6	11	47	78,000

*Bold value indicates trigger exceedance.

Table 5-6: Summary of organic mangrove sediment chemistry (mg/kg)

Site	TPH C10-C36 (sum of total)	TRH >C10-C40 (sum of total)
Guideline value	**280**	**100**
Background	**n/a**	**n/a**
BPMC09	<50	<100
BPMC10	<50	<100
BPMC11	<50	<100
BPMC16	<50	<100
BPMC17	<50	<100
BPMC25	<50	<100
BPMC26	<50	<100
CSMC01-HM	<50	<100
CSMC01-TF	<50	<100
CSMC01-TC	55	<100
CSMC03-HM	<50	<100
CSMC03-TF	<50	<100
CSMC03-TC	<50	<100

5.1.3 Trigger assessment outcomes

There were no trigger exceedances for the 2024 mangrove health and intertidal sediment survey attributable to Ichthys LNG operations. The one exceedance for arsenic represents a decrease from the five recorded during the 2022 mangrove sediment sampling event (AECOM 2022). Exceedances for arsenic have periodically been recorded at a range of impact and control sites during the baseline and construction monitoring phases (URS 2013a, 2013b).

The single exceedance recorded during Survey 5 represents a decrease from the seven exceedances recorded during Survey 4 in 2022. Five arsenic exceedances and two chromium exceedances were recorded during the 2022 mangrove monitoring event.

5.1.4 Program rationalisation

No further rationalisation is proposed for Mangrove Health and Intertidal Sediments, the next round of monitoring will occur in the 2025/2026 AEMR period.

5.2 Nearshore marine pests

5.2.1 Method overview

Nearshore monitoring is undertaken to assess the presence/absence of invasive marine species at the Ichthys LNG LPG/condensate product loading jetties (Figure 5-3). The two sites located on the product loading jetties have been incorporated in the wider Darwin Harbour program, managed by NT Aquatic Biosecurity Unit, within the Fisheries Division of the Northern Territory Department of Industry, Tourism and Trade (NT DITT). NT DITT provide the artificial settlement units (ASUs; Figure 5-4) for INPEX to deploy at the jetties. Each ASU consists of four settlement plates (back-to-back) and two rope mops.

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 and monthly photos of the traps are sent to NT DITT for species identification.

The ASUs were installed in September 2018 with monthly monitoring commencing in October 2018. During the reporting period monthly photo inspections occurred and the traps were collected and provided to NT DITT every four months for identification of species.

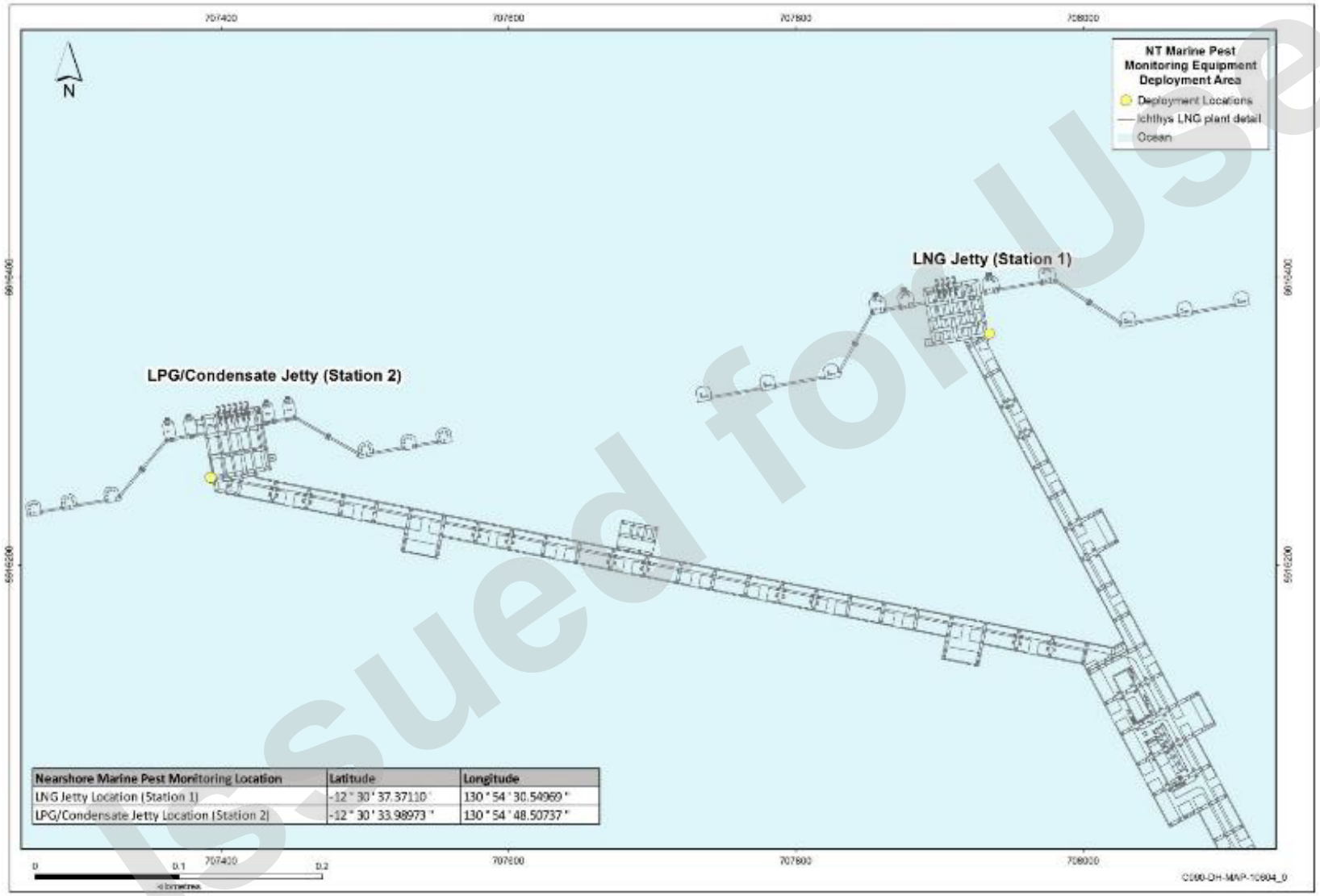

Figure 5-3: Nearshore marine pest monitoring locations

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

NT DITT examined plates and rope mops on submission every four months, and photos submitted after monthly inspections. NT DITT did not identify any invasive marine species on settlement devices deployed as part of the Darwin Harbour marine pest monitoring program.

5.2.3 Program rationalisation

No change proposed to the marine pest monitoring.

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 are undertaken annually at the end of the wet season (nominally in April). Table 5-7 provides a summary of surveys completed during the reporting period.

Table 5-7: Weed survey details

Survey	Date	Report	INPEX Doc #
Survey 9	May 2024	Weed Management Report No. 9	L290-AH-REP-70078

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 5-8. Where identification of a species was not possible in the field, a voucher sample, together with photographs were taken to facilitate post survey identification.

Figure 5-6: Weed survey area

Table 5-8: 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

Survey 9: May 2024

The results of the 2024 weed survey show an increase in the density and distribution of gamba grass and hyptis across the site since the 2023 survey. The increased population is most evident within the GEP corridor, which have increased from 1,682 m^2 to 7,090 m^2. Dense thickets of gamba grass also remain within Section 1888.

No other new declared or non-declared weed species were recorded at Ichthys LNG during the reporting period. Declared weed species previously identified during weed surveys include:

- perennial mission grass (not detected in 2024)
- neem tree (not detected in 2024)
- flannel weed
- lantana
- sicklepod
- gamba grass
- hyptis/horehound.

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 and hyptis infestations have significantly increased during the 2023-2024 wet season. There has been an increase in both individual gamba grass and hyptis plants and multi-plant infestations (Survey 9 compared to Survey 8).

Notably, no perennial mission grass was recorded in Survey 9. Patches of this species are a very high priority for control.

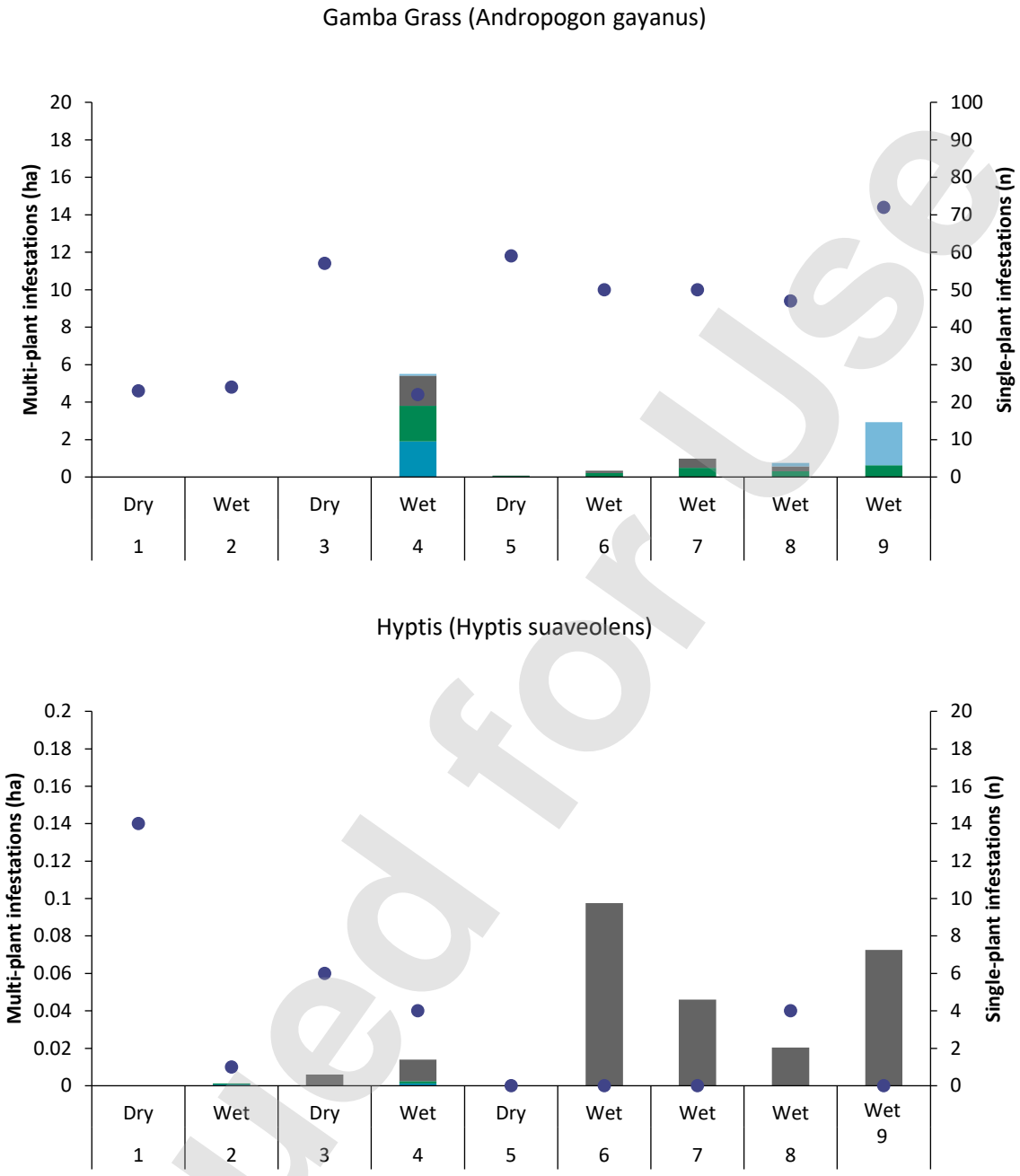

Figure 5-7: Comparison of declared weed infestations between AEMR reporting periods

5.4.3 Program rationalisation

No changes to weed surveys is proposed. 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 is carried out at set intervals of December, February and April during the reporting period. Methods of control include spray application of herbicides, boom spray, quick-spray handguns, and backpacks for the 2023/2024 reporting period. The first weed control work order is actioned in the financial year reporting period is in December. Weed controls are implemented on the recommendations proposed in the survey conducted in Q2 of the previous reporting period.

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 did not result in reduced weed load, particularly in the GEP corridor and Section 1888. Therefore, it is recommended that a gamba grass treatment program is implemented in Section 1888, GEP corridor, the operations area and the production area immediately following each wet season until it has been sufficiently controlled. This may take several years of concentrated controlled effort to see a reduced population of gamba grass across the entire site. A weed maintenance strategy has been developed for onshore, guided by maintenance work instructions (MWIs) that are divided into three separate work orders to balance the required resources to execute the proposed weed control measures. Weed management resources are initiated in the months of February, April and December to action the recommended control measures.

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 are to:

- monitor native vegetation recovery; and
- provide management advice to ensure the establishment of stable, self-sustaining vegetation communities.

In accordance with the OEMP, vegetation rehabilitation is now biennial (every two years). Vegetation rehabilitation monitoring was undertaken in the previous monitoring period, and therefore did not occur in the 2023/24 reporting period.

5.6.1 Program rationalisation

No program rationalisation was proposed for vegetation rehabilitation surveillance from the previously conducted vegetation surveillance Survey 4. The next proposed survey will occur in 2025.

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.

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).

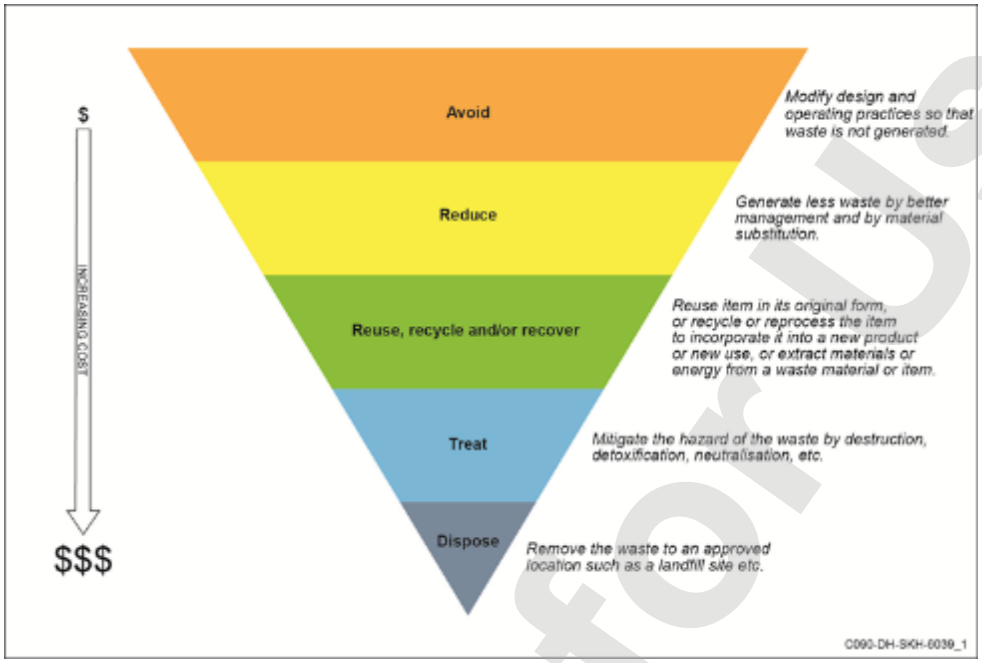

Figure 6-1: INPEX waste control hierarchy

Waste streams at the site are categorised into four broad classes (which include both liquid and solid waste, as outlined in section 3.8.7 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 excluded from reportable waste data (refer to Table 6-1), and only records from licenced waste contractors are used for this waste section.

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 expected waste generated by onsite activities and subsequent control measures are detailed further and in INPEX's Onshore Environmental Management Plan L060-AH-PLN-60005 section 3.8.7

Table 6-1 presents a comparison of the waste streams from the 2020/2021, 2021/2022 and 2022/2023 reporting periods against the current reporting period (2023/2024).

Table 6-1: Waste stream data comparison

Waste Stream	2020-2021 (tonnes)	2021-2022 (tonnes)	2022-2023 (tonnes)	2023-2024 (tonnes)
Recyclable / non-hazardous	304.4	1126.4	459.7	181.9
Recyclable / hazardous	6.4	10.4	15.7	3.9
Non-recyclable / non-hazardous	2413.1	2090.5	4328.3	2395.6
Non-recyclable / hazardous	925.5	626.0	1196.1	363.9

The reporting period 2021/2022 provided an anomality in waste classified as recyclables/non-hazardous as it captured the processing of recyclable steel associated with remedial works onsite during that period. This is reflected when comparing the 2021/2022 and 2022/2023 reporting period data in the table above. The reporting period 2023/2024 saw a decrease in comparison to 2022/2023 across all 4 waste categories,. The 2023/2024 reporting period experienced an overall decrease in comparison with the 2022/2023 reporting period, mainly due to the waste generated during the July /August 2022 shutdown.

The 2020/2021 reporting period serves as a reliable baseline reference after the initial few years of startup from 2018. Not considering any major event such as a shutdown, 2020/2021 provides a datum point in which each reporting period can be directly compared. The 2023/2024 reporting period has seen a reduction in comparison to 2020/2021 across the four waste streams. The main waste reduction measure implemented during this reporting period (i.e. reduce waste being disposed or treated offsite) was through the use of the onsite evaporation basin. The evaporation basin is designed to handle low level chemical and hydrocarbon contaminated water generated at Ichthys LNG, while inter-site transfers to the wastewater treatment plants took place. Approximately 4,018 tonnes of liquid waste were transferred to the evaporation basin and 6,465 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.

Site wide waste reduction initiatives are implemented via the Waste Management Standard (0000-AH-STD-600047) which applies to all waste streams onsite. For the 2023/2024 reporting period, measures were put in place to minimise the amount of liquid waste being generated at Ichthys LNG. This 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 wastewater predominately in the AGRU of each LNG train, where amine is used as a solvent to extract acid gases (including carbon dioxide).

The incumbent waste contractor Cleanaway undertook a waste audit during the Q3 2023 period. The provided report looked at waste measures across the entire business with a focus on potential waste reduction measures such as dehydration of food wastes via a proposed dehydrator. Proposed dehydration measure suggests an overall decrease in tonnage associated with food waste by 85% and associated transportation reduction. Proposal is at review at the time of writing due to waste contractor contract 5-year review.

Although not directly related to solid and liquid waste, energy recovery occurs through the use of the waste heat recovery systems. Heat recovery units are located on the GE Frame 7 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 from the GE Frame 6 turbine stacks 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.

The 2022/2023 AEMR incorrectly reported 5,168 tonnes of liquid waste transferred to the evaporation basin and 652 of wastewater transferred to various water treatment plants onsite due to an administration error. The correct figures are 4,331.5 tonnes of liquid waste transferred to the evaporation basin and 2012.5 tonnes of wastewater transferred to various water treatment plants onsite.

7 PROGRAM RATIONALISATION AND FUTURE SURVEYS SUMMARY

There were no proposed recommendations for changes to monitoring programs and future monitoring will be undertaken in accordance with the current OEMP and EPL228. The proposed next survey dates are outlined below in Table 7-1.

Table 7-1: Survey forecast for future monitoring periods

Survey/Data Collection Scope	Frequency	Previous Survey	Next Survey
Commingled treated effluent	Monthly	June 2023-2024	July 2024 – June 2025
Harbour sediment	Biennial	July 2022	July 2024
Total emissions to air	Annual	June 2024	June 2025
Point source emissions to air	Annual	November 2023	October 2024
Dark smoke events	Ad-hoc	n/a	n/a
Groundwater quality	Bi-annual	April 2024	October 2024 April 2025
Mangrove health and intertidal sediments	Biennial	April 2024	April 2026
Nearshore marine pests	Monthly	June 2024	July 2024 – June 2025
Introduced terrestrial fauna	Annual	June 2024	April 2025
Weed mapping	Annual	April 2024	April 2025
Weed management	Annual – as required	June 2024	~April 2025
Vegetation rehabilitation monitoring	Biennial	June 2023	June 2025
Cultural heritage	Ad-hoc	n/a	n/a

8 REFERENCES

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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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Strickler, G.S. 1959. Use of the densiometer to estimate density of forestry canopy on permanent sample plots. PNW Old Series Research Notes No. 180, pp. 1-5

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 guidelines)
	  • 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 2023-2024 CERTIFICATION

B.1 INPEX

INPEX	I, Tetsuhiro Murayama (President Director, Ichthys LNG Pty Ltd, Australia) confirm that to the best of my knowledge and ability all the information provided in the *EPL228 Annual Environmental Monitoring Report 2023-2024* (L060-AH-REP-70061) is true and accurate.
Name	Tetsuhiro Murayama
Position	President Director, Ichthys LNG Pty Ltd
Signature	
Date	25 September 2024

B.2 Qualified Professional

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INPEX Corporation
Ben Davis Senior Environmental Advisor
Onshore Operations
144 Wickham Road
Wikham NT 0822

DATE
23 September 2024

SUBJECT
2023-2024 AEMR Review and certification report

REFERENCE
ERM 0565508

Dear Ben

Subject: 2023-2024 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 77 of the Environmental Protection Licence (EPL) 228-05 (EPL228-05 came into effect on 13.12.2022), stated as follows:

77 The Annual Environmental Monitoring Report must:

77.1 report on monitoring required under this licence;

77.2 include a tabulation in Microsoft ® Excel ® format, of all monitoring data required to be collected in accordance with this licence;

77.3 summarise performance of the authorised discharge to water, compared to the discharge limits specified in Table 3 in Appendix 2;

77.4 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;

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

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

77.7 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;

77.8 report on outcomes of the REMP monitoring and assessment;

77.9 summarise measures taken to reduce waste;

77.10 consider the NT EPA Guideline for Reporting on Environmental Monitoring;

77.11 be reviewed by Qualified Professional(s); and

[1] A '*qualified professional'* as described by the EPL228-05 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.

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

The purpose of the qualified professional review of the AEMR is to provide an independent assessment verifying that the AEMR is compliant with the conditions of EPL228-05. 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.

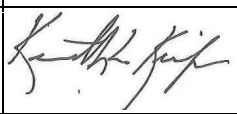
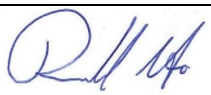
TABLE 1 QUALIFIED PROFESSIONALS

Area of expertise	Qualified professional
Discharges to Water	Ken Kiefer
Air Quality	Christopher Thomson
Waste	Ronald Ho

Each of the qualified professionals individually reviewed the Draft AEMR (Revision B) dated 23 August 2024 with respect to the Condition 76 EPL228-05 (as stated above) 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 (Revision 0) dated 16 September 2024 to ERM for review, which incorporated the agreed changes and the comments register cross-referenced with the revised sections of the AEMR.

ERM was satisfied that each of the responses had been appropriately incorporated into the updated revision and the comments were closed out. Therefore , the following statement of verification was 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 76 of the EPL228-05 for the 2023-2024 period.

Area of expertise	Qualified professional	Qualified profession Signatures
Discharges to Water	Ken Kiefer	
Air Quality	Christopher Thomson	
Waste	Ronald Ho	

Yours sincerely,

For Environmental Resources Management Australia Pty. Ltd.

Christopher Thomson
Consulting Director

Paul Fridell
Partner

ANNEX A COMMENTS REGISTER

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2023-2024

Contract Number	INPEX PO 565508 / 4500135825
Reviewer	ERM
Document Name	EPL228-05 Annual Environmental Monitoring Report 2023-2024
Company Document No#	L060-AH_REP_70061
Document Revision No# / Date	Revision B / 23 August 2024

No.	Report Section	Reviewer Comment/Recommendation	INPEX Response	ERM response
Discharges to Water				
1	Table 2-4 Exceedance events	The discussion and validation of the source of the total nitrogen exceedances would be helped with providing results from the testing from the following locations: • Filter Package L750-SC-002 • Demin Package L720-SC-016 • CCPP L630-MV-6880 • Sewage Treatment Package L750-SC-009 • Liquid Rim Vacuum Pump (LRVP) Seal Water L630-MV-99381 • Observation Basin L750-SU-404 • Irrigation Tank L750-SC-004 • Sea Loading Jetty Outfall L750-SC-003 1 0F.	Results of investitive sampling have been provided to NT EPA as a part of the incident investigation and reporting process. Results of samples are summarised in the AEMR but the AEMR is not intended to provide details of the investigation.	Checked final report, comment closed.
2	2.1.2 Routine Monitoring Results	*"There was a significant reduction in overall EPL228 exceedances associated with wastewater discharges with the total events reducing from ten in the 2022-2023 period, to two in the 2023/2024 period."* Does this mean two exceedances or two discharge events? Please clarify.	Noted - amended There was a significant reduction in overall EPL228 exceedances associated with wastewater discharges with the	Checked final report, comment closed.

No.	Report Section	Reviewer Comment/Recommendation	INPEX Response	ERM response
			total **exceedance** events reducing from ten in the 2022-2023 period, to two in the 2023/2024 period	
3	General	The report states that monitoring equipment were calibrated, field parameters were documented, and laboratory reports (including quality control documentation) were prepared, however these documents were not attached to the report and are therefore unable to be reviewed for quality and consistency with the text.	Noted – Amended Records of calibration are referenced on the Certificate of Authenticity issued by the onsite laboratory for each sample. Applicable calibration records are verified during the statutory audit conducted every two years.	Checked final report, comment closed.
4	2 Discharges to water	The OEMP states that a daily visual inspection is conducted by operational staff to monitor for any visible sheen caused by hydrocarbons at the location of the jetty outfall. Please include statement to these were completed and the findings in the report.	Noted - amended The jetty outfall discharge is visually inspected daily by Inpex operations staff for any visible sheen caused by hydrocarbons. Sightings are recorded only by exception in the J5 logbook for reference. No visible hydrocarbon sheen observed during this reporting period	Checked final report, comment closed.
Unplanned Discharges to Land				

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2023-2024

No.	Report Section	Reviewer Comment/Recommendation	INPEX Response	ERM response
5	4.1.2 Duplicate and triplicate samples	RPD summary tables are not provided in the report and therefore cannot be reviewed for accuracy and consistency with the text.	A summary of QAQC result is provided in the AEMR. QAQC of samples and results is completed by the contractor and only reported in AEMR in detail if the QAQC affects the compliance to EPL Conditions.	Checked final report, comment closed.
6	4.1.4 Trend analysis	What was the basis for the selection of groundwater data to include in the trend graphs? There are several exceedances and trends that are discussed that are not presented on the graphs (e.g., total nitrogen in groundwater from BPGW41 and VWP341, etc.). Presenting the trigger value on the graphs would also aid the discussion. Consider assessing trends using statistical based methods rather than visual interpretation of graphs. Software such as Groundwater Spatial Data Analysis Tool (GWSDAT) (or similar) would aid the interpretation in future.	Trend graphs are selected based on sites experiencing exceedances for at least 3 successive monitoring sampling campaigns. Wording to clarify this has been added to report. Will investigate potential to add trigger and/or benchmark levels to the graphs. If there is more than one site presented then would become crowded quickly as each site has a different background benchmark value. Added to single site figures. Investigate including wording in AMER clarifying the trend graphs included – wording included in the AMER.	Checked final report, comment closed.
7	4.1.4	*"Positive trends were determined"* Suggest using "increasing trend"	Noted - amended	Checked final report,

No.	Report Section	Reviewer Comment/Recommendation	INPEX Response	ERM response
	Trend analysis			comment closed.
8	4.1.4 pH exceedances	*"This is also reflected by no pH exceedances being observed in either sampling survey."* The trigger level stated in the OEMP is <6.0 and >8.5. There were several pH results <6.0.	The reason for no exceedances is, that whilst there were several sampling results below the trigger level <6, there were no exceedances below the background trigger values. "A trigger exceedance occurs when a benchmark level is exceeded, which is defined as the trigger value stated in Table 7-9 of the OEMP and background value. Background value is either the site-specific 20th or 80th percentile of the background dataset for low and high stressors respectively, as described in ANZG (2018)."	Checked final report, comment closed.
9	4.1.4 Ammonia exceedances	*"Ammonia exceedances were recorded at six monitoring bores (BPGW18, BPGW20, BPGW28, BPGW40, BPGW41 and VWP341) during the thirteenth groundwater monitoring event."* The trigger value for ammonia in Table 4-2 and in the OEMP is stated as 20 ug/L. Please update as more concentrations reported in groundwater presented in Table E-8-1 appear to exceed this value. This also applies to other parameters.	As above. The system and route for the discharge from the CCPP Neutralisation Package does not allow for interaction with the ground water prior to outfall discharge.	Checked final report, comment closed.

No.	Report Section	Reviewer Comment/Recommendation	INPEX Response	ERM response
		"Investigations into the ammonia trigger exceedances did not determine any potential sources of ammonia on site". There was an ammonia source identified in the discharges to water section (Section 2) at the CCPP Neutralisation Package. What about the potential for surface water and groundwater interaction?		
10	Figure 4-7 Cobalt concentrations recorded at VWP341	The graph doesn't reflect the description and appears to be a copy of the Figure 4-6.	Wrong graph inserted (as mentioned duplication of 4.6), correct graph has been inserted.	Checked final report, comment closed.
11	Table E-8-1 Groundwater concentration summary	The attached summary of groundwater results from Surveys 12 and 13 does not include trigger values nor identify exceedances.	Data is provided for record only. Trigger exceedances and trigger values are discussed in the main body of the report.	Checked final report, comment closed.
12	Table E-8-1 Groundwater concentration summary	The units for ammonia are not included. The table indicates that the data for BTEX and TRH are reported in mg/L, however the LORs for BTEX and TRH provided suggest that it may be ug/L. Suggest including the specific units for each analyte.	Agree, updated.	Checked final report, comment closed.
13	Appendix B	Typo in heading *"2022-2023"* which should read 2023-2024.	Updated	Checked final report, comment closed.
14	Table E-8-1 Groundwater concentration summary	The concentration of most parameters had decreased at BPGW01 in April 2024, compared to October 2024. The TDS	The results are presented in separate reports, however the interpretation/discussion focus	Checked final report,

No.	Report Section	Reviewer Comment/Recommendation	INPEX Response	ERM response
		was very low in April 2024. Has this been considered in the interpretation of the data (possibly in a separate report)?	is mainly on increasing trends and exceedances. Interpretation/discussion is made for sites and parameters where consecutive exceedances had ceased or increasing trends had stabilised or reversed. TDS at BPGW01 has not been interpreted/discussed.	comment closed.
Air Quality				
1	3.1	On page 26, change "*INPEX is required to provide total emissions to air (tonnes/year) for air quality parameters (Condition 77.5 of EPL228-05 listed in Table 6, Appendix 3 of EPL228*)" to INPEX is required to provide total emissions to air (tonnes/year) for air quality parameters (Condition 77.6 of EPL228-05 listed in Table 6, Appendix 3 of EPL228)	Noted, amended.	Checked final report, comment closed.
2	3.1	On page 26, change "*Table 3-1: Estimated total emissions to air for reporting period*" to "Table 3-1: Estimated total emissions to air for the reporting period"	Noted, amended.	Checked final report, comment closed.

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2023-2024

No.	Report Section	Reviewer Comment/Recommendation	INPEX Response	ERM response
3	3.1	Table 3-1 is meant to list total emissions to air for air quality parameters as listed in licence EPL-228-05 Appendix 3 Table 6. carbon monoxide and total hydrocarbons flared (as listed in Table 6) are not shown in Table 3-1.	Noted, amended for CO. Mass of hydrocarbons flared provided in Table 3-5	Checked final report, comment closed.
4	3.1	On page 26, change "*This review will consider replacing the industry averaged NPI emission factors for flaring and venting with plant specific factors derived from stack testing data, that will more accurately reflect the performance of the ILNG Plant and its associated emissions.*" Change "that" to "which "This review will consider replacing the industry averaged NPI emission factors for flaring and venting with plant specific factors derived from stack testing data, which will more accurately reflect the performance of the ILNG Plant and its associated emissions."	Noted, amended.	Checked final report, comment closed.
5	3.2	On page 26 change "*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…* *Annual monitoring is being undertaken in accordance with the requirements of EPL228*." to	Noted, amended.	Checked final report, comment closed.

No.	Report Section	Reviewer Comment/Recommendation	INPEX Response	ERM response
		"The key objective of point source emission monitoring (commonly referred to as stack sampling) is to ensure that air emissions do not exceed the concentration limit criteria specified in Table 5, Appendix 3 of EPL228... Annual monitoring is undertaken in accordance with the requirements of EPL228."		
6	3.2.1	On page 27, number convention must be consistent "*Stationary source emissions monitoring was completed at ten (10) point sources (out of a total of 18 stacks) on the Frame 7 compression turbines (4), CCPP Frame 6 heat recovery system generator (HRSG) stacks (4) and heating medium furnaces (2).*" change to "Stationary source emissions monitoring was completed at 10 point sources (out of a total of 18 stacks) on the Frame 7 compression turbines (4), CCPP Frame 6 heat recovery system generator (HRSG) stacks (4) and heating medium furnaces (2)."	Noted, amended.	Checked final report, comment closed.
7	3.2.1	On page 27. This is the first mention of BTEX, so it needs to be defined. Change "*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*" to	Noted, amended.	Checked final report, comment closed.

No.	Report Section	Reviewer Comment/Recommendation	INPEX Response	ERM response
		"INPEX conducts inhouse gas sampling and analysis from these locations for benzene, toluene, ethylbenzene and xylene (BTEX), hydrogen sulphide (H_2S) and mercury (Hg) using conventional industry methods which are not NATA accredited"		
8	3.2.1	On page 27, change "*The analysis of these gases are conducted on a monthly basis using test methods that are managed under a NATA accredited Quality Management System.*" to "The analysis of these gases is conducted on a monthly basis using test methods that are managed under a NATA accredited Quality Management System."	Noted, amended.	Checked final report, comment closed.
9	3.2.1	On page 27, Change "*NATA-accredited*" to "NATA accredited". Keep the same terminology.	Noted, amended.	Checked final report, comment closed.
10	3.2.1	On page 27 Change "*All stack sampling ports have been installed in accordance with AS4323.1-1995 stationary source emissions – selection of sampling ports*" To Change "All stack sampling ports have been installed in accordance with AS 4323.1-1995 Stationary Source Emissions - Selection of Sampling Positions"	Noted, amended.	Checked final report, comment closed.

No.	Report Section	Reviewer Comment/Recommendation	INPEX Response	ERM response
		This is the correct title of the standard.		
11	3.2.1	On page 27 change "*USEPA Method 30B for mercury emissions*." to "United States Environmental Protection Agency (USEPA) Method 30B (Mercury Sorbent Trap Procedure) for mercury emissions. "	Noted, amended.	Checked final report, comment closed.
12	3.2.1	Page 28 Table 3-3. For consistency Change "*A8 1*" to "A8-1" Change "*A8 2*" to "A8-2" Optional: All the licence concentration limits in mg/Nm^3 do not list the "@ 15% or 3 % O_2"	Noted, amended.	Checked final report, comment closed.
13	3.2.1	Page 28Table 3-3 Row 2, column 3. Change "*NOx*" to "NO_x"	Noted, amended.	Checked final report, comment closed.
14	3.2.1	Page 28 Table 3-3 In Row 4, column 7 change "*175@15% O_2 dry*" to "175@3% O_2 dry"	Noted, amended.	Checked final report, comment closed.
15	3.2.1	Page 29Table 3-4 Monitoring frequency column All "*annually*" should be changed to "Annual" All "*flare events*" should be changed to "Flare events"	Noted, amended.	Checked final report, comment closed.

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2023-2024

No.	Report Section	Reviewer Comment/Recommendation	INPEX Response	ERM response
16	3.2.1	Page 29 Table 3-4 For column called "parameter" Hg should be removed as it is not a required parameter for testing, see rows A1 till A13-1, A14-1 and A15-A16.	Noted, amended.	Checked final report, comment closed.
17	3.2.1	Page 29 Table 3-4 For column called "parameter" change "*mass of hydrocarbons flared*" to "Mass of hydrocarbons flared"	Noted, amended.	Checked final report, comment closed.
18	3.2.3	Page 31 Change "*Figure 3-2 and Figure 3-3 show the vented acid gas flow rates in m^3/h for Train 1 and Train 2."* To "Figure 3-2 and Figure 3-3 show the vented acid gas flow rates in standard cubic metre per hour (Sm^3/hr) for Train 1 and Train 2 respectively. Standard conditions should be defined.	Noted, amended.	Checked final report, comment closed.
19	3.2.3	Suggestion for figures, 3-2 till 3-5: 1. The Y-axis should have a thousand separator to make the numbers more readable, for example 10000 should read 10,000. 2. The figures should be resized to fill the total page real estate. 3. On Y axis all Sm3/hr should have the "3" as superscript Sm^3/hr	Noted, amended.	Checked final report, comment closed.

No.	Report Section	Reviewer Comment/Recommendation	INPEX Response	ERM response
20	3.3	Page 34 Change "*While the acid gas incinerators were offline, sampling of the vented gas occurred as per EPL228 condition 58.1*." To "While the acid gas incinerators were offline, sampling of the vented gas occurred as per EPL228 condition 58."	Noted, amended.	Checked final report, comment closed.
21	3.2.3	Page 31 Change "*Throughout the reporting period, INPEX has experienced a number of performance issues with Train 1 and Train 2 AGIs which have resulted in subsequent trips of both AGIs and were offline for a full review and Management of Change process before being re-implemented*." to "Throughout the reporting period, INPEX experienced a number of performance issues with Train 1 and Train 2 AGIs, resulting in subsequent trips of both AGIs. They were taken offline for a full review and Management of Change process before being re-implemented."	Noted, amended.	Checked final report, comment closed.
22	3.4	Page 35 Change "*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*	Noted, amended.	Checked final report, comment closed.

No.	Report Section	Reviewer Comment/Recommendation	INPEX Response	ERM response
		impacts from smoke emitted from Ichthys LNG are considered negligible, though smoke could become a cause of visual amenity impact and community concern." to "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 are considered negligible but may cause visual amenity impacts and community concern."		
23	3.4.1	Page 35 change "*Flaring and other data is stored in the sites Process Control System (PCS)*" To "Flaring and other data are stored in the site's Process Control System (PCS)."	Noted, amended.	Checked final report, comment closed.
24	Appendix D.1	Page 82 Concentration Target or limit should include "dry" where necessary as per permit conditions.	Noted, amended	Checked final report, comment closed.
25	Appendix D.1	Page 83 AGRU Incinerators change 175@15%O_2 to 175@3%O_2dry	Noted, amended	Checked final report, comment closed.

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2023-2024

No.	Report Section	Reviewer Comment/Recommendation	INPEX Response	ERM response
26	Appendix D.1 and D.2	In reference to NT EPA Guideline for Reporting on Environmental Monitoring. The AEMR provides monitored results in the AEMR appendix. In addition, INPEX would need to satisfy the conditions described in the said guideline, inter alia: 1. LOR should be stated. 2. Results should be in graphs and tables. 3. Measures of uncertainty listed. 4. Summary of previous results (highlight trends across 2-5 years of data). 5. QA/QC evaluation of monitoring. 6. Major assumptions and Discussion and interpretation of results If this information is available elsewhere, it should be referenced in this AEMR.	The guideline requirements are satisfied throughout Sections 3 (results, discussion, data QAQC, graphs and tables of data) and Appendix D (results in a tabular format). There is little benefit in including all of this information in Appendix D. In addition, the monitoring conditions and program do not require a trend analysis to be completed. INPEX considers this approach is consistent with the requirements of the EPL and OEMP, per previous AEMRs.	Comment closed.
27	Licence EPL-0228-05 Section 77.7	Condition 77.7 states *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;* The contribution of the authorised emissions on Darwin ambient air quality is not provided in the AMER. Please reference in the AEMR if this condition has been satisfied in some other format.	INPEX no longer has an EPL228 requirement to conduct an ambient air toxic monitoring program. Similarly, the OEMP no longer has an ambient air toxic monitoring program. The ambient air toxic monitoring program ceased in October 2021 (after 2 years) and during that period there	Comment closed.

No.	Report Section	Reviewer Comment/Recommendation	INPEX Response	ERM response
			were no exceedances that affected the Darwin region air quality network. INPEX continues to monitor air emissions associated with stationary emission sources (reported in Section 3 and Appendix D of this AEMR), which satisfies the condition requirement of 'contribution of the authorise emissions on Darwin region . .' and is consistent with previous AEMRs.	
Waste				
1	Table 6-1, Section 6 and Section 6, paragraph starting with 'Table 6-1 presents…'	Please add the 2020-2021 data in Table 6-1 as it is mentioned it is reported in Table 6-1 and the paragraph under Table 6-1 also mentioned the 2023-2024 waste data is similar to the 2020-2021 waste data.	Noted, amended	Checked final report, comment closed.
2	Second paragraph under 'Table 6-1….', starting with 'The main waste….'	Please check if the number '6,465' tonnes of wastewater transferred to various water treatment plants is correct. The tonnage reported in 2022-2023 was only '652' in 2022-2023,	Noted, amended. Cleanaway have checked their previously supplied data which was incorrect. Correct figure for 22/23 is 2012.5 tonnes of	Checked final report, comment closed.

No.	Report Section	Reviewer Comment/Recommendation	INPEX Response	ERM response
			wastewater transferred to WWTP.	
3	General Comment Section 6	Improvement in waste reduction across both recyclable and non-recyclable waste is observed when compared to data in 2022-2023. If there are any specific reason driving this decrease, please kindly elaborate.	Noted, amended	Checked final report, comment closed.
4	General Comment Section 6	In "Appendix B:EIS Commitments Relevant to this OEMP" of the OEMO, under ID 22.10, it is stated that ' A *baseline calculation of annual waste volumes will be undertaken in the first year of full steady operations (both LNG trains) and total waste reduction targets will be identified for subsequent years.'* Could INPEX please advise the waste data from which year is considered the baseline year and does INPEX has any specific waste reduction target being set for 2023-2024? If not, does INPEX have any waste reduction targets going forward?	Noted, amended	Checked final report, comment closed.

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, Haveloch 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 20th day of September 2024.

(3) Signature of the person making the declaration

.....

Witnessed by:

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

.....

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

Anna Ignacia Thomson

.....

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

11 Strathcona Rise, Bibra Lake, WA

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

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

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

THE NORTHERN TERRITORY OF AUSTRALIA

STATUTORY DECLARATION

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

I, Kenneth Kiefer of Environmental Resources Management Australia Pty Ltd located at Level 8/501 Swanston St, Melbourne VIC 3000.

(2) Here insert the matter declared to, either directly following the word "declare" or, if the matter is lengthy, insert the words "äs 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 23rd day of September 2024.

(3) Signature of the person making the declaration

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

Witnessed by:

.....

Tanya Kiefer

.....

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

Tanya Kiefer, 28 Ridgegreen View, Caroline Springs. VIC 3023.

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

0421213439

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, Ronald Ho of Environmental Resources Management Australia Pty Ltd located at Level 8/501 Swanston St, Melbourne VIC 3000.

(2) Here insert the matter declared to, either directly following the word "declare" or, if the matter is lengthy, insert the words "äs 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 23rd day of September 2024.

(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

.....

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

Rochelle Malan, U3/558 Moreland Road Brunswick West 3055

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 2019/2020-2022/2023 periods 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

Ronald Ho (Waste – Qualified Professional)

Ronald Ho is an experienced and versatile waste management and contaminated site management consultant at ERM with over 10 years of consulting experience in a variety of environmental projects with a focus on waste management, landfill audits, contaminated site management and infrastructure development. Ronald has experience developing waste management plan and waste management strategies for large-scale facilities such as airports, theme park, oil & gas facilities, hotel groups and government authorities in Australia and across Asia.

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

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.

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.

Ronald Ho

Principal Consultant

Ronald Ho is an experienced and versatile waste management and contaminated site management consultant at ERM with 10 years of consulting experience in a variety of environmental projects including waste management, contaminated site management, waste audit, government policy studies, business and economic analysis and stakeholder engagement.

He has strong business development, consulting and leadership skills and has proven record of managing large and complex waste management consultancy projects with favourable client feedback.

Experience: 10 years of experience in the waste management and environmental sector.

Email: Ronald.Ho@erm.com

Education

- Master of Science (MSc.) in Environmental Engineering and Management, University of Science and Technology, Hong Kong, 2015
- Bachelor of Science (BSc.) (Distinction) in Agricultural & Environmental Economics, McGill University, Canada, 2013

Languages

- English, Native
- Cantonese, Native
- Mandarin, Fluent

Fields of Competence

- Waste Management
- Circular Economy
- Environmental Policy
- Economic and Business Impact Assessment
- Stakeholder Engagement
- Business Case Development
- Contaminated Site Management

Key Industry Sectors

- Government
- Power
- Hospitality
- Food & Beverage

Professional Institutions

- Member, Chartered Institution of Water and Environmental Management
- Former Vice-Convener of Young Members Chapter, Hong Kong Waste Management Association

Key Projects

Dow Chemical Former Chlor-Alkali Plant Mercury Contaminated Waste Excavation and Management (2021-2022)
ERM was engaged Dow Chemical as lead environmental consultant in managing the remediation and waste disposal of mercury contaminated waste at the former chlor-alkali plant in Altona, Victoria. Ronald was the Project Manager responsible for day-to-day communication and delivery of the project.

ENGIE Hazelwood Landfill Annual Interpretive Report (Annually, 2019-2022)
ERM was engaged by ENGIE Australia to prepare an Annual Monitoring and Interpretive Report for the 2018 monitoring period of the various EPA Victoria licensed landfills within the Eastern Overburden Dump (EOD) and Hazelwood Ash Retention Area (HARA) at the Hazelwood Power Complex in Morwell, Victoria.
The main purpose of this annual report is to evaluate the extent to which ENGIE has implemented the landfill environmental monitoring program (LEMP) and to assess the results of the monitoring with respect to environmental discharges and potential environmental impact. Ronald was the Project Manager in charge of analysing the 2018 monitoring data on leachate, groundwater, surface water, landfill gas and dust.

ENGIE Hazelwood Asbestos Landfill Alternative Daily Cover Monitoring & Performance Report (2019 – 2020)
EPA Victoria has granted approval for a 6 month trial period starting on 1 May 2019 for ENGIE to use an alternative daily cover (ADC) known as 'Acryrubber' at the asbestos landfill site located within the Hazelwood Power Complex Landfill in Hazelwood. Ronald was the Project Manager in charge of reviewing the adequacy of the monitoring procedures and assessing the performance of the ADC in order to submit the performance report to EPA Victoria by end of September 2019.

Surf Coast Council Anglesea Landfill Audit (June 2019 – 2020)
ERM was engaged by the Surf Coast Council in Victoria to undertake a section 53V audit of the Anglesea Landfill due on June 2020. Ronald was the Project Manager supporting the Auditor on this landfill audit. He is responsible for assessing the risk of possible harm or detriment to the environment caused by the operation of the landfill including but not limited to groundwater, surface water, landfill gas and make recommendations to address the identified risks.

Hume City Council Riddell Road Landfill Audit (April 2019 – 2020)
ERM was engaged by Hume City Council in Victoria to undertake a section 53V audit of the Riddell Road Landfill due by end of September 2019. Ronald was part of the core team supporting the Auditor on this landfill audit. He is responsible for assessing the risk of possible harm or detriment to the environment caused by the operation of the landfill including but not limited to groundwater, surface water, landfill gas and make recommendations to address the identified risks.

Food Waste Management Plan & Operation Waste Management Plan for Third Runway System Development, for Airport Authority Hong Kong (2016 –2017)
Ronald was responsible for preparing the food waste management plan and operation waste management plan of the 3RS development recommending AAHK the arrangement of waste logistics, associated waste facilities and waste measures to optimise organic waste and recyclable collection.

Waste Management Audit and Strategy Study, for Airport Authority Hong Kong (2015 – 2016)
The study involved a waste stream identification task, a waste composition survey and design of waste management strategy for the airport authority. Ronald was the Project Coordinator managing 50 interns for a three-week-long waste stream identification and composition survey tasks and involved in analysing and producing reports of the analysed waste data.

Waste Characterisation Study, for Hong Kong International Theme Park (2015)
The study involved a waste characterisation study to analyse the composition of waste generated at a major theme park in Hong Kong. The project involved a waste sampling exercise conducted over 4 days with 12 interns in total during the Chinese New Year period and a final report of the analysed waste composition. Ronald was the site supervisor for this study.

Waste Audit & Strategy Study, for a Leading Luxury Hotel Group in Asia (2014)
Ronald was in charge of the Waste Characterisation Study part of the study. He carried out site study and data analysis of the waste composition of hotels in China and South-East Asia and advised the client on how waste could be minimised from an economic and environmental perspective.

TWS Audit Waste Facilities and Waste Management Plan for an International Offshore Oil & Gas Drilling Company (2013)
This study involved desktop research, site audits of up to three hazardous waste treatment facilities and update of the Waste Management Plan (WMP) for an offshore activity for South East Asia. Ronald was part of the project team support team leader in reviewing.

Project Drink Without Waste, for The Single-Use Beverage Packaging Working Group (2018)
The Consultant was commissioned by the Working Group, a consortium of beverage companies, retailers, NGOs, think-tanks etc. to carry out a research report and develop a Positioning Statement on how best Hong Kong can comprehensively and effectively manage single-use beverage packaging. Ronald is the local waste specialist responsible for baseline anaylsis, stakeholder engagement and strategy recommendation.

ENGIE Hazelwood Water Management Strategy Program Management (2019 – 2021)
Ronald is overall program manager responsible for consolidating and reviewing the program of the Water Management Strategy (WMS) of the Eastern Overburden Dump (EOD) and the Hazelwood Ash Retention Area (HARA) of the Hazelwood Power Complex Rehabilitation Project. The WMS is anticipated to be completed by end of 2021.

Study on Enhancing the Cost Effectiveness of Glass Bottle Collection and Recycling Services in Hong Kong, for Environmental Protection Department (EPD) of HKSAR (2014 – 2015)
The objective of this study is to advise EPD on optimising the cost effectiveness of glass collection service in Hong Kong with reference to local and overseas experience. Stakeholders from local glass collection and recycling sectors were engaged and interviewed to assess the best practice in glass collection. Field work on glass collection technology was also conducted. Ronald was the Project Coordinator.

Business Impact Assessment on Producer Responsibility Scheme for Glass Beverage Containers, for EPD (2013 – 2015). The objective of the study is to understand and mitigate the business impact of the glass beverage bottle PRS on relevant stakeholders. Ronald is the Project Coordinator responsible for doing market research on the business structure and environment of HK Beverage Industry, quantitative analysis of trade statistics, conducting stakeholder view-seeking interviews, business impact analysis and recommending mitigation measures.

Low-Level Radioactive Waste Storage Facility Follow-On Contract, for EPD (2014 – 2015)
Ronald engaged users of the LLRWSF to review how the performance of the facility can be improved. He is also responsible for forecasting the waste arising of low level radioactive waste in Hong Kong in the next 20 to 30 years using the Monte Carlo Simulation Model and reviewing the Environmental Monitoring & Audit practice of the Initial Contract.

Environmental Impact Assessment for Development of a New Seawater Cooling System – Intake Offshore & Discharge Culvert in Macau, for Companhia de Electricidade de Macau (2016 – 2017)
CEM is the utility company that supplies electricity to the Macau. ERM was commissioned to undertake an EIA to assess the impact of developing a new seawater cooling system to supplement the new at the Coloane Power Station. Ronald is responsible for assessing the waste management impact of the development.

South East New Territories (SENT) Landfill Annual Audit (2014-2017)
SENT landfill was one of the three strategic operating landfills in Hong Kong with a space of 100ha. Ronald was the Project Manager and Audit Leader in conducting a focused site audit annually, ensuring the Operator fulfil all the regulatory requirements and adopt good environmental, health and safety practice. The findings from the annual audit were submitted as part of the audit report.

Consultancy Service to Review the Administrative and Regulatory Frameworks for Implementation of the Minamata Convention on Mercury in the HKSAR, for EPD (2015 – 2017)
The objective of the study is to review and identify the gaps between regulations of Hong Kong and the clauses of the Convention and devise an implementation roadmap for the Government. Ronald is the Project Coordinator responsible for regulatory review, business environment research, stakeholder engagement, impact analysis and recommendation of implementation strategies. The study included strategies of disposal of mercury containing waste.

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

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

Shaded purple cells with bold text indicate a trigger exceedance associated with subsequent discharge via jetty outfall. These are further described in Table 2-4

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	Thermotolerant/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**	**mg N/L**	**mg P/L**	**mg P/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**cfu/ 100mL**	**cfu/ 100mL**	**cfu/ 100mL**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Discharge limit			**6-9**	**n/a**	**35**	**n/a**	**n/a**	**6**	**n/a**	**n/a**	**10**	**20**	**125**	**2**	**n/a**	**10**	**2**	**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**
18/07/2023	7:45	L2303366001	8	174	26.5	1	84	<1	<20	<100	<5	<2	9	0.03	3	3	0.6	<0.5	<0.1	<1	<1	<1	<0.1	<1	<1	23	33	26	28	<0.1	<5	<5	<5
8/08/2023	8:10	L2303790001	8.1	373	27.8	1.0	73	2	<20	<100	< 5	<2	9	0.04	8	8	< 0.5	< 0.5	<0.1	<1	3	<1	<0.1	<0.1	<1	74	4	6	18	<0.1	< 5	< 5	< 5
5/09/2023	8:50	L2304269001	7.9	390	28.9	1.0	68	< 1	<20	<100	< 5	<2	15	0.04	6	7	< 0.5	< 0.5	<0.1	<1	3	<1	<0.1	<0.1	<1	146	13	1	49	<0.1	< 5	< 5	< 5
17/10/2023	8:15	L2304825001	8.5	363	30.7	3.5	84	< 1	<20	<100	< 5	<2	14	0.03	7	**7**	0.8	0.6	<0.1	<1	3	<1	<0.1	<0.1	<1	202	<1	<1	14	<0.1	< 5	< 5	< 5
14/11/2023	8:55	L2305379001	8.2	380	31.7	1.0	79	< 1	<20	<100	< 5	<2	16	0.02	8	10	< 0.5	< 0.5	<0.1	<1	<1	<1	<0.1	<0.1	<1	214	8	5	10	<0.1	< 5	< 5	< 5
12/12/2023	7:55	L2305821001	7.9	347	31.0	1.5	63	< 1	<20	<100	< 5	5	16	0.03	< 2	< 2	< 0.5	< 0.5	<0.1	<1	3	<1	<0.1	<0.1	<1	458	1	3	10	<0.1	< 5	< 5	< 5
8/01/2024	8:10	L2400119001	8.3	472	30.9	2.0	60	1	<20	<100	< 5	7	12	0.05	12	**12**	< 0.5	< 0.5	<0.1	<1	<1	<1	<0.1	<0.1	<1	77	70	10	230	<0.1	< 5	< 5	< 5
19/01/2024	8:10	L2400305001													<2	< 2																	
13/02/2024	8:08	L2400723001	7.8	268	27.2	3.5	73	< 1	<20	<100	< 5	<2	14	< 0.02	4	4	< 0.5	< 0.5	<0.1	<1	1	<1	<0.1	<0.1	<1	194	42	6	270	<0.1			
16/02/2024	8:15	L2400815001																													<5	<5	<5
12/03/2024	8:50	L2401242001	7.6	358	28.6	3.5	59	< 1	<20	<100	**60**		15	0.03	< 2	2	< 0.5	< 0.5													< 5	< 5	< 5
12/03/2024	9:15	L2401325001									<5																						
14/03/2024	8:45	L2401314001							<20	<100		<2							<0.1	<1	1	<1	<0.1	<0.1	<1	212	60	28	140	0.3			
9/04/2023	8:35	L2401805001														2																	
15/04/2024	8:50	L2401929001	7.8	354	30.4	4.5	80	< 1	<20	<100	9	7	23	0.04	2	3	0.5	< 0.5	<0.1	<1	3	<1	<0.1	<0.1	<1	85	18	4	35	<0.1	< 5	< 5	< 5
23/04/2023	10:45	L2402482001														5																	
8/05/2023	8:41	L2402279001														3																	
15/05/2024	8:22	L2402370001	7.7	366	29.0	1.0	72	< 1	<20	<100	< 5	4	13	0.03	< 2	5	1.7	1.5	0.2	<1	6	<1	<0.1	<0.1	<1	87	2	1	100	<0.1	< 5	< 5	< 5
23/05/2023	15:45	L2402482001														8																	
5/06/2023	8:45	L2400279001														4																	
11/06/2024	8:35	L2402901001	8.0	396	26.3	2.0	78	< 1	<20	<100	< 5	2	12	0.06	< 2	8	0.6	< 0.5	<0.1	<1	9	<1	<0.1	<0.1	<1	40	<1	<1	51	<0.1	< 5	< 5	< 5
19/06/2024	11:25	L2403330001														9																	

APPENDIX D: AUTHORISED STATIONARY SOURCE EMISSION RELEASE RESULTS

D.1 Stationary source emission test results by Ektimo

Sampling Point Number	Sampling Location Number	Date/Time	LIMS Number	NO_x as NO_2 - Concentration Target		NO_x as NO_2 - Concentration Limit		NOx as NO_2 -Measured Concentration		CO Measured Concentration		Temperature	Efflux velocity	Volumetric flow rate
				mg/Nm³	ppm	mg/Nm³	ppm	mg/Nm³	ppmv	mg/m³	ppm	ºC	m/s	m³/min
LNG Refrigerant Compressor Driver Gas Turbines (GE Frame 7s)				**50 @ 15%O2 dry**	**25 @ 15%O2 dry**	**70**	**35 @ 15%O2 dry**	**LNG Refrigerant Compressor Driver Gas Turbines (GE Frame 7s)**						
A1	L-641-A-001	02/11/2023 09:56	L2302642001					50	24	50	40	170	24	15000
A2	L-642-A-001	02/11/2023 13:19	L2302644001					15	7.2	12	9.6	169	24	15000
A3	L-641-A-002	03/11/2023 12:11	L2302643001					6.7	3.3	13	10	176	24	15000
A4	L-642-A-002	04/11/2023 09:22	L2302645001					11	5.3	37	30	174	24	15000
CCPP Gas Turbine Generators (GE Frame 6s, 38MW) - HRSG stack								**CCPP Gas Turbine Generators (GE Frame 6s, 38MW) - HRSG stack**						
A5-1	L-780-GT-001	-	-					-	-	-	-	-	-	-
A6-1	L-780-GT-002	-	-					-	-	-	-	-	-	-
A7-1	L-780-GT-003	-	-					-	-	-	-	-	-	-
A8-1	L-780-GT-004	-	-					-	-	-	-	-	-	-
A9-1	L-780-GT-005	-	-					-	-	-	-	-	-	-
A5-2	L-630-F-001	01/11/2023 13:27	L2302646001	**150 @15%O2 dry**	**75 @15%O2 dry**	**350**	**175 @15%O2 dry**	12	6	49	39	201	22	7300
A6-2	L-630-F-002	01/11/2023 13:10	L2302647001					9.4	4.6	140	110	213	25	7900
A7-2	L-630-F-003	-	-					-	-	-	-	-	-	-
A8-2	L-630-F-004	01/11/2023 10:47	L2302649001					9.2	4.5	60	48	220	23	7300
A9-2	L-630-F-005	01/11/2023 09:56	L2302650001					10	5.1	59	47	220	23	7200

Sampling Point Number	Sampling Location Number	Date/Time	LIMS Number	NO_x as NO_2 - Concentration Target		NO_x as NO_2 - Concentration Limit		NOx as NO_2 -Measured Concentration		CO Measured Concentration		Temperature	Efflux velocity	Volumetric flow rate
				mg/Nm³	ppm	mg/Nm³	ppm	mg/Nm³	ppmv	mg/m³	ppm	ºC	m/s	m³/min
AGRU Incinerators				**320 @3%O2 dry**	**160 @3%O2 dry**	**350**	**175 @3%O2 dry**	**AGRU Incinerators**						
A13-1	L-551-FT-031	-	-					-	-	-	-	-	-	-
A14-1	L-552-FT-031	-	-					-	-	-	-	-	-	-
Heating medium furnaces				**160 @3%O2 dry**	**80 @3%O2 dry**	**350**	**175 @3%O2 dry**	**Heating medium furnaces**						
A15	L-640-A-001-A	03/11/2023 10:01	L2302640001					140	70	69	55	157	4.1	700
A16	L-640-A-001-B	03/11/2023 09:54	L2302639001					130	61	63	50	159	4.2	720

D.2 Monthly Feed 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								
24/07/2023 11:00	L2303336001	160	<30	<30	<30	<30	<30	NA
14/08/2023 12:08	L2303891001	150	<30	<30	<30	<30	<30	NA
29/09/2023 15:15	L2304357001	140	<30	<30	<30	<30	<30	NA
30/10/2023 12:15	L2304953001	140	110	80	<30	<30	<30	NA
12/11/2023 10:15	L2305345001	140	90	60	<30	<30	<30	NA
13/12/2023 09:25	L2305795001	160	100	70	<30	<30	<30	NA
02/01/2024 12:21	L2400015001	NA	210	160	<30	<30	<30	NA
20/01/2024 13:48	L2400113001	140	220	180	<30	<30	<30	NA
13/02/2024 14:20	L2400694001	140	80	50	<30	<30	<30	NA
04/03/2024 13:30	L2401098001	140	110	70	<30	<30	<30	NA
13/04/2024 16:45	L2401785001	140	200	130	<30	<30	<30	NA
20/05/2024 14:20	L2402356001	150	240	180	<30	<30	<30	NA
24/07/2023 11:00	L2303336001	160	<30	<30	<30	<30	<30	NA
11/06/2024 11:31	L2402868001	140	130	70	<30	<30	<30	NA
A13-3 (L-541-SC-001) Feed gas to AGRU – LNG Train 1 – prior to release at A3								
31/07/2023 13:00	L2303469001	NA	NA	NA	NA	NA	NA	< 0.005
25/08/2023 11:10	L2304017001	NA	NA	NA	NA	NA	NA	< 0.005
28/09/2023 14:40	L2304486001	NA	NA	NA	NA	NA	NA	< 0.005
07/11/2023 07:10	L2304907001	NA	NA	NA	NA	NA	NA	< 0.005
17/11/2023 10:30	L2305471001	NA	NA	NA	NA	NA	NA	< 0.005
15/12/2023 09:00	L2305986001	NA	NA	NA	NA	NA	NA	< 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
15/01/2024 07:20	L2400238001	NA	NA	NA	NA	NA	NA	< 0.005
19/02/2024 09:15	L2400867001	NA	NA	NA	NA	NA	NA	< 0.005
21/03/2024 12:55	L2401410001	NA	NA	NA	NA	NA	NA	< 0.005
24/04/2024 12:55	L2401914001	NA	NA	NA	NA	NA	NA	< 0.005
May-24	no sample	NA	NA	NA	NA	NA	NA	NA
Jun-24	no sample	NA	NA	NA	NA	NA	NA	NA
A14-2 (L-552-SC-003) AGRU hot Vent Train2, prior to release at A4								
24/07/2023 14:20	L2303337001	140	< 30	< 30	< 30	< 30	< 30	NA
30/09/2023 14:00	L2304358001	140	50	30	< 30	< 30	< 30	NA
31/10/2023 13:02	L2304954001	140	120	70	< 30	< 30	< 30	NA
12/11/2023 14:55	L2305347001	140	150	110	< 30	< 30	< 30	NA
13/12/2023 13:45	L2305796001	140	150	100	< 30	< 30	< 30	NA
01/01/2024 12:51	L2400016001	NA	150	110	< 30	< 30	< 30	NA
23/01/2024 15:38	L2400114001	140	170	130	< 30	< 30	< 30	NA
13/02/2024 10:45	L2400695001	160	90	60	< 30	< 30	< 30	NA
08/03/2024 13:50	L2401144001	120	100	80	< 30	< 30	< 30	NA
10/04/2024 15:45	L2401786001	140	150	120	< 30	< 30	< 30	NA
19/05/2024 15:27	L2402357001	120	220	150	< 30	< 30	< 30	NA
11/06/2024 14:27	L2402869001	140	190	120	< 30	< 30	< 30	NA
A14-3 (L-542-SC-001) Feed gas to AGRU – LNG Train 2 – prior to release at A4								
25/07/2023 14:00	L2303468001	NA	NA	NA	NA	NA	NA	< 0.005
28/08/2023 09:10	L2304016001	NA	NA	NA	NA	NA	NA	< 0.005
27/09/2023 15:40	L2304485001	NA	NA	NA	NA	NA	NA	< 0.005
Oct-23	no sample	NA	NA	NA	NA	NA	NA	NA

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
11/11/2023 10:45	L2304906001	NA	NA	NA	NA	NA	NA	< 0.005
27/11/2023 17:05	L2305470001	NA	NA	NA	NA	NA	NA	< 0.005
15/12/2023 10:15	L2305985001	NA	NA	NA	NA	NA	NA	< 0.005
21/03/2024 12:30	L2401409001	NA	NA	NA	NA	NA	NA	< 0.005
17/04/2024 09:00	L2401913001	NA	NA	NA	NA	NA	NA	< 0.005
22/05/2024 09:15	L2402428001	10	120	110	<30	<30	<30	< 0.005
03/06/2024 10:10	L2402460001	NA	NA	NA	NA	NA	NA	< 0.005
18/06/2024 09:40	L2402999001	NA	NA	NA	NA	NA	NA	< 0.005

APPENDIX E: GROUNDWATER QUALITY MONITORING DATA

Table E-8-1: Groundwater sampling results for all sites, Groundwater Surveys 12 and 13

Monitoring Round	LocCode	Sampled Date-Time	Ammonia as N	Nitrogen (Total)	Oxides of Nitrogen	Phosphate total (P)	Reactive Phosphorus as P	TSS	TDS	Aluminium (Filtered)	Arsenic (Filtered)	Cadmium (Filtered)	Chromium (hexavalent) (Filtered)	Chromium (Trivalent) (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	Biological oxygen demand (BOD)	E. coli	Dissolved Oxygen (%)	EC (field)	pH (Field)	Redox	Temp
Units	n/a	n/a	mg/l	mg/l																										MPN/ 100mL	% sat	uS/cm	pH_Units	mV	°C
Operations Survey 12	BPGW01	10/10/2023	0.057	0.21	0.095	0.046	0.017	-	1,430	0.238	0.0021	0.00227	<0.001	<0.001	0.0261	0.0013	0.0074	0.703	<0.00004	0.0187	0.0005	<0.0002	0.111	<1	<2	<2	<2	<100	-	-	19.9	3,000	4.69	135.8	30.3
	BPGW07	10/10/2023	0.489	0.81	0.039	0.042	0.017	-	67,100	0.008	0.0142	0.0003	<0.001	<0.01	0.0167	<0.001	0.0009	0.793	<0.00004	0.0189	<0.0001	<0.0005	0.05	<1	<2	<2	<2	<100	-	-	23.2	96,564	5.85	61.2	31.1
	BPGW08A	10/10/2023	0.123	0.17	<0.02	0.04	0.035	-	10,700	0.073	0.0144	0.00051	<0.001	<0.001	0.0564	0.0013	0.0033	4.16	<0.00004	0.0317	<0.0001	0.0005	0.048	<1	<2	<2	<2	<100	-	-	16.3	17,117	4.86	138.7	31.5
	BPGW09	10/10/2023	0.386	0.62	<0.02	<0.01	0.009	-	81,000	<0.005	0.0438	<0.0002	0.002	<0.01	0.0025	<0.001	<0.0002	0.505	<0.00004	0.0013	<0.0001	<0.0005	0.01	<1	<2	<2	<2	<100	-	-	30.2	112,692	6.21	-15.9	30.9
	BPGW18	12/10/2023	0.416	0.57	0.157	0.058	0.005	-	51,800	0.011	0.0029	<0.0002	<0.001	<0.01	<0.0002	<0.001	0.0002	0.178	<0.00004	<0.0005	<0.0001	<0.0005	0.016	<1	<2	<2	<2	<100	-	-	28.3	71,145	6.15	-26.4	30
	BPGW19A	11/10/2023	1.16	2.04	0.078	0.012	0.011	-	56,000	0.021	0.0013	<0.00005	<0.001	0.001	<0.0001	0.0014	<0.0001	0.0388	<0.00004	<0.0005	<0.0001	0.0033	0.002	<1	<2	<2	<2	<100	2.1	<1	3.8	71,895	6.06	-241.5	31.9
	BPGW20	12/10/2023	0.134	0.03	0.31	0.018	0.006	-	930	<0.005	0.0035	<0.00005	<0.001	<0.001	0.0037	<0.0005	<0.0001	0.0583	<0.00004	0.002	<0.0001	0.0002	0.011	<1	<2	<2	<2	<100	-	-	14.8	1,516	5.48	39.4	33
	BPGW26	11/10/2023	0.309	0.5	<0.02	<0.005	0.004	-	6,050	<0.005	0.004	0.00005	<0.001	<0.001	0.0097	<0.0005	0.0002	2.99	<0.00004	0.001	<0.0001	0.0002	0.008	<1	<2	<2	<2	<100	-	-	4.3	10,178	5.32	73.6	32.2
	BPGW27A	11/10/2023	0.308	0.35	<0.02	0.005	0.005	-	1,440	<0.005	0.0016	<0.00005	<0.001	<0.001	0.0019	0.0008	<0.0001	0.0233	<0.00004	<0.0005	<0.0001	<0.0002	0.006	<1	<2	<2	<2	<100	2.7	<1	5.3	2,565	5.25	57.5	33.4
	BPGW28	12/10/2023	0.876	0.9	0.178	0.076	<0.001	-	74,200	<0.005	0.0152	<0.00005	<0.001	<0.01	0.0002	<0.0005	<0.0001	0.0692	<0.00004	0.0006	<0.0001	0.001	0.003	<1	<2	<2	<2	<100	-	-	16.3	99,575	6.47	-43.1	30.9
	BPGW38A	11/10/2023	0.072	0.09	0.008	0.009	0.009	-	1,050	<0.005	0.0006	0.00401	<0.001	<0.001	0.0006	<0.0005	0.0001	0.0232	<0.00004	<0.0005	<0.0001	0.0003	0.01	<1	<2	<2	<2	<100	-	-	8.1	1,915	5.89	70.2	32.5
	BPGW40	11/10/2023	0.475	0.93	<0.02	<0.025	0.008	-	2,930	<0.005	0.0061	<0.00005	<0.001	<0.001	0.0011	<0.0005	<0.0001	0.132	<0.00004	<0.0005	<0.0001	<0.0002	0.005	<1	<2	<2	<2	<100	-	-	3.9	4,888	6.07	-40	30.9
	BPGW41	12/10/2023	0.704	0.58	0.126	0.027	0.003	-	11,800	0.005	0.0063	<0.00005	<0.001	<0.001	0.0001	0.0008	<0.0001	0.0142	<0.00004	0.0007	<0.0001	0.0006	0.014	<1	<2	<2	<2	<100	-	-	39.1	19,105	6.51	-51.3	29.9
	VWP328	12/10/2023	0.227	0.12	<0.02	<0.005	0.004	-	87,900	<0.005	0.549	<0.0002	<0.001	<0.01	0.0189	<0.001	0.0003	0.409	<0.00004	0.0027	<0.0001	<0.0005	0.007	<1	<2	<2	<2	<100	-	-	49.6	94,583	5.98	-18.9	31.1
	VWP341	10/10/2023	0.638	0.9	<0.02	0.023	0.005	-	2,260	0.006	0.0071	<0.00005	<0.001	<0.001	0.124	<0.0005	0.0002	1.67	<0.00004	0.014	0.0005	0.0003	0.1	<1	<2	<2	<2	<100	-	-	19.8	4,489	5.6	45.8	32.6
Operations Survey 13	BPGW01	2/04/2024	0.02	0.12	0.008	0.029	0.004	-	57	0.044	0.004	<0.00005	<0.001	<0.001	0.0024	<0.0005	0.0002	0.177	<0.00004	0.0006	<0.0001	0.00025	0.004	<1	<2	<2	<2	<100	-	-	2.23	120	5.27	120.2	29.6
	BPGW07	2/04/2024	0.029	0.6	0.003	0.037	0.035	-	68,000	<0.005	0.0148	0.0004	<0.001	<0.001	0.0228	0.002	0.0013	0.971	<0.00004	0.0238	<0.0001	0.0011	0.05	<1	<2	<2	<2	<100	-	-	1.95	96,126	5.69	110.2	30.9
	BPGW08A	2/04/2024	0.114	0.18	<0.002	0.037	0.014	-	3,490	0.005	0.0306	<0.00005	<0.001	<0.001	0.0606	<0.0005	<0.0001	3.26	<0.00004	0.0236	<0.0001	0.00025	0.011	<1	<2	<2	<2	<100	-	-	2.4	6,437	5.57	108.5	31.2
	BPGW09	2/04/2024	0.341	0.4	<0.02	0.017	0.013	-	108,000	<0.005	0.0787	<0.0002	<0.001	0.001	0.0056	<0.001	0.0003	0.638	<0.00004	0.0013	<0.0001	0.00138	<0.005	<1	<2	<2	<2	<100	-	-	1.8	39,675	6	67.3	30.7
	BPGW18	4/04/2024	0.554	0.64	<0.02	0.05	0.001	-	53,500	0.005	0.0107	<0.0002	0.001	<0.01	<0.0002	<0.001	<0.0002	0.0803	<0.00004	0.0015	<0.0001	0.00118	<0.005	<1	<2	<2	<2	<100	-	-	2.49	84,079	6.1	6.2	30.2

Monitoring Round	LocCode	Sampled Date-Time	Ammonia as N	Nitrogen (Total)	Oxides of Nitrogen	Phosphate total (P)	Reactive Phosphorus as P	TSS	TDS	Aluminium (Filtered)	Arsenic (Filtered)	Cadmium (Filtered)	Chromium (hexavalent) (Filtered)	Chromium (Trivalent) (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	Biological oxygen demand (BOD)	E. coli	Dissolved Oxygen (%)	EC (field)	pH (Field)	Redox	Temp
	BPGW19A	4/04/2024	1.64	1.96	<0.02	0.058	0.005	-	56,600	0.014	0.0056	<0.0002	0.002	<0.01	<0.0002	<0.001	<0.0002	0.0497	<0.00004	<0.0005	<0.0001	0.0044	0.009	<1	<2	<2	<2	<100	<1	<1	2.17	87,273	6.03	40	30.8
	BPGW20	3/04/2024	0.104	0.13	<0.002	0.007	0.005	-	442	0.005	0.002	<0.00005	<0.001	<0.001	0.0012	<0.0005	<0.0001	0.0208	<0.00004	0.0009	<0.0001	0.00025	0.003	<1	<2	<2	<2	<100	-	-	2.62	1,142	5.46	57.6	32.9
	BPGW26	4/04/2024	0.188	0.22	<0.002	0.032	0.005	-	4,670	<0.005	0.0028	<0.00005	<0.001	<0.001	0.0073	<0.0005	<0.0001	2.12	<0.00004	0.001	<0.0001	0.00025	0.004	<1	<2	<2	<2	<100	-	-	3.07	10,034	5.38	103	31.6
	BPGW27A	4/04/2024	0.182	0.18	<0.002	0.006	<0.001	-	1,260	<0.005	0.0007	<0.00005	<0.001	<0.001	0.0017	<0.0005	<0.0001	0.0249	<0.00004	0.0005	<0.0001	0.00025	0.003	<1	<2	<2	<2	<100	<1	<1	2.68	2,811	5.11	119.6	33
	BPGW28	3/04/2024	1.11	1.28	<0.02	0.024	0.007	-	78,700	0.023	0.003	<0.0002	<0.001	<0.001	<0.0002	<0.001	0.0005	0.2	<0.00004	<0.0005	<0.0001	0.00188	<0.005	<1	<2	<2	<2	<100	-	-	2.94	117,280	6.38	17.1	30.9
	BPGW38A	3/04/2024	0.04	0.48	0.412	0.02	0.003	-	197	0.005	<0.0002	0.00017	<0.001	<0.001	<0.0001	<0.0005	<0.0001	0.0005	<0.00004	<0.0005	<0.0001	0.00025	0.002	<1	<2	<2	<2	<100	-	-	3.74	4,513	6.11	106	31.5
	BPGW40	3/04/2024	0.514	0.71	<0.02	0.017	0.01	-	2,510	0.008	0.0077	<0.00005	<0.001	<0.001	0.0018	<0.0005	<0.0001	0.154	<0.00004	<0.0005	<0.0001	0.00025	0.003	<1	<2	<2	<2	<100	-	-	2.68	5,186	5.95	46.8	30.4
	BPGW41	3/04/2024	0.736	0.97	<0.02	0.012	<0.01	-	12,900	0.019	0.0046	<0.00005	<0.001	<0.001	<0.0001	<0.0005	<0.0001	0.0155	<0.00004	<0.0005	<0.0001	0.0007	0.001	<1	<2	<2	<2	<100	-	-	2.91	23,167	6.48	29.8	29.8
	VWP328	4/04/2024	0.326	0.48	<0.02	<0.005	0.001	-	73,000	<0.005	0.542	<0.0002	<0.01	<0.01	0.0223	<0.001	<0.0002	0.387	<0.00004	0.003	<0.0001	0.0009	0.006	<1	<2	<2	<2	<100	-	-	2.62	112,575	5.85	1.7	30.8
	VWP341	2/04/2024	0.685	0.7	<0.002	0.015	0.004	-	1,800	0.016	0.0056	<0.00005	<0.001	<0.001	0.168	<0.0005	0.0001	2.67	<0.00004	0.0165	<0.0001	0.00025	0.173	<1	<2	<2	<2	<100	-	-	2.95	3,711	5.46	82.9	33.1

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