Modification Notice - Regulation 22

Interest Holder	Imperial Oil and Gas Pty Ltd	EMP Title	Environment Management Plan Imperial Oil & Gas 2021-2025 EP187 Work Program NT Exploration Permit (EP) 187	Unique EMP ID No.	IMP4-3	Mod No.	2	Date	02/12/2022 Updated 09/12/2022

Brief Description	The modification to the activity is to re-use flowback fluid from the Carpentaria-2H well for Hydraulic Fracturing of the Carpentaria-3H well on the Carpentaria 2 well pad. This proposal including monitoring and reporting is described in **Attachment 1,** including a risk assessment **Appendix 1**
Geospatial Files Included?	Not applicable

Does the proposed change result in a new, or increased, potential or actual environmental impact or risk?	If an INCREASE in an existing potential or actual environmental impact or risk is it provided for in the approved EMP?	Does the proposed change require additional mitigation measures to be included?	Has additional stakeholder engagement been conducted?	Does it require additional environmental performance standards and measurement criteria?	Does it affect compliance with Sacred Site Authority Certificates?	Does it affect current rehabilitation, weed, fire, wastewater, erosion and sediment control, spill or emergency response plans?	Will the environmental outcome continue to be achieved and will the impacts and risks be managed to ALARP and acceptable?
No	Not Applicable	No	No	No	No	No	Yes

Current EMP Text	Amended EMP Text
3.11.5 Hydraulic Fracturing Fluids *"Imperial has considered the use of recycled water for HF operations, but the volume required and the remoteness of the location does not make it reasonably practical;*	*3.11.5 Hydraulic Fracturing Fluids* "Imperial will use Carpentaria-2H flowback for the Hydraulic Fracturing of the Carpentaria-3H well on the Carpentaria-2 well pad only. *This recycling reduces the amount of freshwater used in exploration*. *The Appendix 1 - Northern Territories –*

Imperial will consider utilising Flowback Fluid and Produced Water from this operation in future EP187 operation"	*Regulation 22 Flowback Water Risk Assessment* by EHS Support has determined that the use of flowback water from Carpentaria-2H well location is suitable as make-up water in the hydraulic fracturing process on wells located under the same EMP IMP4-3 as it will not significantly increase risks and is considered adequate to minimise risk to as low as reasonably practicable. ~~*considered the use of recycled water for HF operations, but the volume required and the remoteness of the location does not make it reasonably practical; Imperial will consider utilising Flowback Fluid and Produced Water from this operation in future EP187 operation*~~"
3.11.6 HF Chemical Risk Assessment The life cycle of the hydraulic stimulation fluid system chemicals was assessed specifically for hydraulic stimulation operations and included: • Activities associated with hydraulic stimulation chemical mixing and use at the well pad, and • Management of flowback water (i.e., stored on-site) during or after the completion of hydraulic stimulation activities at the well pad The Risk Assessment found that hydraulic stimulation chemicals within the life cycle (i.e., mixing, usage and storage) may potentially expose human receptors and the environment through accidental releases. These potential releases, whilst unexpected, are considered to have a very low probability of occurrence and are constrained by the EMP requirements to managing risk, existing legislative requirements and the ongoing mitigating of potential impacts.	3.11.6 HF Chemical Risk Assessment The life cycle of the hydraulic stimulation fluid system chemicals was assessed specifically for hydraulic stimulation operations and included: • Activities associated with hydraulic stimulation chemical mixing and use at the well pad, ~~and~~ • Management of flowback water (i.e., stored on-site) during or after the completion of hydraulic stimulation activities at the well pad, and • Imperial will reuse and recycle flowback water from the Carpentaria-2H well for the Hydraulic Fracturing of the Carpentaria-3H well on the Carpentaria-2 wellpad only. The Risk Assessment found that hydraulic stimulation chemicals within the life cycle (i.e., mixing, usage, reuse, recycling and storage) may potentially expose human receptors and the environment through accidental releases. These potential releases, whilst unexpected, are considered to have a very low probability of occurrence and are constrained by the EMP requirements to managing risk, existing legislative requirements and the ongoing mitigating of potential impacts. *The Appendix 1 - Northern Territories – Regulation 22 Flowback Water Risk Assessment* by EHS Support has determined that the use of flowback water from Carpentaria-2H well location is suitable as make-up water in the hydraulic fracturing process on wells located under the same EMP IMP4-3 as it will not significantly increase risks and is considered adequate to minimise risk to as low as reasonably practicable. Imperial will use Carpentaria-2H flowback for the Hydraulic Fracturing of the Carpentaria-3H well on the Carpentaria-2 well pad only.

3.12 Flowback and Extended Production Testing Activities "Flowback Fluid or Produced Water in drilling fluids or hydraulic fracturing fluids will not contain BTEX at levels greater than those expected in water produced (including flowback) from the well being drilled. BTEX levels in water used for drilling fluids or stimulation fluid will not exceed the levels prescribed in Table 9 of the Code. Imperial plans to use no BTEX in its drilling fluids as per Section 3.10.12."	3.12 Flowback and Extended Production Testing Activities "Flowback Fluid or Produced Water in drilling fluids or hydraulic fracturing fluids will not contain BTEX at levels greater than those expected in water produced (including flowback) from the well being drilled. BTEX levels in water used for drilling fluids or stimulation fluid will not exceed the levels prescribed in Table 9 of the Code. Imperial plans to use no BTEX in its drilling fluids as per Section 3.10.12. Imperial will use Carpentaria-2H flowback for the Hydraulic Fracturing of the Carpentaria-3H well on the Carpentaria-2 well pad only. This recycling reduces the amount of freshwater used in exploration."
g. Chemical Risk Assessment A tiered assessment was conducted on the compiled hydraulic fracturing fluid systems using screening of the potential human health and ecological hazards that should be considered for potential exposure to the hydraulic fracturing fluids during transportation, hydraulic fracturing activities (including storage), and subsequent treatment and disposal of flowback. The tiered assessment includes the following steps: • Tier 1 – Identify chemicals of low human health and ecological concern that do not require additional chemical risk assessment in the tier assessment process • Tier 2 – Chemicals that are not identified as a low human health and ecological concern and therefore require an additional risk assessment to characterise potential risks. This is done using a quantitative evaluation of the risks based on the potential complete exposure pathways and Tier 1 assessment	g. Chemical Risk Assessment A tiered assessment was conducted on the compiled hydraulic fracturing fluid systems using screening of the potential human health and ecological hazards that should be considered for potential exposure to the hydraulic fracturing fluids during transportation, hydraulic fracturing activities (including storage), ~~and~~ subsequent treatment and disposal of flowback or reuse and recycle. The tiered assessment includes the following steps: • Tier 1 – Identify chemicals of low human health and ecological concern that do not require additional chemical risk assessment in the tier assessment process • Tier 2 – Chemicals that are not identified as a low human health and ecological concern and therefore require an additional risk assessment to characterise potential risks. This is done using a quantitative evaluation of the risks based on the potential complete exposure pathways and Tier 1 assessment.
Appendix 06 – Waste and wastewater management plan Section 7. Waste Management Table 6. Waste Management.	Appendix 06 – Waste and wastewater management plan Section 7. Waste Management Table 6. Waste Management.

Flowback fluids and produced water	Cannot avoid	Recycling of fluids reduces the consumption of additives and, therefore, the production of waste	No reuse of fluids is proposed	No recycling of fluids is proposed.	Maximise evaporati on rates to reduce the volume	Flowback Fluids and Produced water will be evaporated as much as possible; the remaining fluid will be appropriately transported and disposed of at a licenced facility

Flowback fluids and produced water	Cannot avoid	Recycling of fluids reduces the consumption of additives and, therefore, the production of waste	~~No~~ reuse of fluids is proposed in hydraulic fracturing fluid.	~~No~~ recycling of fluids is proposed. in hydraulic fracturing fluid.	Maximise evaporati on rates to reduce the volume	Flowback Fluids and Produced water will be evaporated as much as possible; the remaining fluid will be appropriately transported and disposed of at a licenced facility

Attachment 1 to Modification Notice

Proposal

Flowback fluid is defined in the approved EMP IMP4-3[1] and the Petroleum (Environment) Regulations[2] as "Fluid that is a mixture of hydraulic fracturing fluid and formation fluid that is allowed to flow from the well following hydraulic fracturing".

Hydraulic fracturing fluid is described in the approved EMP IMP4-3[3] as "primarily consists of water and sand (proppant), plus chemicals commonly found in food and other household domestic products".

This proposal is to re-use flowback from the Carpentaria-2H well for Hydraulic Fracturing of the Carpentaria-3H well on the Carpentaria 2 well pad:

- For up to as many hydraulic fracturing stages as possible, hydraulic fracturing fluid will be a mixture of flowback fluid/bore water, sand proppant, and minor chemical additives.
- For the remaining hydraulic fracturing stages, hydraulic fracturing fluid will be bore water, sand proppant, and minor chemical additives.

Improved overall environmental performance and outcomes through the re-use of flowback during hydraulic fracturing reducing waste, reducing the volume of flowback fluid in the tanks, and maintaining surface and subsurface risks at ALARP.

The proposal is in accordance with the *Code of Practice: Onshore Petroleum Activities in the Northern Territory*, and a risk assessment that has considered and assessed the observed flowback fluid characteristics is at **Appendix 1**.

Objectives met by the proposed modification

- Meet the requirements of the Code
- Risk remains ALARP subsurface during fracture stimulation and risk remains ALARP at the surface when flowback is in the above ground tanks
- Reduce use of groundwater for hydraulic fracturing fluid
- In accordance with the waste hierarchy minimise the total volume of waste (flowback/wastewater)
- Reduce the volume of flowback fluid in above ground tanks
- Hydraulic fracturing fluid composition in accordance with the Code
- Monitor and report to DEPWS

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1 Abbreviation and units table in EMP IMP4-3, page 29,

2 PETROLEUM (ENVIRONMENT) REGULATIONS 2016, page 28, flowback fluid definition

3 Appendix 2 Project Activities Section 2.10 Hydraulic Fracturing, 2.10.1 Overview

The *Code of Practice: Onshore Petroleum Activities in the Northern Territory*

1. Provides a framework for the management of water used in and produced by petroleum activities including re-use and recycling of water and wastewater (C.2), including flowback fluid (C.2.1(a)).
2. Identifies that waste hierarchy must be implemented, re-use of wastewater is preferred over treatment and/or disposal (C.3.1)
3. Stipulates a preference for the reuse of flowback fluid as a means of managing flowback fluid (C.4.2.3)
4. Stipulates requirements for the Wastewater Management Plan to include:
   a. Proposed method and location of water and wastewater re-use as part of the proposed activity (see C.7.1(c)iii)
   b. Strategies to minimise of reduce the volume of wastewater that will be disposed of off site (see C.7.1(c)iv)
   c. The expected quality and quantity of water and wastewater that will be re-used (see C.7.1(c)iv)
   d. An analysis of environmental impacts and environmental risks associated for any proposed re-use (C.7.1.1(b)i)
   e. Proposed environmental performance standards and measurement criteria which demonstrate these environmental risks have been reduced to ALARP and acceptable (C.7.1.1(b)ii)
5. Stipulates requirements regarding hydraulic fracturing fluids and BTEX concentrations that are met by the proposed re-use (B.4.13.2, B.5)

The *Water Act 1992*

The Water Act prohibits allowing hydraulic fracturing waste (whether treated or untreated) to come into contact with waters. This includes all types of waters (including water in a waterway, groundwater and tidal water). However, The Water Act does not prohibit flowback fluid and produced water following hydraulic fracturing from being reused as the basis for fluids in future hydraulic fracturing events.

To provide certainty regard monitoring and reporting

In accordance with the approved EMP IMP4-3:

- Per section 7.5.4 Monitoring and Tracking, of the sampling of the hydraulic fracture stimulation fluid will be undertaken:
  - An initial sample post blender and before injection will be taken of the hydraulic fracture stimulation fluid.
  - A subsequent sample when the hydraulic fracture stimulation fluid returns, known as flowback fluid, is to be sampled at the treatment tank.
- Per section 7.5.4 Monitoring and Tracking, sampling frequency of flowback will occur at least weekly for Analytes, listed in Section C.8 of The Code until the weekly fluid is stable, then every six months.
- Per section 7.3.1 of the WWMP Wastewater tracking documentation will be reported to the Minister at least annually including;
  - Volumes of produced water and flowback fluid from each well
  - Volumes of wastewater transferred into each tank, where applicable

- Estimates for evaporation rates from each tank, updated weekly
- Volumes of wastewater reused in petroleum operations, including drilling and hydraulic fracturing
- Volumes of water and wastewater removed from the site and its destination (whether by vehicle or flowline), including details of the licence number of any licensed waste transporters
- Wastewater tracking will be documented in an auditable chain of custody (COC) system.
- Wastewater tracking will be following other legislative requirements such as those imposed under the Waste Management and Pollution Control Act 1998 (NT) and the Radiation Protection Act 2004 (NT).

In accordance with Condition 20 of the Approval Notice, for EMP IMP4-3, a report will be provided on the risk assessment of flowback wastewater from the hydraulic fracturing phase. The report will quantify the estimated reduction in flowback fluid volume at the completion of well flowback operations

MEMO

To: Nick Fraser, InGauge

From: Chrissy Peterson, EHS Support

CC: Charles Deck, Empire
Tent Smith, inGauge
Daniel Kalinin, inGauge
Joe Hayes, EHS Support

Date: 24 November 2022

Re: Northern Territories – Regulation 22 Flowback Water Risk Assessment

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1 Introduction

Imperial Oil and Gas Pty Ltd ("Imperial") is conducting an exploration and appraisal program within Exploration Permit (EP)-187, located in the Beetaloo Sub-basin of the broader McArthur Basin. As requested, EHS Support LLC ("EHS Support") performed a risk assessment on flowback water from the Carpentaria-2H well location for use as make-up water in the hydraulic fracturing process. This risk assessment leveraged the following existing risk assessments:

- Hydraulic Stimulation Chemical Risk Assessment Update Imperial Oil & Gas Exploration Permit 187. EHS Support, May 2021. (EHS Support, 2021)
- Hydraulic Stimulation Chemical Risk Assessment Imperial Oil & Gas and Imperial Oil and Gas A Northern Territory Tenement. EHS Support, August 2022. ("2022 CRA", EHS Support, 2022)

The McArthur Basin is located southeast of Katherine, Northern Territory (NT), and covers approximately 180,000 square kilometres. Imperial has undertaken exploration activities within EP-187 since 2013, including drilling of two exploration wells (Carpentaria-1H and Carpentaria-2H). Imperial prepared an Environment Management Plan (EMP), titled Environmental Management Plan Imperial Oil & Gas 2021-2025 EP187 Work Program NT Exploration Permit (EP) 187 (IMP4-3) (inGauge, 2021). The EMP proposed Hydraulic Fracture Stimulation (HFS) to be conducted in 2021 through 2025 at the varied well locations. The EMP IMP4-3 for Imperial does not include use of flowback water for make-up water in the hydraulic fracturing process. Therefore, this assessment is being conducted to satisfy Regulation 22 of the Petroleum (Environment) Regulations 2016 (Northern Territory of Australia, 2021), to modify regulated activities for the EMP IMP4-3.

The Petroleum (Environment) Regulations define produced water as "*produced water means naturally occurring water that is extracted from the geological formation following hydraulic fracturing*"[1] whereas flowback fluid is defined as "*flowback fluid means fluid that is a mixture of hydraulic fracturing fluid and formation fluid that is allowed to flow from the well following hydraulic fracturing*"[2]. For the purposes of this assessment the fluid has been classified as flowback fluid. Imperial have confirmed that flowback fluid is limited to the material received out of the well post

[1] Petroleum (Environment) Regulations 2016, produced water definition on page 29
[2] Petroleum (Environment) Regulations 2016, flowback water definition on page 28

hydraulic fracturing to the fluid volume limit of 100% the stimulation fluid amount. Once 100% of the injected volume of material has been retrieved from the well the remainder would be classified as produced water. This assessment is for flowback fluid only.

A Chemical Risk Assessment (CRA) on vendor chemicals that might be used in hydraulic fracturing was completed for potential hydraulic stimulation fluid systems that were identified for use in EP-187, EP-167, and EP-168 (EHS Support, 2022). The 2022 CRA evaluated the chemistry of the hydraulic fracturing fluid systems, estimated the probable concentration of these chemicals in flowback, presented ecotoxicity and developed Predicted No-Effects Concentrations (PNECs) where data were available, as well as bioaccumulation and persistence information. Included in the 2022 CRA, chemicals that did not pass the Tier 1 screening evaluation were evaluated quantitatively for receptors identified in the conceptual exposure model (CEM; e.g., avian receptors). Quantitative Tier 2 evaluation of these chemicals did not identify unacceptable levels of risk. This risk assessment concluded there is no unacceptable risk to receptors due to use of vendor chemicals in the hydraulic fracturing fluid systems.

Therefore, no unacceptable risk to receptors was identified based on current or future flowback scenarios. At the time of this assessment, flowback water is situated at Carpentaria-2 well pad, having been generated from the Carpentaria-2H well. The following sections include an assessment of potential risks associated with use of flowback water using the baseline from Carpentaria-2H flowback as make-up water in the hydraulic fracturing process of wells located under the same EMP IMP4-3.

2 Assessment Methodology

The evaluation of flowback water criteria identifies which levels of chemicals are appropriate for flowback water future re-use in all hydraulic fracturing operations under the EMP IMP4-3. The flowback water samples are reviewed against the chemicals observed, as well as the same vendor chemicals injected down hole. Risk ratios were calculated and compared for injected vendor chemicals and chemicals detected in flowback water to determine the relative increase in risk based on the use of flowback or produced water as make-up water in the hydraulic fracturing process. Risk ratios, or hazard quotients (HQs), were calculated using the following methodology:

$$HQ = \frac{CI}{RBSL}$$

Where:
HQ = hazard quotient
CI = concentration injected
RBSL = risk-based screening level

In addition to the calculation of individual HQs, a cumulative hazard index (HI) was also calculated to evaluate potential additive effects of individual chemicals to target end points. To do this, individual HQs were summed for each fluid evaluated.

The post-job disclosure form provides the specific chemicals and volumes used in the hydraulic stimulation of Carpentaria-2H well (**Attachment A**). Additionally, three hydraulic fracturing fluid systems were assessed in the 2022 CRA and consisted of different compositions of chemicals. For the purposes of this evaluation, a composite system was assessed using the Carpentaria-2H disclosure form and the three systems evaluated in the 2022 CRA. For the composite system, if chemicals were present in multiple fluid systems, the maximum concentration between the fluid systems and Carpentaria-2H disclosure was conservatively used in calculation of the HQ. Risk-based screening levels (RBSLs) presented in the 2022 CRA included PNECs for aquatic receptors. Derived using conservative ecotoxicity data, these PNECs were the RBSLs used to calculate the HQs for the chemicals in the composite fluid system injected as part of hydraulic fracturing activities. In toxicological testing, aquatic species are more sensitive than terrestrial species to chemicals due to their immersion within the fluid, additional modes of action (e.g., impacts on gill function), and the potential for secondary stressors to impact on health. Therefore, assessment of aquatic receptors is a conservative evaluation of potential risks.

The maximum concentration of detected chemicals in samples collected from Carpentaria-2H well flowback stored in the Hydrera frac pond (i.e., wastewater) from 11 September 2022 to 9 October 2022 (**Attachment B**) was conservatively selected to be the concentration injected (CI) to calculate HQs for flowback water. The minimum of aquatic trigger values set forth by the Australian and New Zealand Guidelines (ANZG) for Fresh and Marine Water Quality (ANZG, 2018), Freshwater Trigger Values (FTVs), were used as the RBSLs to calculate HQs for flowback water chemicals. The FTVs are deemed to be protective of aquatic species, such as fish, invertebrates, and algae, assuming chronic, continual, and prolonged contact with surface water. In instances where no FTVs were available, alternative RBSLs protective of freshwater environments were employed.

It should be noted, the alternative RBSLs for gross alpha and gross beta are only generic screening values (0.5 Becquerels per litre [Bq/L]). Consistent with the Australian Drinking Water Guidelines (ADWG; NHMRC, 2022), if these RBSLs are exceeded, a more detailed assessment is triggered. As outlined in the assessment framework under ADWG for radiological exposures, an order-of-magnitude higher radiological exposure is acceptable as the natural background is higher than the screening level, and thresholds for active intervention have been established at corresponding doses 10 to 50 times higher than the corresponding screening value. Concentrations of gross alpha and gross beta observed in the Carpentaria-2H are within the range of flowback anticipated from the formation (Kleinfelder, 2021) and further reduction of concentrations are anticipated if blending with bore water occurs.

Precipitation of naturally occurring radioactive materials (NORMs) typically occurs in the flowback tank and accompany non-NORM solids that were produced with the flowback, rather than remaining dissolved in flowback water (Australian Radiation Protection and Nuclear Safety Agency [ARPANSA], 2008). Solids within the frac tank will be managed in accordance with the EMP IMP4-3.

In addition to the risk evaluation, assessment of benzene, toluene, ethylbenzene, and xylene (BTEX) in flowback water was conducted pursuant to Section B.5 of the Code of Practice (Department of Environment and Natural Resources [DENR] and Department of Primary Industry and Resources [DPIR], 2019). Section B.5 states that recycled produced water used in hydraulic fracturing fluids must not contain BTEX levels greater than those expected in produce water from the well being drilled, or in the event BTEX levels expected in produced water are unknown, then BTEX levels in water cannot exceed levels prescribed in Table 8 of Section B.5.

3 Results

Attachment C presents the results of the calculation of the HQs and cumulative HI for the composite hydraulic fracturing fluid system, including the chemicals and their Chemical Abstract Service (CAS) numbers, the maximum injected concentrations, the RBSL, the calculated HI, and the cumulative HI. Similarly, **Attachment D** presents the inputs and results of the risk ratio calculation for individual chemicals and cumulative HI for the flowback water in the frac tank.

Table 1 includes cumulative HIs for both assessed fluids. As shown below, the cumulative HI for the Composite System is more than one-order-of-magnitude greater than the HI calculated for the 2022 flowback water chemicals. Combination of the composite fluid system and the flowback chemicals would result in a less than 1 percent increase in the cumulative HI. In addition, Imperial can blend the Carpentaria-2H flowback water with bore water at a rate of 1:2 or 1:4. Should blending occur, this would further reduce HI associated with flowback by 50 to 75 percent.

Table 1 Cumulative Hazard Indices

Fluid	HI
2022 Composite System	1.7E+06
2022 Injected Flowback Chemicals	1.5E+03
Combined Risk (Composite System and Flowback as makeup water)	1.7E+06

HI = hazard index

Imperial is not making any changes to the operational procedures and controls used in hydraulic fracturing, consistent with the methodologies employed at the Carpentaria-2H well location. These controls include well construction and associated zonal isolation, and extensive management and monitoring systems of the hydraulic fracturing activities to preclude impacts to the overlying aquifer systems and human and ecological receptors. In this context, this incremental increase in the HI in the injected fluid will not result in overall increased risk.

In terms of the anticipated changes in flowback chemistry from use of produced water as make-up water, the minor increase in the HI will not result in material changes in risk. The risk assessments previously conducted on the injected vendor chemicals (EHS Support, 2022) determined that the risk to avian receptors from storage of produced water was *de minimus* (HIs ranging from 8.2×10^{-4} to 1.1×10^{-3} versus a target of 1). In the context of the estimated increase in the HI of the injected fluid presented in **Table 1**, the risk to avian receptors from storage of flowback water will continue to be *de minimus* (i.e., below a HI of 1).

As shown in **Attachment B**, BTEX were not detected in any sample collected from the frac tank containing Carpentaria-2H flowback water, except benzene at 2 micrograms per litre (µg/L). **Table 2** presents a comparison of the maximum detection limit and limits of reporting from the Carpentaria-2 flowback data to the BTEX levels in water used for stimulation and drilling fluids from Table 8 in Section 8.5 of the Code of Practice (DENR and DPIR, 2019). Additionally, detection limits for BTEX did not exceed the Code of Practice thresholds. Therefore, conditions set forth in Section B.5 of the Code of Practice regarding BTEX are satisfied.

Table 2 BTEX Evaluation

Chemical	ANZG (99% Protection Level) (µg/L)	Maximum Detection (µg/L)
Benzene	600	2
Toluene	180	< 2
Ethylbenzene	80	< 2
Xylene	200	< 2

% = percent
µg/L = micrograms per litre
< = less than limit of detection
ANZG = Australian and New Zealand Guidelines

4 Conclusion

The use of flowback water from Carpentaria-2H well location as make-up water in the hydraulic fracturing process on wells located under the same EMP IMP4-3 will not significantly increase risks to ecological (aquatic and avian) receptors, and the current storage and management methods for flowback are considered adequate to minimise risk to as low as reasonably practicable.

5 References

ANZG. 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines.

ARPANSA. 2008. Management of Naturally Occurring Radioactive Material (NORM). Safety Guide. Radiation Protection Series No. 15. August.

DENR and DPIR. 2019. Code of Practice: Onshore Petroleum Activities in the Northern Territory. Northern Territories Government. https://depws.nt.gov.au/__data/assets/pdf_file/0011/705890/code-of-practice-onshore-petroleum-activity-nt.pdf

EHS Support. 2021. Hydraulic Stimulation Chemical Risk Assessment Update Imperial Oil & Gas Exploration Permit 187. May.

EHS Support. 2022. Hydraulic Stimulation Chemical Risk Assessment. Imperial Oil & Gas and Imperial Oil and Gas A Northern Territory Tenement. February.

inGauge Energy Australia (inGauge). 2021. Environment Management Plan Imperial Oil and Gas 2021-2025 EP187 Work Program NT Exploration Permit (EP) 187.

Kleinfelder. 2021. EP187 Flowback Fluid 6 Month Report. Imperial Oil and Gas – Carpentaria-1 Well. 28 October.

National Health and Medical Research Council (NHMRC). 2022. Australian Drinking Water Guidelines 6 2011. Version 3.8. Updated September 2022.

Northern Territory of Australia. 2021. Petroleum (Environment) Regulations 2016. As in force at 1 January 2021.

Attachment A Carpentaria-2 Post Job Disclosure

Schlumberger

Client:	Imperial Oil and Gas
Well:	Carpenteria 2
Basin/Field:	Beetaloo
State:	
County/Parish:	
Case:	
Disclosure Type:	Post-Job
Well Completed:	
Date Prepared:	8/4/2022
Report ID:	RPT-1492

Fluid Description(s)		
YF125FlexD:YF120FlexD: WF120:HCL 15:SW:HVFR	3,256,872 gal	Contains: Water, Propping Agent, Natural Corrosion Inhibitor B499, Surfactant , Acid, Breaker J475, Breaker, Gel J580, Crosslinker J604, Dry High Viscosity Friction Reducer J711, Scale Inhibitor, Clay Control Agent, Myacide GA 25, 100 Mesh Sand, Activator

† Proprietary Technology

The total volume listed in the tables above represents the summation of water and additives. Water is supplied by client.

CAS Number	Chemical Name	Mass Fraction	Mass	Volume	Volume Fraction
-	Water (Including Mix Water Supplied by Client)*	80.80975 %	27,107,568.8	3,241,012.9	91.38151 %
14808-60-7	Quartz, Crystalline silica	18.72265 %	6,280,500.0	289,450.0	8.16115 %
67-48-1	2-hydroxy-N,N,N-trimethylethanaminium chloride	0.14845 %	49,798.9	5,424.8	0.15295 %
7647-01-0	Hydrochloric acid	0.10726 %	35,978.9	3,193.5	0.09004 %
9000-30-0	Guar gum	0.08075 %	27,089.1	3,246.0	0.09152 %
1319-33-1	Ulexite	0.03196 %	10,721.9	944.7	0.02664 %
107-21-1	Ethylene Glycol	0.02380 %	7,982.8	726.9	0.02050 %
25085-02-3	Acrylamide sodium acrylate copolymer	0.02206 %	7,400.7	1,108.5	0.03125 %
1310-73-2	Sodium hydroxide (impurity)	0.00961 %	3,223.1	294.9	0.00831 %
7727-54-0	Diammonium peroxodisulphate	0.01418 %	4,756.60	233.1	0.00657 %
111-30-8	Glutaraldehyde	0.00711 %	2,384.0	269.5	0.00760 %
31726-34-8	Poly(oxy-1,2-ethanediyl), alphahexyl-omega-hydroxy-	0.00545 %	1,828.6	219.1	0.00618 %
129898-01-7	2-Propenoic acid, polymer with sodium phosphinate	0.00495 %	1,658.8	168.2	0.00474 %
9000-70-8	Gelatins	0.00382 %	1,283.0	153.7	0.00433 %
1303-96-4	Sodium Tetraborate Decahydrate	0.00353 %	1,185.1	104.4	0.00294 %
25038-72-6	Vinylidene chloride/methylacrylate copolymer	0.00165 %	554.3	33.2	0.00094 %
7647-14-5	Sodium chloride	0.00099 %	331.8	33.6	0.00095 %
110-17-8	but-2-enedioic acid	0.00084 %	282.2	24.9	0.00070 %
10043-52-4	Calcium chloride	0.00051 %	170.4	17.3	0.00049 %
61789-77-3	Dicoco dimethyl quaternary ammonium chloride	0.00023 %	76.2	9.1	0.00026 %
7631-86-9	Non-crystalline silica (impurity)	0.00020 %	67.9	8.1	0.00023 %
111-46-6	2,2''-oxydiethanol (impurity)	0.00005 %	17.9	1.8	0.00005 %
14807-96-6	Magnesium silicate hydrate (talc)	0.00005 %	16.9	1.0	0.00003 %
67-63-0	Propan-2-ol	0.00005 %	15.2	1.8	0.00005 %
595585-15-2	Diutan	0.00004 %	14.1	1.2	0.00003 %
7447-40-7	Potassium chloride (impurity)	0.00003 %	9.0	0.9	0.00003 %
9002-84-0	poly(tetrafluoroethylene)	0.00002 %	7.2	0.4	0.00001 %
		100 %	33,544,923 lbm	3,546,683 gal	100 %

** Mix water is supplied by the client. Schlumberger has performed no analysis of the water and cannot provide a breakdown of components that may have been added to the water by third-parties.*

** The evaluation of attached document is performed based on the composition of the identified products to the extent that such compositional information was known to GRC - Chemicals as of the date of the document was produced. Any new updates will not be reflected in this document.*

Attachment B Carpentaria-2H Analytical

Attachment B
Carpentaria-2H Frac Pond Water Analytical Results
McArthur Basin
Imperial

Parameter - Chemical		Location	Hydrera_carp_2	Carp 2 Flowback
		Sample Date	9/11/2022 6:00	10/19/2022 12:00
		Lab Sample ID	ES2232272002	ES2238034001
	Unit	Fraction	Result	Result
Fluoride	mg/L	T	1	1.2
Dissolved Oxygen	mg/L	T	1.8	2.7
Mercury	mg/L	T	< 0.0001	< 0.0001
Dissolved Organic Carbon	mg/L	T	416	382
pH Value	pH Unit	T	5.79	6.74
Electrical Conductivity @ 25°C	µS/cm	T	62000	72600
Total Organic Carbon	mg/L	T	454	414
Formaldehyde	mg/L	T	10.5	8.6
Arsenious Acid (As (III))	µg/L	F	11.2	< 0.1
Arsenic Acid (As (V))	µg/L	F	< 4	8.8
Total Cyanide	mg/L	T	< 0.02	< 0.001
3-Methylcholanthrene	µg/L	T	< 0.2	< 0.1
7.12-Dimethylbenz(a)anthracene	µg/L	T	< 0.2	< 0.1
m-Cresol	µg/L	T	0.2	0.3
p-Cresol	µg/L	T	4.9	146
Hexachlorophene	µg/L	T	< 0.2	< 0.1
4-Nitrophenol	µg/L	T	< 0.2	< 0.1
Suspended Solids (SS)	mg/L	T	79	36
Total Dissolved Solids @180°C	mg/L	T	42400	56100
Mercury	mg/L	F	< 0.0001	< 0.0001
Aluminium	mg/L	F	< 0.1	< 0.01
Chromium	mg/L	F	0.011	< 0.001
Cobalt	mg/L	F	< 0.01	< 0.001
Copper	mg/L	F	< 0.01	< 0.001
Antimony	mg/L	F	< 0.01	0.011
Lead	mg/L	F	< 0.01	< 0.001
Lithium	mg/L	F	7.7	11
Manganese	mg/L	F	5.92	7.73
Molybdenum	mg/L	F	< 0.01	0.028
Arsenic	mg/L	F	< 0.01	0.015
Nickel	mg/L	F	0.014	0.018
Selenium	mg/L	F	< 0.1	< 0.01
Beryllium	mg/L	F	< 0.01	< 0.001
Tin	mg/L	F	< 0.01	< 0.001
Vanadium	mg/L	F	< 0.1	< 0.01
Zinc	mg/L	F	0.146	0.145
Barium	mg/L	F	240	338
Boron	mg/L	F	23	23
Iron	mg/L	F	33.9	42.2
Cadmium	mg/L	F	< 0.001	< 0.0001
Silver	mg/L	F	< 0.01	< 0.001
Strontium	mg/L	F	217	292
Thorium	mg/L	F	< 0.01	< 0.001
Uranium	mg/L	F	< 0.01	< 0.001
Bromide	mg/L	T	299	353
Aluminium	mg/L	T	0.24	< 0.01

Attachment B
Carpentaria-2H Frac Pond Water Analytical Results
McArthur Basin
Imperial

Parameter - Chemical		Location Sample Date Lab Sample ID	Hydrera_carp_2 9/11/2022 6:00 ES2232272002	Carp 2 Flowback 10/19/2022 12:00 ES2238034001
	Unit	Fraction	Result	Result
Chromium	mg/L	T	0.016	0.014
Cobalt	mg/L	T	< 0.01	< 0.001
Copper	mg/L	T	< 0.01	< 0.001
Antimony	mg/L	T	0.014	0.016
Lead	mg/L	T	< 0.01	< 0.001
Lithium	mg/L	T	8.57	10.7
Manganese	mg/L	T	6.32	8.01
Molybdenum	mg/L	T	0.025	0.026
Arsenic	mg/L	T	0.021	0.012
Nickel	mg/L	T	0.033	0.024
Selenium	mg/L	T	< 0.1	< 0.01
Beryllium	mg/L	T	< 0.01	< 0.001
Tin	mg/L	T	< 0.01	< 0.001
Vanadium	mg/L	T	< 0.1	< 0.01
Zinc	mg/L	T	0.206	0.156
Barium	mg/L	T	258	345
Boron	mg/L	T	25.8	22.8
Iron	mg/L	T	37.5	45.4
Cadmium	mg/L	T	< 0.001	< 0.0001
Silver	mg/L	T	< 0.01	< 0.001
Strontium	mg/L	T	232	285
Thorium	mg/L	T	< 0.01	< 0.001
Uranium	mg/L	T	< 0.01	< 0.001
C10 - C14 Fraction	µg/L	T	420	900
>C10 - C16 Fraction	µg/L	T	420	1040
C15 - C28 Fraction	µg/L	T	400	570
>C16 - C34 Fraction	µg/L	T	210	480
C29 - C36 Fraction	µg/L	T	< 50	130
>C34 - C40 Fraction	µg/L	T	< 100	< 10
>C10 - C40 Fraction (sum)	µg/L	T	630	1520
>C10 - C16 Fraction minus Naphthalene (F2)	µg/L	T	420	1040
C10 - C36 Fraction (sum)	µg/L	T	820	1600
Benzene	µg/L	T	2	< 1
C6 - C10 Fraction	µg/L	T	300	< 10
C6 - C9 Fraction	µg/L	T	300	< 10
C6 - C10 Fraction minus BTEX (F1)	µg/L	T	300	< 10
Toluene	µg/L	T	< 2	< 1
Ethylbenzene	µg/L	T	< 2	< 1
meta- & para-Xylene	µg/L	T	< 2	< 1
ortho-Xylene	µg/L	T	< 2	< 1
Total Xylenes	µg/L	T	< 2	< 1
Sum of BTEX	µg/L	T	2	< 1
Naphthalene	µg/L	T	< 5	< 1
Naphthalene (Ex SVOC)	µg/L	T	< 1	< 0.1
Phenol	µg/L	T	7.9	36.6
2-Chlorophenol	µg/L	T	< 1	< 0.1

Attachment B
Carpentaria-2H Frac Pond Water Analytical Results
McArthur Basin
Imperial

Parameter - Chemical		Location Sample Date Lab Sample ID	Hydrera_carp_2 9/11/2022 6:00 ES2232272002	Carp 2 Flowback 10/19/2022 12:00 ES2238034001
	Unit	Fraction	Result	Result
2-Methylphenol	µg/L	T	2.7	< 0.1
3- & 4-Methylphenol	µg/L	T	3.9	101
Acenaphthylene	µg/L	T	< 1	< 0.1
2-Nitrophenol	µg/L	T	< 1	< 0.1
Acenaphthene	µg/L	T	< 1	< 0.1
2.4-Dimethylphenol	µg/L	T	< 1	< 0.1
Fluorene	µg/L	T	< 1	< 0.1
2.4-Dichlorophenol	µg/L	T	< 1	< 0.1
Phenanthrene	µg/L	T	< 1	< 0.1
2.6-Dichlorophenol	µg/L	T	< 1	< 0.1
Anthracene	µg/L	T	< 1	< 0.1
4-Chloro-3-methylphenol	µg/L	T	< 1	< 0.1
Fluoranthene	µg/L	T	< 1	< 0.1
2.4.6-Trichlorophenol	µg/L	T	< 1	< 0.1
Pyrene	µg/L	T	< 1	< 0.1
2.4.5-Trichlorophenol	µg/L	T	< 1	< 0.1
Benz(a)anthracene	µg/L	T	< 1	< 0.1
Chrysene	µg/L	T	< 1	< 0.1
Pentachlorophenol	µg/L	T	< 2	< 0.1
Benzo(b+j)fluoranthene	µg/L	T	< 1	< 0.1
Benzo(k)fluoranthene	µg/L	T	< 1	< 0.1
Benzo(a)pyrene	µg/L	T	< 0.5	< 0.1
Indeno(1.2.3.cd)pyrene	µg/L	T	< 1	< 0.1
Dibenz(a.h)anthracene	µg/L	T	< 1	< 0.1
Benzo(g.h.i)perylene	µg/L	T	< 1	< 0.1
Sum of polycyclic aromatic hydrocarbons	µg/L	T	< 0.5	< 0.1
Benzo(a)pyrene TEQ (zero)	µg/L	T	< 0.5	< 0.1
Total Residual Chlorine	mg/L	T	< 0.2	< 0.01
Free Chlorine	mg/L	T	< 0.2	< 0.01
Total Nitrogen as N	mg/L	T	66.5	82.8
Nitrite as N	mg/L	T	< 0.01	< 0.01
Ammonia as N	mg/L	T	38.2	65.2
Nitrate as N	mg/L	T	< 0.01	< 0.01
Reactive Phosphorus as P	mg/L	T	0.35	0.89
Total Phosphorus as P	mg/L	T	0.66	< 0.01
Nitrite + Nitrate as N	mg/L	T	< 0.01	< 0.01
Total Kjeldahl Nitrogen as N	mg/L	T	66.5	82.8
2,4-Dinitrophenol	µg/L	T	< 0.01	< 0.01
2-Methyl-4.6-dinitrophenol	µg/L	T	< 0.05	< 0.01
Dinoseb	µg/L	T	< 0.1	< 0.01
Calcium	mg/L	F	3590	4170
Magnesium	mg/L	F	725	938
Sodium	mg/L	F	9950	12900
Potassium	mg/L	F	87	108
Sodium Adsorption Ratio	-	F	39.6	47
Chloride	mg/L	T	22200	29100

Attachment B
Carpentaria-2H Frac Pond Water Analytical Results
McArthur Basin
Imperial

Parameter - Chemical	Unit	Fraction	Hydrera_carp_2	Carp 2 Flowback
		Location	Hydrera_carp_2	Carp 2 Flowback
		Sample Date	9/11/2022 6:00	10/19/2022 12:00
		Lab Sample ID	ES2232272002	ES2238034001
	Unit	Fraction	Result	Result
Total Anions	meq/L	T	631	827
Total Cations	meq/L	T	674	849
Ionic Balance	%	T	3.29	1.31
Hydroxide Alkalinity as CaCO3	mg/L	T	< 1	< 1
Carbonate Alkalinity as CaCO3	mg/L	T	< 1	< 1
Bicarbonate Alkalinity as CaCO3	mg/L	T	236	319
Total Alkalinity as CaCO3	mg/L	T	236	319
Sulfate as SO4 - Turbidimetric	mg/L	F	< 1	< 1
Gross beta (bq/l)	Bq/L	T	NA	26.6
Gross alpha (bq/l)	Bq/L	T	NA	49.3

Notes:
% = percent
- = not applicable
< = less than limit of reporting
µg/L = micrograms per litre
µS/cm = microSiemens per centimetre
Bq/L = Becquerels per litre
F = filtered
meq/L = milliequivalents per litre
mg/L = milligrams per litre
T = total

Attachment C Composite Fluid Hazard Quotients

Attachment C
Composite Fluid Hazard Quotients
McArthur Basin
Imperial Oil Gas

Chemical Name	CAS Number	Composite System Concentration in Injected Fluid (mg/L)	PNEC/Water Guideline (mg/L)	Cumulative HI 1.7E+06 Composite System HQ (Injected Concentration/PNEC)
1,4-Dioxane-2,5-dione, 3,6-dimethyl-, (3R,6R)-, polymer with rel-(3R,6S)-3,6-dimethyl-1,4-dioxane-2,5-dione and (3S,6S)-3,6-dimethyl-1,4-dioxane-2,5-dione	9051-89-2	2.18	-	-
2,2"-oxydiethanol - impurity (Diethylene glycol)	111-46-6	0.53	27	2.0E-02
2-Ethyl hexanol	104-76-7	0.0696	0.012	5.8E+00
2-Propenamid (impurity)	79-06-1	0.0174	0.05	3.5E-01
2-Propenoic acid, polymer with sodium phosphinate (1:1), sodium salt	129898-01-7	49.5	0.13	3.8E+02
Acetaldehyde	75-07-0	0.0703	0.30	2.3E-01
Acetic acid	64-19-7	66.0	3.0	2.2E+01
Acrylamide acrylate copolymer	9003-06-9	22.0	0.1	2.2E+02
Acrylamide, 2-acrylamido-2-methylpropanesulfonic acid, sodium salt polymer	38193-60-1	1	10	1.0E-01
Acrylamide, sodium acrylate copolymer	25085-02-3	221	-	-
Acrylamide, sodium acrylate polymer	25987-30-8	143	-	-
Acrylamide/ammonium acrylate copolymer	26100-47-0	5.78	-	-
Acrylonitrile	107-13-1	0.10	0.017	5.9E+00
Alcohols, C10-16, ethoxylated propoxylated	69227-22-1	71	0.14	5.1E+02
Alcohols, C12-14-secondary, ethoxylated	84133-50-6	0.062	0.140	4.4E-01
Alcohols, C12-15, ethoxylated	68131-39-5	1.0	0.14	7.1E+00
Alcohols, C12-16, ethoxylated	68551-12-2	1.0	0.14	7.1E+00
Alcohols, C6-12, ethoxylated propoxylated	68937-66-6	199	0.14	1.4E+03
Aldol	107-89-1	1.29	0.13	9.9E+00
Amides, tall-oil fatty, N,N-bis(hydroxyethyl)	68155-28-4	1.0	0.007	1.4E+02
Amine oxides, cocoalkyldimethyl	61788-90-7	3.0	0.009	3.3E+02
Ammonium Chloride	12125-02-9	0.26	0.25	1.1E+00
Ammonium sulfate	7783-20-2	1	0.312	3.2E+00

Attachment C
Composite Fluid Hazard Quotients
McArthur Basin
Imperial Oil Gas

Chemical Name	CAS Number	Composite System Concentration in Injected Fluid (mg/L)	PNEC/Water Guideline (mg/L)	Cumulative HI 1.7E+06 Composite System HQ (Injected Concentration/PNEC)
Benzaldehyde	100-52-7	2.0	0.002	1.0E+03
Bismuth Oxide	1304-76-3	0.09	2.20	4.1E-02
but-2-enedioic acid (Fumaric Acid)	110-17-8	8.41	1.0	8.4E+00
Butyl alcohol	71-36-3	1.0	0.08	1.3E+01
Calcium Chloride	10043-52-4	5.08	11	4.6E-01
Ceramic Materials and wares, chemicals	66402-68-4	1199.35	-	-
Chlorous acid, sodium salt	7758-19-2	0.12	0.001	1.2E+02
Choline Chloride (2-hydroxy-N,N,N-trimethylethanaminium chloride)	67-48-1	1485	0.3	5.0E+03
Cinnamaldehyde	104-55-2	14	0.04	3.5E+02
Citric acid	77-92-9	4.0	0.44	9.1E+00
Cocobetaine	61789-40-0	2.62	0.0032	8.2E+02
Copper(II) sulfate	7758-98-7	0.001	0.0014	7.1E-01
Crontonaldehyde	123-73-9	0.12	0.0005	2.4E+02
Crystalline silica, quartz	14808-60-7	187227	-	-
Decamethyl cyclopentasiloxane	541-02-6	0.001	0.0012	8.3E-01
Diammonium peroxidisulphate	7727-54-0	142	0.076	1.9E+03
Dicoco dimethyl quaternary ammonium chloride	61789-77-3	2.27	0.00068	3.3E+03
Diethanolamine	111-42-2	65	0.02	3.3E+03
Diethylene glycol	111-46-6	14	27	5.2E-01
Dimethyl siloxanes and silicones	63148-62-9	0.001	0.063	1.6E-02
Disodium octaborate tetrahydrate	12008-41-2	25	0.37	6.8E+01
Distillates (petroleum), solvent-dewaxed heavy paraffinic	64742-65-0	1.40	1.00	1.4E+00
Diutan	595585-15-2	0.42	1	4.2E-01
Dodecamethylcyclohexasiloxane	540-97-6	0.001	0.0012	8.3E-01
Ethanol	64-17-5	1.0	0.96	1.0E+00
Ethoxylated branched C13 alcohol	78330-21-9	10	0.14	7.1E+01

Attachment C
Composite Fluid Hazard Quotients
McArthur Basin
Imperial Oil Gas

Chemical Name	CAS Number	Composite System Concentration in Injected Fluid (mg/L)	PNEC/Water Guideline (mg/L)	Cumulative HI 1.7E+06 Composite System HQ (Injected Concentration/PNEC)
Ethoxylated oleic acid	9004-96-0	0.44	0.00039	1.1E+03
Ethylene glycol	107-21-1	238	10	2.4E+01
Fatty acids, C8-C16, ethylhexyl ester	135800-37-2	6.31	0.001	6.3E+03
Fatty acids, tall-oil, ethoxylated	61791-00-2	1.0	0.12	8.3E+00
Gelatins	9000-70-8	38.2	-	-
Glutaraldehyde	111-30-8	71.1	0.0025	2.8E+04
Glycerine	56-81-5	0.43	100.00	4.3E-03
Guar gum	9000-30-0	808	0.006	1.3E+05
Hydrochloric acid	7647-01-0	1073	-	-
Hydrotreated light petroleum distillate	64742-47-8	3.15	0.005	6.3E+02
Hydroxylpropyl guar	39421-75-5	1.35	-	-
Iron gluconate	299-29-6	2.50	2.70	9.3E-01
Magnesium Silicate Hydrate (talc)	14807-96-6	0.50	72.0000	6.9E-03
Methanol	67-56-1	4.0	10.0	4.0E-01
Non-crystalline Silica (impurity)	7631-86-9	2.02	-	-
Octamethylcyclotetrasiloxane	556-67-2	0.001	0.0012	8.3E-01
Poly(oxy-1,2-ethanediyl), alphahexyl-omega-hydroxy	31726-34-8	54.5	8.8	6.2E+00
Poly(tetrafluoroethylene)	9002-84-0	0.21	-	-
Polyethylene glycol	25322-68-3	16	10	1.6E+00
Polymer of 2-acrylamido-2-methylpropanesulfonic acid sodium salt and methyl acrylate	136793-29-8	0.10	10.00	1.0E-02
Polypropylene glycol	25322-69-4	0.353	0.200	1.8E+00
Potassium chloride	7447-40-7	0.27	1.000	2.7E-01
Propan-2-ol	67-63-0	0.45	0.3	1.5E+00
Propylene glycol n-propyl ether	1569-01-3	1.0	1.0	1.0E+00

Attachment C
Composite Fluid Hazard Quotients
McArthur Basin
Imperial Oil Gas

Chemical Name	CAS Number	Composite System Concentration in Injected Fluid (mg/L)	PNEC/Water Guideline (mg/L)	Cumulative HI 1.7E+06 Composite System HQ (Injected Concentration/PNEC)
Silica dioxide	112926-00-8	0.003	-	-
Siloxanes and silicones, dimethyl, reaction products with silica	67762-90-7	0.001	0.063	1.6E-02
Sodium bicarbonate	144-55-8	1.93	-	-
Sodium bisulfite	7631-90-5	47	0.8	5.9E+01
Sodium carbonate	497-19-8	0.002	-	-
Sodium Chloride	7647-14-5	10	-	-
Sodium diacetate	126-96-5	13.0	1.7	7.6E+00
Sodium hydroxide	1310-73-2	96.1	-	-
Sodium iodide	7681-82-5	1.0	0.0034	2.9E+02
Sodium perborate tetrahydrate	10486-00-7	1.02	0.37	2.8E+00
Sodium persulfate	7775-27-1	25	1.2	2.1E+01
Sodium polyacrylate	9003-04-7	0.33	1.20	2.7E-01
Sodium sulfate	7757-82-6	0.10	11.00	9.1E-03
Sodium Sulfite	7757-83-7	0.0043	0.7000	6.1E-03
Sodium Tetraborate Decahydrate	1303-96-4	35	0.94	3.8E+01
Sodium thiosulfate	7772-98-7	0.94	1.10	8.5E-01
Sorbitan monooleate polyoxyethylene derivative	9005-65-6	13	0.2	6.5E+01
Sorbitan, mono-9-octadecenoate, (Z)	1338-43-8	13	0.32	4.1E+01
Tetrasodium ethylenediaminetetraacetate	64-02-8	0.0010	2.2	4.5E-04
Tributyl tetradecyl phosphonium chloride	81741-28-8	28	0.000019	1.5E+06
Triethanol amine	102-71-6	0.47	0.32	1.5E+00
Ulexite	1319-33-1	320	-	-
Urea	57-13-6	0.1	0.94	1.1E-01
Vinylidene chloride/methylacrylate copolymer	25038-72-6	16.5	-	-

Notes:

- indicates screening level or hazard quotient not developed

HQ = hazard quotient

HI = hazard index

NA = not applicable

mg/L = milligrams per litre

PNEC = predicted no effects concentration

Attachment D Flowback Fluid Hazard Quotients

Attatchment D
Frac Pond Water Hazard Quotients
McArthur Basin
Imperial

Parameter - Chemical	Maximum Concentration	Units	Freshwater Trigger Value (FTV, µg/L)[1] FTVs by Protection Level (% Species) 99%	95%	90%	80%	Alernative SW Screening Criteria (µg/L)[2]	Reference	Minimum RBSL[3]	Cumulative HI[3] 1.5E+03 HQs[4]
Fluoride	1200	µg/L	NC	NC	NC	NC	120	b	120	1.0E+01
Formaldehyde	10500	µg/L	NC	NC	NC	NC	1610	c	1610	6.5E+00
m-Cresol	0.3	µg/L	NC	NC	NC	NC	200	g	200	1.5E-03
p-Cresol	146	µg/L	NC	NC	NC	NC	100	g	100	1.5E+00
Bromide	353000	µg/L	NC	NC	NC	NC	NC		NC	NA
Aluminium	240	µg/L	27	55	80	150	NC		27	8.9E+00
Chromium	16	µg/L	3.3	3.3	3.3	3.3	NC		3.3	4.8E+00
Antimony	16	µg/L	9	9	9	9	NC		9	1.8E+00
Lithium	10700	µg/L	NC	NC	NC	NC	NC		NC	NA
Manganese	8010	µg/L	1200	1900	2500	3600	NC		1200	6.7E+00
Molybdenum	26	µg/L	34	34	34	34	NC		34	7.6E-01
Arsenic	21	µg/L	0.8	13	42	140	NC		0.8	2.6E+01
Nickel	33	µg/L	8	11	13	17	NC		8	4.1E+00
Zinc	206	µg/L	2.4	8	15	31			2.4	8.6E+01
Barium	345000	µg/L	NC	NC	NC	NC	1000	d	1000	3.5E+02
Boron	25800	µg/L	90	370	680	1300	NC		90	2.9E+02
Iron	45400	µg/L	NC	NC	NC	NC	300	b	300	1.5E+02
Strontium	285000	µg/L	NC	NC	NC	NC	2500	e	2500	1.1E+02
>C10 - C16 Fraction	1040	µg/L	NC	NC	NC	NC	443	f	443	2.3E+00
>C16 - C34 Fraction	480	µg/L	NC	NC	NC	NC	640	f	640	7.5E-01
Benzene	2	µg/L	600	950	1300	2000			600	3.3E-03
C6 - C10 Fraction	300	µg/L	NC	NC	NC	NC	443	f	443	6.8E-01
Sum of BTEX	2	µg/L	NC	NC	NC	NC	NC		NC	NA
Phenol	36.6	µg/L	85	320	600	1200	NC		85	4.3E-01

Attatchment D
Frac Pond Water Hazard Quotients
McArthur Basin
Imperial

Parameter - Chemical	Maximum Concentration	Units	Freshwater Trigger Value (FTV, µg/L)[1] FTVs by Protection Level (% Species) 99%	95%	90%	80%	Alernative SW Screening Criteria (µg/L)[2]	Reference	Minimum RBSL[3]	Cumulative HI[3] 1.5E+03 HQs[4]
2-Methylphenol	2.7	µg/L	NC	NC	NC	NC	NC		NC	NA
3- & 4-Methylphenol	101	µg/L	NC	NC	NC	NC	100	g	100	1.0E+00
Total Nitrogen as N	82800	µg/L	NC	NC	NC	NC	NA		NC	NA
Ammonia as N	65200	µg/L	320	900	1430	2300	NC		320	2.0E+02
Reactive Phosphorus as P	890	µg/L	NC	NC	NC	NC	NC		NC	NA
Total Phosphorus as P	660	µg/L	NC	NC	NC	NC	NC		NC	NA
Total Kjeldahl Nitrogen as N	82800	µg/L	NC	NC	NC	NC	NC		NC	NA
Calcium	4170000	µg/L	NC	NC	NC	NC	NC		NC	NA
Magnesium	938000	µg/L	NC	NC	NC	NC	2000000	a	2000000	4.7E-01
Sodium	12900000	µg/L	NC	NC	NC	NC	NC		NC	NA
Potassium	108000	µg/L	NC	NC	NC	NC	NC		NC	NA
Chloride	29100000	µg/L	NC	NC	NC	NC	120000	b	120000	2.4E+02
Total Anions	827	meq/L	NC	NC	NC	NC	NC		NC	NA
Total Cations	849	meq/L	NC	NC	NC	NC	NC		NC	NA
Ionic Balance	3.29	%	NC	NC	NC	NC	NC		NC	NA
Bicarbonate Alkalinity as CaCO3	319000	µg/L	NC	NC	NC	NC	NC		NC	NA
Total Alkalinity as CaCO3	319000	µg/L	NC	NC	NC	NC	NC		NC	NA

Notes:

% = percent
µg/L = micrograms per litre
µS/cm = microSiemens per centimetre
FTV = Freswater Trigger Value
HI = hazard index

HQ = hazard quotient
meq/L = milliequivalents per litre
NC = No appropriate screening criterion
RBSL = risk-based screening level
PAHs = polycyclic aromatic hydrocarbons

1/ Default Freshwater Trigger Values. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. 2021.
Available online at: https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/water-quality-toxicants

2/ Alternative water screening criteria notes

a - Major ions of concern for livestock drinking water quality -
Available online at: https://www.waterquality.gov.au/sites/default/files/documents/anzecc-armcanz-2000-guidelines-vol1.pdf

b - Canadian Council of Ministers of the Environment. Water Quality Guidelines for the Protection of Aquatic Life.
Available online at: https://ccme.ca/en/summary-table

c - Chronic aquatic life water quality criterion from Hohreiter DW1, Rigg DK.Derivation of ambient water quality criteria for formaldehyde.
Chemosphere. 2001. Chemosphere. Nov;45(4-5):471-86. https://www.ncbi.nlm.nih.gov/pubmed/11680743

d - From Oak Ridge National Laboratory - Risk Assessment Information System) https://rais.ornl.gov/tools/eco_search.php

e - Canadian Environmental Protection Act, 1999 Federal Environmental Quality Guidelines Strontium. Environment and Climate Change Canada July 2020.
https://www.canada.ca/en/environment-climate-change/services/evaluating-existing-substances/federal-environmental-quality-guidelines-strontium.html

f - California Regional Water Quality Control Board. 2019. INTERIM FINAL - Environmental Screening Levels. Table IP-5, California EPA Aquatic Toxicity Levels

g - Guidelines for chemical compounds in water found to cause tainting of fish flesh and other aquatic organisms -
Available online at: https://www.waterquality.gov.au/sites/default/files/documents/anzecc-armcanz-2000-guidelines-vol1.pdf

3/ HI calculated by summing HQ for individual chemicals.

4/ HQ calculated using following equation:

$$HQ = \frac{CI}{RBSL}$$

Where:

HQ = hazard quotient
CI = concentration injected
RBSL = risk-based screening level

EHS Support