Modification Notice - Regulation 22

Interest Holder	**Imperial Oil and Gas Pty Ltd**	**EMP Title**	**2021-2025 EP187 Work Program**	**Unique EMP ID No.**	**IMP4-3**	**Mod No.**	**10**	**Date**	**October 2024**
Brief Description	Imperial proposes to modify the regulated activity in IMP4-3 by including additional hydraulic stimulation chemicals from supplier Haliburton and water tracers from Tracerco. A human health and environmental risk assessment (HHERA) has been undertaken in October 2024 for the additional chemical list. Based on the outcomes of this assessment, no further management controls are considered necessary.								
Geospatial Files Included?	NA								

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. There are no new or increased environmental impacts or risks through the addition of the new chemicals. The chemical list has undergone a human health and environmental risk assessment (HHERA) by a qualified third party (EHS) which identified no further management controls are considered necessary.	N/A	No. HHERA determined that no further management controls are considered necessary.	No. Previous stakeholder engagement has included chemical use.	No. Environmental performance standards within the existing approved EMP are sufficient.	No. Activity covered under existing AAPA certificate.	Yes. IMP 4-3 Appendix 6 Wastewater Management Plan and Appendix 7 Spill Management plan is updated to include the additional proposed chemicals. All other plans remain valid and appropriate.	Yes.

Current EMP Text	Amended EMP Text
IMP 4-3 Executive Summary Section g. Chemical Risk Assessment A chemical risk assessment has been completed for all chemicals to be used in the Hydraulic Fracturing process. This risk assessment provides the details about any chemical or other substance that may be in or added to any treatment fluids to be used in the course of Hydraulic Fracturing. A risk assessment was carried on HF Chemicals; the full risk assessment is provided in Appendix 06.01 (HF Chemical Risk Assessment).	**IMP 4-3 Section g. Chemical Risk Assessment** *Amend EMP text to modify text and include additional Appendix 06.02 in IMP 4-3 WWMP as provided in Section B of this Reg 22.* A chemical risk assessment has been completed for all chemicals to be used in the Hydraulic Fracturing process. This risk assessment provides the details about any chemical or other substance that may be in or added to any treatment fluids to be used in the course of Hydraulic Fracturing. A risk assessment was carried on HF Chemicals; the full risk assessment is provided in Appendix 06.01 (HF Chemical Risk Assessment, date of issue May 2021). An additional human health and environmental risk assessment (HHERA) was undertaken in October 2024 to incorporate a change of chemical suppliers from 2024 onwards. The full HHERA is provided as in an additional Appendix 06.02 (HHERA). Based on the outcomes of this assessment, no further management controls are considered necessary.
IMP 4-3 Appendix 06 WWMP Appendix 1. Full Hydraulic Fracturing Chemical List *Original list of Schlumberger chemicals.*	**IMP 4-3 Appendix 06 WWMP Appendix 1. Full Hydraulic Fracturing Chemical List** *Amend EMP text to include additional chemical list provided in Section A of this Reg 22.*

Current EMP Text	Amended EMP Text
Appendix 07 Spill Management Plan **Table 8. List of potential HF fluids to be used.** *Original EMP text includes list of potential HF fluids.*	**Appendix 07 Spill Management Plan** **Table 8. List of potential HF fluids to be used.** *Modify EMP text to include additional chemical list-*

Material Name	Material/Cas Number	Description
[redacted]	[redacted]	Metal to metal friction reducer
		Corrosion Inhibitor
		Liquid Caustic Soda
		Crosslinker
		Acid
		Iron Control Agent
		Scale Inhibitor
		Surfactant
		Gelling Agent
		Biocide
		Breaker
		High Viscosity Friction Reducer
		Buffer
		Acid
		Sand
		Sand
		Water Tracer
		Water Tracer
		Water Tracer
		Water Tracer
		Water Tracer
		Water Tracer
		Water Tracer
		Water Tracer

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Section A - IMP 4-3 Appendix 06 WWMP Appendix 1. Full Hydraulic Fracturing Chemical List

HALLIBURTON CONFIDENTIAL INFORMATION - ONLY TO BE USED FOR REGULATOR NOTIFICATION (QLD FORMAT)

Comments:
Empire C5H Fluid: DFS-BGL & HVFR PreJob

Total injected fluid volume (kiloliters):	[redacted]

Comprising of: (Kilograms, liters or kiloliters)		
Base Fluid type (e.g. water)	Liters	% of total volume
Makeup Water	[redacted]	

Proppant type (e.g sand)	Proppant Size	Kilograms	Liters	% of total volume
Sand	[redacted]			
Sand				

Any wet chemical constitutes:	Liters	% of total volume
Water in Products	[redacted]	
Hydrochloric acid		
Acrylamide, sodium acrylate polymer		
Alcohols, C6-12, ethoxylated propoxylated		
Hydrotreated light petroleum distillate		
Alcohols, C10-16, ethoxylated propoxylated		
Sodium perborate tetrahydrate		
Sodium polyacrylate		
Acetic acid		
Guar gum		
Tributyl tetradecyl phosphonium chloride		
Diethylenetriaminepentakis (methylene phophonic acid), sodium salt		
Polyethylene glycol		
Ethoxylated branched C13 alcohol		
Sobitan, mono-9-octadecenoate, (Z)		
Sodium diacetate		
Sorbitan monooleate polyoxyethylene derivative		
Citric acid		
Cinnamaldehyde		
Soybean oil		
Diethylene glycol		
Sodium hydroxide		
Methanol		
Amine oxides, cocoalkyldimethyl		
Disodium octaborate tetrahydrate		
2-Propenoic acid, homopolymer		
Benzaldehyde		
Polypropylene glycol		
Alcohols, C12-16, ethoxylated		
Methyloxirane polymer with oxirane, ether with 1,2,3-propanetriol (3:1)		
Methyloxirane polymer with oxirane, ether with 1,2-propanediol (2:1)		
Poly(oxy-1,2-ethanediyl), a-hydro-w-hydroxy-, mono-C10-14-alkyl ethers, phosphates		
2-Propenoic acid, telomer with mercaptoacetic acid		
Acetic acid, 2-mercapto-, sodium salt (1:1)		
Sodium iodide		
Sodium bicarbonate		

Section B - IMP 4-3 Appendix 06 WWMP Appendix 2. HHERA

Commencing on following page.

Human Health and Environmental Risk Assessment for Carpentaria Gas Project

Imperial Oil & Gas and Imperial Oil and Gas A Northern Territory Tenement

Prepared for:

INGAUGE
Well Engineering & Project Management
Reliable | Experienced | Engaged

Prepared by:

EHS Support

October 2024

Document Control

PROJECT DETAILS

Project No.	PTY.05995.0000
Report Revision No.	4
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Project Manager	Joe Hayes
Project Director	Nigel Goulding

REPORT DETAILS

Title	Human Health and Environmental Risk Assessment for Carpentaria Gas Project
Main Author(s)	Ben Petrides, Chrissy Peterson, Chris Smitt, Joe Hayes, Damani Parran
Client	Imperial Oil & Gas, Imperial Oil and Gas A
Client Contact	Trent Smith

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Note:
(e) electronic file
(h) hardcopy

REVISION HISTORY

Date	Revision #	Status / Summary of Key Changes
21/12/2021	A	Draft for client review
27/01/2022	B	Draft for client review
04/02/2022	0	Final
14/04/2023	1	Minor corrections in response to regulator comments. Added revision history and corrected revision numbers.
31/10/2023	2	Updated title of report, incorporate summary information on human health evaluation as Table 2 in text, revision to Appendix B (V-Leach model)
22/01/2024	3	Removal of poly(tetrafluoroethylene) from evaluations.
04/10/2024	4	Updated to include new stimulation formulation.

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Acronyms

AICIS	Australian Industrial Chemicals Introduction Scheme, 2022
bw	body weight
CAS	Chemical Abstracts Service
COPC	constituent of potential concern
CRA	chemical risk assessment
DoEE	Department of the Environment and Energy
EMP	Environment Management Plan
EP	Exploration Permit
HHERA	human health and environmental risk assessment
LC50/EC50	lethal concentration 50 / effect concentration 50
MoE	Margin of Exposure
NEPC	National Environment Protection Council
NEPM	National Environment Protection (Assessment of Site Contamination) Measure
NICNAS	National Industrial Chemicals Notification and Assessment Scheme
NOAEL	no observed adverse effect level
NOEC	no observed effect concentration
NT	Northern Territory
PBT	persistent (P), bioaccumulative (B) and toxic (T)
SDS	safety data sheet

Units of Measure

Area	
ha	hectare
m^2	square metres
Density	
kg/m^3	kilograms per cubic metre
Electrical Conductance	
µS/cm	microsiemen per centimetre
dS/m	decisiemen per metre
mS/cm	millisiemen per centimetre
mV	millivolt
Length	
µm	micrometres
cm	centimetres
km	kilometres
m	metres
mm	millimetres
Mass	
µg	micrograms
g	grams
kg	kilograms
mg	milligrams
t	metric tonnes
Concentration by Mass	
µg/kg	microgram per kilogram
mg/kg	milligram per kilogram
Pressure	
kPa	Kilopascals
Pa	Pascals
Temperature	
°C	degrees Celsius
°F	degrees Fahrenheit
K	Kelvin
Velocity	
m/s	metres per second

Volume	
µL	microlitres
cL	centilitres
cm^3	cubic centimetre
GL	gigalitre
L	litres
m^3	cubic metre
mL	millilitres
ML	megalitre
Concentration by Volume	
µg/L	microgram per litre
mg/L	milligram per litre
ppmv	parts per million by volume
ppbv	parts per billion by volume

1 Introduction

Imperial Oil & Gas and Imperial Oil & Gas A (for the purpose of this report referred to as "Imperial" and "Imperial A" respectively) operate petroleum tenements in the Northern Territory (NT) within a number of basins (see **Figure 1-1**). Imperial and Imperial A are progressing exploration activities across their respective tenements, including undertaking seismic surveys, drilling targeted exploration wells and subsequent hydraulic fracturing of these wells. inGauge Energy Australia ("inGauge"), acting for Imperial and Imperial A, has been supporting their program and has prepared an Environment Management Plan (EMP) for Imperial's 2021 Hydraulic Fracturing Program NT Exploration Permit (EP) 187 (inGauge 2021) and subsequently and EMP for Imperial's 2021-2025 EP187 Drilling Program (inGauge 2021) (which also covers stimulation activities). Imperial and Imperial A are expanding outside of EP187, and inGauge is progressively extending EMPs across Imperial and Imperial A's other tenements in the NT as exploration programs are developed. At this stage, EMPs have also been developed for EP167 and EP168.

Under the Code of Practice: Petroleum Activities in the Northern Territory 2019 (the Code), an EMP is required for oil and gas activities. Hydraulic stimulation (or fracturing) activities were reviewed in the "Independent Scientific Inquiry into Hydraulic Fracturing of Onshore Unconventional Reservoirs in the Northern Territory" report issued on 27 March 2018 (NT, 2018). The Inquiry concluded that the risks associated with unconventional onshore shale gas extraction in the NT could be appropriately managed provided all the recommendations of its report were adopted and implemented. The NT Government accepted all 135 recommendations and announced the lifting of a previous moratorium on exploration on 17 April 2018. Of the 135 recommendations, 35 were required to be implemented prior to the commencement of exploration, with the remaining recommendations required to be implemented prior to the commencement of production. The development of an EMP is a key component of meeting these requirements. The EMP documents the relevant natural environment, proposed activities and methods to manage the environmental impacts and risks associated with proposed activities, including how to address regulatory obligations and relevant report recommendations that have underpinned the Code of Practice: Onshore Petroleum Activities in Northern Territory 2019.

Imperial has been drilling in EP187, which is located within the Carpentaria and McArthur Basins, for which the EMPs noted above have been developed. These EMPs include specific reference to hydraulic stimulation (inGauge 2021), which includes a hydraulic stimulation chemical risk assessment (CRA) (EHS Support Pty Ltd, 2021). The CRA was prepared specifically for that tenement, and at the time the report was issued, two wells within the tenement have been drilled and either stimulated or planned to be stimulated (i.e. Carpentaria 1 and Carpentaria 2, respectively[1]). Imperial and Imperial A are now planning exploration activities, including drilling wells and undertaking hydraulic stimulation within its other tenement across the NT, which are grouped for the purpose of this report as the Eastern (Imperial tenement) and Western (Imperial A tenement), in **Figure 1-2** and **Figure 1-3**, respectively.

inGauge Energy ("inGauge") has been undertaking planning for the drilling and the hydraulic stimulation program across all of Imperials NT tenements and has retained EHS Support Pty Ltd ("EHS Support") to prepare and then update the CRA to better reflect the existing and proposed exploration tenements and stimulation fluids. Additionally, the CRA was updated to address the Petroleum (Environment) Regulations 2016, as in force at 22 June 2023 (NT, 2023), requirement to perform a full human health risk assessment. An assessment of human health risks was performed as part of the

[1] As of 31/10/2023, Carpentaria 1, 2 and 3 have all been stimulated.

previous CRAs; however, a summary of information specific to human health hazards was not included. In January 2024, the Human Health and Environmental Risk Assessment (HHERA; January 2024 HHERA) report documented the relevant EMP requirements utilising the chemicals present in the hydraulic stimulation formulations historically utilised or proposed in EP187 (EHS Support 2021) as well as the updated formulation proposed for future stimulation activities. This HHERA updated the January 2024 HHERA to include an additional stimulation formulation. The chemicals within these formulations have been specifically referred to within this HHERA using the following:

- March 2020
- May 2021
- January 2022
- October 2024

These four formulations are presented in tables in **Appendix A** and this HHERA includes evaluation of all four fluid systems, with the exception of poly(tetrafluoroethylene) that is listed in the May 2021 and January 2022 formulations. It was decided not to use the product containing this chemical for future stimulation activities. Therefore, this chemical will not be evaluated in the HHERA even though it is shown in **Appendix A**. This HHERA applies to hydraulic stimulation of wells commencing from the published date forward. Additional updates to this HHERA are possible in the future, with the evaluation of any additional proposed chemicals/revised chemical concentrations, and this will be undertaken where applicable.

This HHERA and any update will follow the tiered risk evaluation approach presented in the EP187 CRA. The overall chemical risk assessment methodology, results, and conclusions are applicable to other Imperial and Imperial A tenements that have the same conceptual exposure model, including environmental setting, hydrogeology/geology, the lifecycle of chemicals and potentially complete exposure pathways.

This assessment evaluates potential hazards associated with chemicals and the potential for human and environmental receptor exposure, and where potentially hazardous chemicals have complete exposure pathways, quantification of the potential risks. This chemical risk assessment is supported by a broader evaluation of environmental conditions and risks and recommended avoidance, mitigation and management strategies.

This chemical risk assessment for the hydraulic stimulation activities developed as part of the EMPs meets the requirements of the NT Code of Practice as well as being in general accordance with the following:

- NT Government, Department of Environmental and Natural Resources, Draft Guideline for the Preparation of an Environmental Management Plan under the Petroleum (Environment) Regulations (NT, 2023);
- Department of the Environment and Energy, Exposure Draft - Chemical Risk Assessment Guidance Manual: for chemicals associated with coal seam gas extraction (DoEE, 2017);
- Australian Industrial Chemicals Introduction Scheme, 2024 (AICIS) (which has progressively replaced National Industrial Chemicals Notification and Assessment Scheme [NICNAS] below, since 31 August 2020)
- NICNAS, National Assessment of Chemicals Associated with Coal Seam Gas Extraction in Australia (NICNAS, 2017a);
- enHealth Environmental Health Risk Assessment, Guidelines for Assessing Human Health Risks from Environmental Hazards (enHealth, 2012); and

- National Environment Protection (Assessment of Site Contamination) Measure 1999 ("ASC NEPM"); Schedule B4, Site-specific health risk assessment methodology (National Environment Protection Council [NEPC], 2013).

Reference has also been made to the relevant information available within the Northern Territory Governments "POINT" online mapping and data catalogue and the Australian Governments, Geological and Bioregional Assessment for the Beetaloo GBA (where appropriate).

The chemicals assessed in this HHERA have been compiled from several formulations that have been used (or are planned for use) in the Beetaloo Sub-Basin and potentially in other tenements and basins. The lists of chemicals assessed are presented in **Appendix A**, were provided by inGauge and includes research undertaken on maximum concentrations that potentially would be used in a hydraulic stimulation. It should be noted that the compiled lists of chemicals have been assessed as "one formulation" (noting that they contain a number of separately used components that are applied at various stages during the stimulation process) with maximum concentrations provided by inGauge. This is a conservative assessment for the hydraulic stimulation program because the actual concentration of individual chemicals will likely be less, and there will be fewer chemicals represented in a selected formulation.

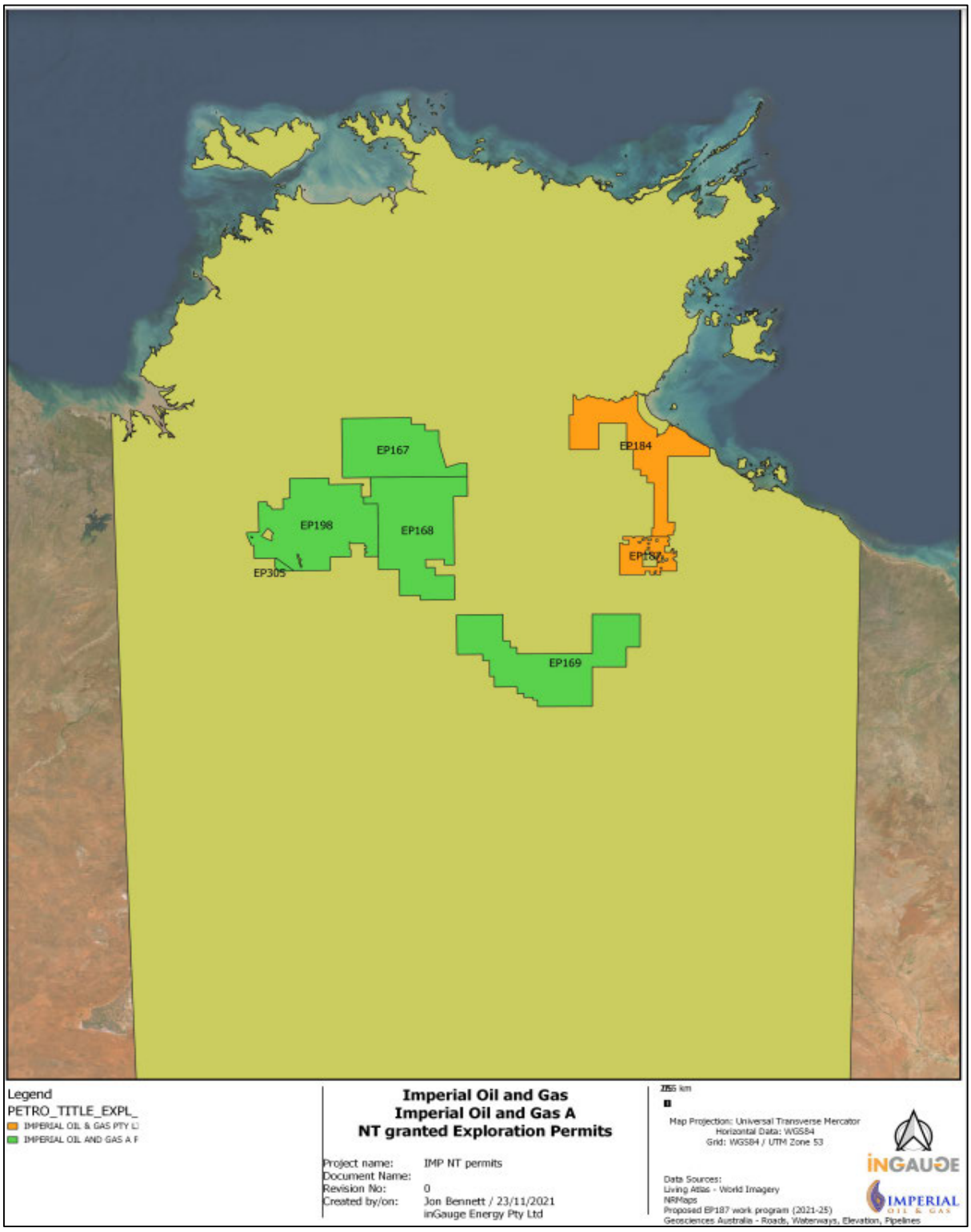

Figure 1-1 Location of Imperial and Imperial A Tenements

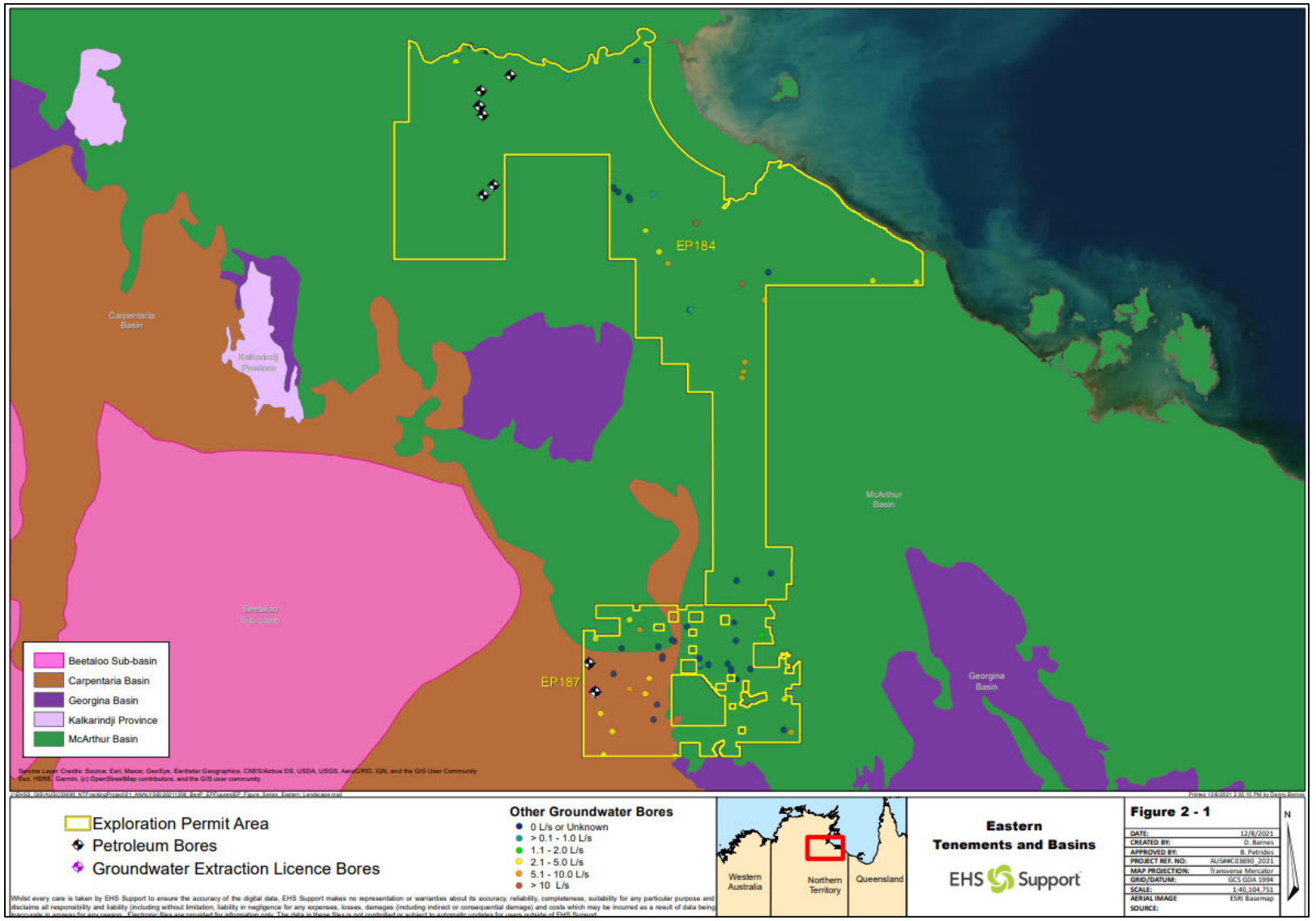

Figure 1-2 Eastern (Imperial) Tenements (EP184 and EP187) and Geological Basins

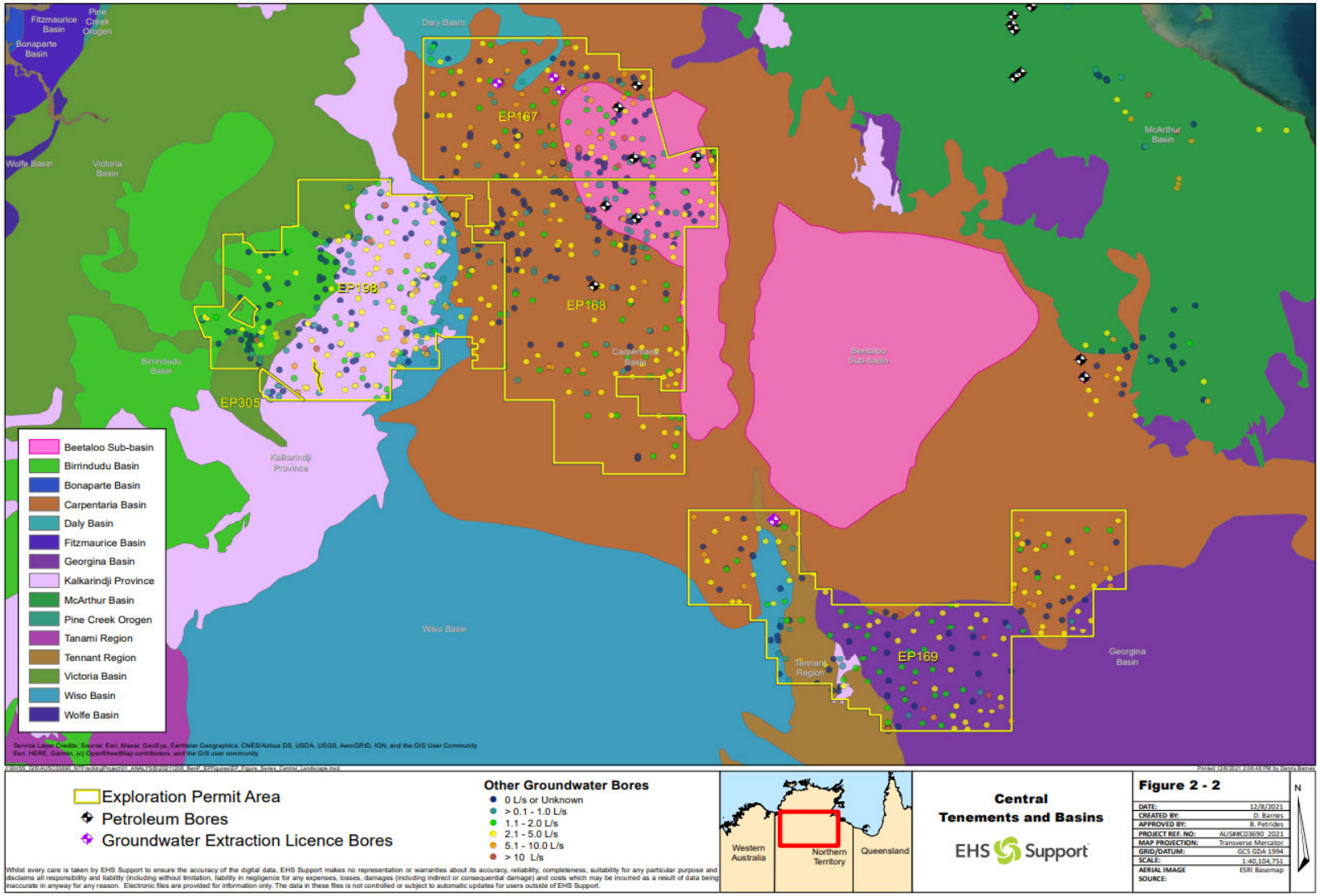

Figure 1-3 Western (Imperial A) Tenements (EP167-9, EP198 and EP305) and Geological Basins

2 Tier 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 tier 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.

The assessment followed the methodology and guidance presented in the following:

- Northern Territory Government, Department of Environmental and Natural Resources, Draft Guideline for the Preparation of an EMP under the Petroleum (Environment) Regulations (NT, 2023) (herein referred to as NT 2023);
- Department of the Environment and Energy (DoEE), Exposure Draft - Chemical Risk Assessment Guidance Manual: for chemicals associated with coal seam gas extraction (DoEE, 2017) (herein referred to as DoEE 2017);
- NICNAS, National Assessment of Chemicals Associated with Coal Seam Gas Extraction in Australia (NICNAS, 2017a);
- enHealth “Environmental Health Risk Assessment, Guidelines for Assessing Human Health Risks from Environmental Hazards” (enHealth, 2012); and
- ASC NEPM; Schedule B4, Site-specific health risk assessment methodology (NEPC, 2013).
- Environmental risk assessment guidance manual for industrial chemicals (NEPC, 2009)

2.1 Conceptual Exposure Model

The EMP developed for EP187 for the 2021-25 work program (inGauge, 2021) provides an overview of the proposed hydraulic stimulation program, which is similar to that which will be utilised on Imperials other NT tenements. The stimulation process involves pumping slurry, primarily consisting of water and sand (proppant) plus a minor volume of a specific blend of chemicals down the well to a specific geological target at sufficient pressure to create a fracture in the target geological formation. Proppant keeps the fractures open once the pump pressure is released, thereby improving the wells productive potential. Chemicals used in hydraulic stimulation fluid systems are designed to optimise stimulation outcomes and are commonly found in food and other household domestic products.

There are several techniques for hydraulic fracture stimulation. The two more viable methods to be implemented by Imperial and Imperial A are Plug and Perf, and coiled tubing assisted annular stimulation. Plug and Perf is commonly implemented in wells with cemented casing and consists of pumping down a bridge plug on a wireline with perforating guns to a given horizontal location near the toe of the well. The plug is set, and the zone is perforated. The tools are then removed from the well, and the fracture stimulation treatment is pumped in. The set plug or ball-activated plug then diverts fracture fluids through the perforations into the formation. The stage is completed by flushing

the casing with fluid. The next plug and perforations stage can be initiated, and the process is repeated, moving back to the heel of the well. The coiled tubing method is used to provide a conduit for "pinpoint fracturing". Coiled tubing is run into the well to the deepest target. The bottom-hole assembly run on the end of the coiled tubing incorporates a jetting assembly that allows low concentration sand slurry to cut holes or slots into the casing and cement. The hydraulic stimulation treatment is then pumped into the coiled tubing/casing annulus to initiate and propagate the fracture.

Both of these techniques for fracture stimulation can take approximately 5 to 40 days per well, depending on the number of zones perforated. The hydraulic stimulation technique will be confirmed once the drilling program has been completed and well conditions are assessed.

The life cycle of chemicals used during the hydraulic fracturing of wells includes the following general categories:

- Transportation of chemicals – from the supplier warehouse to the well lease and between well leases
- Hydraulic fracturing activities – storage of chemicals, usage (e.g., blending, injecting) and subsequent recovery of fluids (including storage in produced water and flowback fluid treatment tanks) at the well lease and associated vendor chemical additives
- Disposal and management – recovered vendor chemical additives in wastes and hydraulic fracturing flowback.

Throughout the life cycle of chemical additive products, without adequate management controls in place, there is the potential for human and environmental receptors to be exposed to the chemical additives. Based on an evaluation of the life cycle of products and chemicals, environmental conditions in the areas of development, anticipated populations and location selection, the following potentially complete exposure pathways were identified:

- Transportation of chemicals:
  - Human and environmental receptor exposure to chemicals as a result of accidental release during transport from supplier warehouse to well lease or between well leases (i.e., truck rollover).
  - Human and environmental receptors exposed to surface water bodies that received runoff from an accidental release during transportation.
- Hydraulic fracturing activities:
  - Human and environmental receptor exposure to chemicals as a result of accidental release during the storage and preparation of products on the well lease for hydraulic fracturing activities.
  - Human and environmental receptor exposure to residual chemicals (vendor chemicals) in recovered materials as a result of an accidental release from storages (treatment tanks) on the well lease.
  - Human and environmental receptors exposed to surface water bodies that received runoff from an accidental release during hydraulic fracturing activities.
- Treatment and disposal:
  - Human and environmental receptor exposure to chemicals as a result of accidental release during transport of surplus chemicals and wastes (i.e., flowback) from the well lease to a disposal/management facility.
  - Human and environmental receptor exposure to chemicals as a result of accidental release of stored wastes and/or flowback.

- Human and environmental receptors exposed to surface water bodies that received runoff from an accidental release of stored wastes and/or flowback.

To assess the unmitigated risks from the improbable scenario where some fluids were to overflow the bunded area, a range of release scenarios are considered comprising:

- Smaller release volumes of 1,000 L and 100,000 L which would reflect small scale releases, and
- An improbable release out of the bunded area (1,000,000 L).

Appendix B provides an assessment of the potential for effects on groundwater associated with a release of hydraulic fracturing fluid, waste or flowback to the land surface scenarios. The results of this assessment, undated to include the additional NT tenements of Imperial and Imperial A, showed the travel times for surface releases to reach groundwater are very long, thereby providing ample opportunity for containment and remedial action. Therefore, the potential for impacts to groundwater is considered low.

Both mitigated and unmitigated risks from an overland flow scenario from a release have been assessed as part of the assessment. inGauge has proposed to construct a 2 ha well pad, with approximately 1.0 m high berm walls surrounding any inground treatment tanks and/or double-lined aboveground tanks to contain and manage the risk from potential releases. In the absence of this structure, a major release could have the potential to migrate a distance off the well pad. However, with these measures, any releases would be limited to the potential for incidental/minor spillage outside the fluid storage and containment area. In the context of a potential release scenario of 100,000 L outside of the containment and storage area, the maximum affected area of spreading will be less than 4.7 ha and limited to the proximity of the release area.

Therefore, given the planned management control of the construction of a bunded area surrounding treatment tanks, the potential for a complete exposure pathway to surface water bodies associated with runoff from an accidental release is considered unlikely and not assessed further.

The risks associated with the transport of chemicals and wastes is considered to be managed to a level as low as reasonably practicable. This is because the potential for a release is controlled through the implementation of a traffic management plan (including use of designated trucking routes, vehicle signage, vehicle management systems (to manage speed and driving behaviour/habits). In the unlikely event of a vehicular accident, incident and spill response procedures will be implemented. In this context, this scenario is not assessed further.

The management of chemicals and wastes will be conducted at the well lease using drums, intermediate bulk containers and engineered tanks designed to contain the fluids. No permanent storage of chemicals, flowback or wastes will be conducted in ponds or sumps, and therefore the potential for releases is considered limited. Wastewater will be managed through the use of engineered treatment tanks that will contain liquids and may have the potential for exposures to avian receptors; however, this exposure route is unlikely given the salinity of the water. In the unlikely event of a release to the ground, the potential for exposures (other than workers) is limited. The well pad sites are fenced to limit access to the public and prevent entry by livestock and large native fauna. If materials are spilled to the ground, then investigation, remediation and rehabilitation activities will be immediately implemented to address soil impacts. In this context, exposure during and post-activity are unlikely.

Lastly, chemical exposures to workers are controlled through engineering, management controls and personal protective equipment, which are focused on elimination and mitigation of the potential for dermal contact and potential for incidental ingestion (therefore, the exposures are considered unlikely). Respiratory protection may not always be standard on hydraulic fracturing worksites, so this is considered a potential complete exposure pathway for volatile constituents.

2.2 Tier 1 Assessment

The Tier 1 assessment includes an evaluation of the human health and environmental hazards of the chemicals in the two hydraulic fracturing fluid systems. The objective of the Tier 1 assessment is to identify chemicals of low human health and ecological concern that do not require additional chemical risk assessment in the Tier 2 assessment. A persistent, bioaccumulative and toxic (PBT) assessment was conducted because of specific concerns for substances that can be shown to persist for long periods in the environment, bioaccumulate in food chains, and that can give rise to toxic effects after a longer time and over a greater spatial scale than chemicals without these properties.

Further, a regulatory review was conducted to determine if the chemicals were identified as potential chemicals of concern in the Australian AICIS (formerly NICNAS). Additional information is provided in the risk assessment dossiers (**Appendix C**) and safety data sheets (SDSs) (**Appendix D**) for the compiled hydraulic fracturing fluid systems. This information can be used for emergency responders, health and safety managers and environmental hazard clean-up teams.

As per the NT Government Guidance (Department of Environment, Parks, and Water Security, 2022), the Tier 1 assessment included the following:

- Name of chemical;
- Chemical purpose;
- Chemical Abstract Service (CAS) number;
- Total mass in kg;
- Approximate downhole concentration for that chemical expressed in mg/L;
- Appropriate ecotoxicity (aquatic and oral values) data including for acute lethal concentration 50 / effect concentration 50 (LC50/EC50) and chronic no observed effect concentration (NOEC) data where available; and
- Information on the biodegradation and bioaccumulation potential of organic chemicals.

The results of the Tier 1 assessment for the hydraulic fracturing fluid system formulations noting which chemical additives were assessed, the information used for the assessment, and the chemicals categorised as Tier 1 or Tier 2, is presented in **Table 1**, attached. **Table 2**, below, includes a summary of relevant information for the human health assessment in addition to the summary in **Table 1**, attached, and chemical dossiers (**Appendix C**). Discussion is provided in **Table 1**, attached, on the Tier 1 assessment findings as to whether a chemical was retained for further evaluation in the Tier 2 assessment. Observed recovery of drilling, well development, and hydraulic fracturing fluids chemicals in flowback from other regional operators of Oil and Gas petroleum tenements is approximately 20 percent or less of the injected fluid chemical concentration. Concentration declines have been attributed to dilution by pore water within the shales, sorption, complexation and decay (bio-decay, hydrolysis). For the purposes of the Tier 1 and Tier 2 assessments, the higher injected fluid concentrations have been considered.

The following general approach was used to screen the constituents of potential concern (COPCs):

- A chemical was identified by AICIS (2024) or NICNAS (NICNAS, 2017a; NICNAS, 2017b; as a chemical of low concern, and the PBT assessment did not identify a PBT substance, and no human health hazard was identified; therefore, a Tier 2 assessment was deemed not to be warranted.
- If the chemical was not categorised by NICNAS as a chemical of low concern (either because it needed further evaluation or was not included in the 2017 NICNAS assessment) but was not a PBT substance and no human health hazard was identified, then a Tier 2 assessment was deemed not to be warranted.
- If the chemical satisfied the toxicity criteria for the PBT assessment because of aquatic toxicity values or a human health hazard was identified, the potential for complete exposure pathways was then assessed to determine the potential for risk (an incomplete pathway precludes an exposure occurring and an associated potential risk). In this context, site setting and management protocols associated with the action were evaluated, and if the pathway was incomplete, a Tier 2 assessment was not deemed to be warranted. Key controls limiting the potential for exposure included:
    - Implementation of the management controls within the EMP, which ensures the well site is located away from surface water (the current location is greater than 2.5 km away from the major tributary, precluding a surface release from impacting surface water).
    - Maintenance of access control restrictions during hydraulic fracturing activities that will prevent access by the public, livestock and large native fauna.
    - Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure.

The outcome of the Tier 1 assessment identified the chemicals of low human health and environmental concern. Based on this outcome, no further management or mitigation is considered necessary for the majority of the chemicals. The following section presents the nine (9) chemicals that could potentially pose significant hazards or risks evaluated in the Tier 2 Assessment.

Table 2 Summary of Human Health Assessment

Chemical Name	CAS Number	Tier	Concentration in Injected Fluid (mg/L)	LC50 (mg/L)	Rat Lethal Dose (mg/kg)	Ratio of Lethal Dose to Maximum Concentration	Persistence	Environmental Fate Summary	NICNAS - Low Concern Chemical/Polymer	Dangerous Goods Code Required for Transport
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	[redacted]	1	[redacted]	ND	ND			Data from degradation testing according to standard methods are not available. However, there is evidence that PLA can undergo degradation via isolated and variable bacterial populations. Given the plasticine nature of the polymer and its high molecular weight, bioconcentration, bioaccumulation, and sorption are not expected to be appreciable.	NA	No
2,2"-oxydiethanol - impurity (Diethylene glycol)	[redacted]	1	[redacted]	5.08	16500			Readily biodegradable, up to 92% degradation after 28 days. Is not expected to bioaccumulate based on a BCF value of 100 and a log K_{ow} value of -1.98.	No recommendations as existing regulatory controls are considered sufficient.	No
2-Ethyl hexanol	[redacted]	1	[redacted]6	>0.89	2047			Readily biodegradable, reaching >95% degradation within five days. It is not expected to bioaccumulate based on an experimental Log K_{ow} of 2.9.	NA	No
2-Propenamid (impurity)	[redacted]	1	[redacted]	12	177			Found to degrade approximately 100% in 28 days. Log K_{ow} of -0.9. Not expected to bioaccumulate.	NA	UN number: 2074 (solid)
2-Propenoic acid, homopolymer	[redacted]	1	[redacted]	>5.1	1500			It is readily biodegradable, degradation after 28 days was 87.4%. It is not expected to bioaccumulate with a log P_{ow} = 0.27.	NA	No
2-Propenoic acid, polymer with sodium phosphinate (1:1), sodium salt	[redacted]	1	[redacted]	ND	>5000			Read-across substance found to be not readily biodegradable; 20% degradation in 28 days. Not expected to bioaccumulate due to its molecular weight.	NA	No
2-Propenoic acid, telomer with mercaptoacetic acid	[redacted]	1	[redacted]	>5.1	1500			It is readily biodegradable, degradation after 28 days was 87.4%. It is not expected to bioaccumulate with a log P_{ow} = 0.27.	NA	No
Acetaldehyde	[redacted]	1	[redacted]	24.04	660			Readily biodegradable with 80% degradation achieved after 14 days. It is not expected to bioaccumulate based on a Log K_{ow} of -0.17 and a BCG value of -0.033 for upper trophic levels	NA	Transport hazard class 3; UN Number 1089
Acetic acid	[redacted]	1	[redacted]	11.4	3310			Readily biodegradable with 96% degradation after 20 days. Bioaccumulation is not expected to occur because acetic acid dissociates completely in aqueous solution to acetate and its hydrogen ion which are both ubiquitous in the environment	NA	Class 8
Acetic acid, 2-mercapto-, sodium salt (1:1)	[redacted]	1	[redacted]	ND	50-200			Readily biodegradable, 67% biodegradation at day 28. It has low potential for bioaccumulation based on log K_{ow} <= 3.	NA	No

Chemical Name	CAS Number	Tier	Concentration in Injected Fluid (mg/L)	LC50 (mg/L)	Rat Lethal Dose (mg/kg)	Ratio of Lethal Dose to Maximum Concentration	Persistence	Environmental Fate Summary	NICNAS - Low Concern Chemical/Polymer	Dangerous Goods Code Required for Transport
Acrylamide acrylate copolymer	[redacted]	1	[redacted]	ND	ND			Not expected to be readily biodegradable and it is not expected to bioaccumulate due to its very high molecular weight and low water solubility.	Low concern polymer	No
Acrylamide, 2-acrylamido-2-methylpropanesulfonic acid, sodium salt polymer	[redacted]	1	[redacted]	ND	>5000			No data is available. Not expected to be readily biodegradable or bioaccumulate due its molecular weight and low water solubility (1000 g/L). Less than 10% biodegradation after 44 days.	Low concern polymer	No
Acrylamide, sodium acrylate copolymer	[redacted]	1	[redacted]	ND	ND			Not expected to be readily biodegradable and it is not expected to bioaccumulate due to its very high molecular weight and low water solubility.	Polymer identified as low concern to human health by application of expert validated rules	No
Acrylamide, sodium acrylate polymer	[redacted]	1	[redacted]	ND	ND			Not expected to be readily biodegradable and it is not expected to bioaccumulate due to its very high molecular weight and low water solubility.	Low concern polymer	No
Acrylamide/ammonium acrylate copolymer	[redacted]	1	[redacted]	ND	ND			Not expected to be readily biodegradable and it is not expected to bioaccumulate due to its very high molecular weight and low water solubility.	Low concern polymer	No
Acrylonitrile	[redacted]	1	[redacted]	1.38	72			Inherently biodegradable, reaching 61% after 14 days and 100% after 28 days. It is not expected to bioaccumulated based on a log K_{ow} of 0.017	NA	Hazard Class 3; UN Number 1093
Alcohols, C10-16, ethoxylated propoxylated	[redacted]	1	[redacted]	>0.22	1100			Readily biodegradable. It has a low potential to bioaccumulate based on reported BCF values ranging from <5 to 387.5.	NA	No
Alcohols, C12-14-secondary, ethoxylated	[redacted]	1	[redacted]	ND	1000			Readily biodegradable, 80-88% degradation after 28 days. It has a low potential to bioaccumulate based on BCF values of <5 to 387.5	NA	No
Alcohols, C12-15, ethoxylated	[redacted]	1	[redacted]	ND	1000			Readily biodegradable with 80-88% degradation reached within 28 days. It has a low potential for bioaccumulation based on BCF values of <5 to 387.5	NA	No
Alcohols, C12-16, ethoxylated	[redacted]	1	[redacted]	ND	1000			Readily biodegradable with 80-88% degradation reached within 28 days. It has a low potential for bioaccumulation based on BCF values of <5 to 387.5	NA	No
Alcohols, C6-12, ethoxylated propoxylated	[redacted]	1	[redacted]	>0.22	1100			Readily biodegradable with 63% degradation reached within 28 days. It has a low potential for bioaccumulation based on BCF values of <5 to 387.5	NA	No

Chemical Name	CAS Number	Tier	Concentration in Injected Fluid (mg/L)	LC50 (mg/L)	Rat Lethal Dose (mg/kg)	Ratio of Lethal Dose to Maximum Concentration	Persistence	Environmental Fate Summary	NICNAS - Low Concern Chemical/Polymer	Dangerous Goods Code Required for Transport
Aldol	[redacted]	1	[redacted]	ND	2180			This substance is predicted to be readily biodegradable based on predictions from EPISUITE. It is not expected to bioaccumulate based on a log K_{ow} value of -0.722	NA	Class 6.1; Packing Group II; UN number 2839
Amides, tall-oil fatty, N,N-bis(hydroxyethyl)	[redacted]	1	[redacted]	ND	10000			It is readily biodegradable, 70% degradation after 28 days. It has a low potential to bioaccumulate based on a calculated BCF (BCFBAF v3.01) value of 112.53 L/kg.	NA	No
Amine oxides, cocoalkyldimethyl	[redacted]	1	[redacted]	ND	846			Readily biodegradable, 93% degradation after 28 days. It is not expected to bioaccumulate based on a log K_{ow} value of <2.7	NA	Environmentally hazardous substances
Ammonium Chloride	[redacted]	1	[redacted]	3.6	1410		Inorganic, N/A	Bioaccumulation is not expected due to this chemical's high water solubility (372 g/L) and ionic nature	NA	No
Ammonium sulfate	[redacted]	1	[redacted]	0.0035	>2000		Inorganic, N/A	Not expected to bioaccumulate due to a log K_{ow} of -5.1	Chemical identified as low concern for human health	UN number: 20506 (Solid)
Benzaldehyde	[redacted]	1	[redacted]	ND	1300			Readily biodegradable with 100% degradation reported after 19 day. It is not expected to bioaccumulate based on a log K_{ow} value of 1.4	NA	Class 9; UN Number 1990
Benzoic acid, 2-chloro-3-methyl-, sodium salt (1:1)	[redacted]	1	[redacted]	12.2	>2000			It is expected to be readily biodegradable both aerobically and anaerobically. This chemical has low potential for bioaccumulation based on the BCF value of 4.79 L/kg and log K_{ow} value of 0.138	NA	No
Benzoic acid, 2-chloro-4-fluoro-, sodium salt (1:1)	[redacted]	1	[redacted]	12.2	>2000			It is expected to be readily biodegradable both aerobically and anaerobically. This chemical has a low potential for bioaccumulation based on the BCF value of 3.98 L/kg and log K_{ow} value of -1.36.	NA	No
Benzoic acid, 3-chloro-2-methyl-, sodium salt (1:1)	[redacted]	1	[redacted]	12.2	>2000			It is expected to be readily biodegradable both aerobically and anaerobically. This chemical has low potential for bioaccumulation based on the BCF value of 4.79 L/kg and log K_{ow} value of 0.138	NA	No
Benzoic acid, 3-fluoro-, sodium salt (1:1)	[redacted]	1	[redacted]	12.2	>2000			It is expected to be readily biodegradable both aerobically and anaerobically. This chemical has low potential for bioaccumulation based on the BCF value of 4.79 L/kg and log K_{ow} value of 0.138	NA	No
Benzoic acid, 3-fluoro-2-methyl-, sodium salt (1:1)	[redacted]	1	[redacted]	12.2	>2000			It is expected to be readily biodegradable both aerobically and anaerobically. This chemical has low potential for bioaccumulation based on the BCF value of 4.37 L/kg and log K_{ow} value of 0.193	NA	No
Benzoic acid, 4-fluoro-, sodium salt (1:1)	[redacted]	1	[redacted]	12.2	>2000			It is expected to be readily biodegradable both aerobically and anaerobically. This chemical has low potential for bioaccumulation based	NA	No

Chemical Name	CAS Number	Tier	Concentration in Injected Fluid (mg/L)	LC50 (mg/L)	Rat Lethal Dose (mg/kg)	Ratio of Lethal Dose to Maximum Concentration	Persistence	Environmental Fate Summary	NICNAS - Low Concern Chemical/Polymer	Dangerous Goods Code Required for Transport
								on the BCF value of 4.79 L/kg and log K_{ow} value of 0.138		
Bismuth Oxide	[redacted]	1	[redacted]	ND	2000		Inorganic, N/A	It is an inorganic mineral that is slightly soluble in water, thus it is not expected to be bioaccumulative	NA	No
but-2-enedioic acid (Fumaric Acid)	[redacted]	1	[redacted]	1306	9300			Readily biodegradable, 67.5 % biodegradation after 28 days. Low potential for bioaccumulation based on a log $K_{ow} \leq 3$	NA	No
Butyl alcohol	[redacted]	1	[redacted]	>20	2290			Readily biodegradable, 87% degradation after 10 days. It is not expected to bioaccumulate based on a Log Kow value of 1.0.	NA	Hazard class 3; UN Number 1120
Calcium Chloride	[redacted]	1	[redacted]	ND	2301		Inorganic, N/A	Dissociates completely in aqueous media. Essential ions to biological systems. Neither calcium chloride or its dissociated ions are expected to bioaccumulate.	NA	No
Ceramic Materials and wares, chemicals	[redacted]	1	[redacted]	>2.3	>2000		Inorganic, N/A	It is not expected to biodegrade and it is not expected to bioaccumulate	NA	No
Chlorous acid, sodium salt	[redacted]	2	[redacted]	ND	284		Inorganic, N/A	Chlorous acid, sodium salt readily dissolves in water to the sodium (Na+) and chlorite (ClO_2^-) ions. The chlorite (ClO_2^-) ion is in equilibrium with chlorous acid ($HClO_2$) in water. It is not expected to bioaccumulate	NA	Class 8; Packing Group II; UN1908
Choline Chloride	[redacted]	1	[redacted]	ND	3500			Choline chloride is readily biodegradable. Distribution modelling shows choline to completely dissolve in water.	Chemical identified as low concern for human health	No
Cinnamaldehyde	[redacted]	1	[redacted]	ND	2200			Readily biodegradable, 100% degradation after 28 days. It is not expected to bioaccumulate based on a Log K_{ow} value of 2.107	NA	No
Citric acid	[redacted]	1	[redacted]	ND	5400			Readily biodegradable based on results of the ready and inherent aerobic biodegradation studies. It is not expected to bioaccumulate based on log K_{ow} values of -1.61 to -1.80	NA	No
Cocobetaine	[redacted]	1	[redacted]	ND	>1500			Readily biodegradable, 100% degradation after 28 days. Has a low bioaccumulation potential based on results from a QSAR model BCFBAF v3.01	NA	No
Copper(II) sulfate	[redacted]	2	[redacted]	ND	481		Inorganic, N/A	Natural element and transition metal that is not expected to become biomagnified	NA	UN number: 3288 (Solid)
Crontonaldehyde	[redacted]	2	[redacted]	0.19	174			Readily biodegradable, 55% degradation after 28 days. It is not expected to bioaccumulate based on a log K_{ow} value of 0.6	NA	Hazard class 6.1; UN Number 1143
Crystalline silica, quartz	[redacted]	1	[redacted]	ND	ND		Inorganic solid, N/A	This is a naturally occurring mineral that is not expected to biodegrade and it is not expected to bioaccumulate	NA	No

Chemical Name	CAS Number	Tier	Concentration in Injected Fluid (mg/L)	LC50 (mg/L)	Rat Lethal Dose (mg/kg)	Ratio of Lethal Dose to Maximum Concentration	Persistence	Environmental Fate Summary	NICNAS - Low Concern Chemical/Polymer	Dangerous Goods Code Required for Transport
Decamethyl cyclopentasiloxane	[redacted]	2	[redacted]	8.70E-06	>5000			Is not readily biodegradable in water, 0.14% biodegradation was reached after 28 days. Volatilisation from water surfaces is an important fate and transport process due to the Henry's Law Constant (3.3 x 10^6 Pa m3/mol at 24.6°C). Estimated half lives for a model river and model lake are 5 hours and 6.8 days, respectively. Adsorption to suspended solids and sediment in the water column is expected to attenuate volatilisation from water surfaces. Calculated BCF of 1040-4920 L/kg indicate that it has a high to moderate potential to bioaccumulate in fish.	NA	No
Diammonium peroxidisulphate	[redacted]	1	[redacted]	2.95	700		Inorganic, N/A	Is not expected to bioaccumulate. All decomposition products are ubiquitous in the environment	NA	Class 6.1; UN1444
Dicoco dimethyl quaternary ammonium chloride	[redacted]	2	[redacted]	ND	226			Readily biodegradable, 75% biodegradation reached after 28 days. Unlikely to bioaccumulate based on a low log K_{ow} value of 2.39	NA	No
Diethanolamine	[redacted]	1	[redacted]	ND	1600			Readily biodegradable, 93% degradation after 28 days. It is not expected to bioaccumulated based on an estimated BCF value of 2.3 obtained from OASIS Catalogic v.5.11.15[BCF-base-line model v. 0208].	NA	No
Diethylene glycol	[redacted]	1	[redacted]	5.08	16500			Readily biodegradable, up to 92% degradation after 28 days. Is not expected to bioaccumulate based on a BCF value of 100 and a K_{ow} value of -1.98.	NA	No
Diethylenetriaminepentakis (methylene phophonic acid), sodium salt	[redacted]	1	[redacted]	ND	>2145			Not readily biodegradable. Using [14C]-DTPMP, there was 64% and 62.6% biodegradation in riverbank soil and silt loam soil, respectively, after 148 days. BCF values in fish studies ranged from <10 to <94.	Poses no unreasonable risk to human health	UN 3265 CORROSIVE LIQUID, ACIDIC, ORGANIC N.O.S. (diethylene triamine penta(methylene phosphonic acid) sodium salt) Class: 8 Packing Group: III
Dimethyl siloxanes and silicones	[redacted]	1	[redacted]	695	>4800			It is considered not readily biodegradable under field conditions, the half-life in soil was 2.4 to 3.9 years. In freshwater sediments, 5 to 10% was hydrolysed after 1 year. Bioaccumulate is not expected due to its molecular weight.	Low concern polymer	No
Disodium octaborate tetrahydrate	[redacted]	1	[redacted]	>2.01	>2000		Inorganic, N/A	Inorganic mineral that is unlikely to bioaccumulate	NA	No

Chemical Name	CAS Number	Tier	Concentration in Injected Fluid (mg/L)	LC50 (mg/L)	Rat Lethal Dose (mg/kg)	Ratio of Lethal Dose to Maximum Concentration	Persistence	Environmental Fate Summary	NICNAS - Low Concern Chemical/Polymer	Dangerous Goods Code Required for Transport
Distillates (petroleum), solvent-dewaxed heavy paraffinic	[redacted]	1	[redacted]	2.18	>5000			Inherently biodegradable, with a reported mean degradation value of 31.13% after 28 days. There is some potential for bioaccumulation based on the Log Kow values (ranging from 1.99-18.02). However, the inherent biodegradability of this substance suggests that the bioaccumulation would be mitigated.	NA	No
Diutan	[redacted]	1	[redacted]	ND	5000			Readily biodegradable, 95% degradation reached after 28 days. Is not expected to bioaccumulated based on a log K_{ow} of -3.56.	NA	No
Dodecamethylcyclohexasiloxane	[redacted]	2	[redacted]	ND	>2000			Is not readily biodegradable in water, 4.47% biodegradation reached after 28 days. Moderate potential to bioaccumulate based on BCF values of 240-1160 L/kg in fish.	NA	No
Ethanol	[redacted]	1	[redacted]	124.7	>2000			Readily biodegradable, 84% degradation after 20 days. It is not expected to bioaccumulate based on a log K_{ow} value of -0.35	NA	Class 3; Packing Group II; UN Number 1170
Ethoxylated branched C13 alcohol	[redacted]	1	[redacted]	ND	1700			Readily biodegradable, 75% degradation after 28 days. It is not expected to bioaccumulate based on an calculated log K_{ow} value of 4.9.	NA	No
Ethoxylated oleic acid	[redacted]	1	[redacted]	1.6	>5050			Readily biodegradable, 83% degradation reached within 28 days after acidification. It is not expected to bioaccumulate based on a reported BCF value of 237 L/kg.	NA	No
Ethylene glycol	[redacted]	1	[redacted]	>2.5	7712			Readily biodegradable, 96% degradation after 28 days. Is not expected to bioaccumulated based on a calculated log K_{ow} values of -1.36 and a BCF value of 10 for fish	NA	No
Fatty acids, C8-C16, ethylhexyl ester	[redacted]	1	[redacted]	>5.7	>2000			Readily biodegradable, 97% degradation after 30 days. Bioaccumulation is not expected	NA	No
Fatty acids, tall-oil, ethoxylated	[redacted]	1	[redacted]	ND	>10000			It is considered readily biodegradable based on experimental results for a surrogate chemical which resulted in 90-100% degradation after 28 days. It is not considered to be bioaccumulative based on its components Log Kow values (ranging from 5 to >10, KOWWIN v1.68).	NA	No
Gelatins	[redacted]	1	[redacted]	ND	ND			A natural polymer that is readily biodegradable. Low potential to bioaccumulate	Chemical identified as low concern to human health	No
Glutaraldehyde	[redacted]	2	[redacted]	0.8	123			Readily biodegradable, 90-100% biodegradation reached after 28 days. It is not expected to bioaccumulate based on a measured log Kow value of -0.26 @ pH 7	NA	Class 8; Packing Group III; UN3265 (Corrosive Liquid, Acidic, Organic, N.O.S. (Contains Glutaraldehyde))

Chemical Name	CAS Number	Tier	Concentration in Injected Fluid (mg/L)	LC50 (mg/L)	Rat Lethal Dose (mg/kg)	Ratio of Lethal Dose to Maximum Concentration	Persistence	Environmental Fate Summary	NICNAS - Low Concern Chemical/Polymer	Dangerous Goods Code Required for Transport
Glycerine	[redacted]	1	[redacted]	ND	>5000			Readily biodegradable, 92% degradation after 30 days. It is not expected to bioaccumulate based on an experimental Log K_{ow} of -1.75	Chemical identified as low concern to human health by application of expert validated rules	No
Guar gum	[redacted]	1	[redacted]	ND	7060			It is expected to readily undergo microbial biodegradation. This polymer has a low potential to bioaccumulate	Chemical identified as low concern to human health	No
Hydrochloric acid	[redacted]	1	[redacted]	5666	238		Dissociates completely	Dissolves completely in water. Dissociates completely to hydrogen (H+) and chloride (Cl-). Both ions are ubiquitous in the environment	NA	Class 9; Packing Group II or III; UN1789
Hydrotreated light petroleum distillate	[redacted]	2	[redacted]	4.951	>5000			It is expected to be readily biodegradable, 69% degradation after 28 days. It is expected to have constituents with the potential to bioaccumulate	Chemical not considered to pose an unerasonable risk to health of workers and public health on the basis of the Tier 1 IMAP Assessment.	No
Hydroxylpropyl guar	[redacted]	1	[redacted]	ND	7060			It is expected to be biodegradable. It is not expected to bioaccumulate based on its large molecular weight	Chemical not considered to pose an unerasonable risk to health of workers and public health on the basis fo the Tier 1 IMAP Assessment.	No
Iron gluconate	[redacted]	1	[redacted]	ND	2237			Readily biodegradable, 78% after 28 days. It has a low potential to bioaccumulate based on an estimated BCF value of 3.162 L/kg obtained from EPISUITE.	NA	No
Magnesium Silicate Hydrate (talc)	[redacted]	1	[redacted]	2.1	>5000		Inorganic, N/A	Biodegradability is not relevant thus it meets the screening criteria for persistence. Bioaccumulation not expected to occur based on its log K_{ow} value of -9.4.	Chemical identified as low concern for human health	No
Methanol	[redacted]	1	[redacted]	87.5	6200			Is readily biodegradable in sea water (84 and 95% after 10 and 20 days, respectively) and soil (53.4% degradation under aerobic conditions and 46.3% degradation under anaerobic conditions). It has a BCF of 1.0 in fish which suggests that it has a low potential to bioaccumulate	NA	Class 8; Packing Group III; UN3265
Methyloxirane polymer with oxirane, ether with 1,2,3-propanetriol (3:1)	[redacted]	1	[redacted]	ND	ND			This polymer is expected to be readily biodegradable and not expected to bioaccumulate due to its molecular weight.	Low concern polymer	No
Methyloxirane polymer with oxirane, ether with 1,2-propanediol (2:1)	[redacted]	1	[redacted]	ND	ND			This polymer is expected to be readily biodegradable and not expected to bioaccumulate due to its molecular weight.	Low concern polymer	No

Chemical Name	CAS Number	Tier	Concentration in Injected Fluid (mg/L)	LC50 (mg/L)	Rat Lethal Dose (mg/kg)	Ratio of Lethal Dose to Maximum Concentration	Persistence	Environmental Fate Summary	NICNAS - Low Concern Chemical/Polymer	Dangerous Goods Code Required for Transport
Non-crystalline Silica (impurity)	[redacted]	1	[redacted]	ND	ND		Inorganic, N/A	This is a naturally occurring mineral that is not expected to biodegrade and it is not expected to bioaccumulate	NA	No
Octamethylcyclotetrasiloxane	[redacted]	2	[redacted]	3.60E-05	>4800			Is not biodegradable in water. 3.7% biodegradation reached after 29 days. Susceptible to biodegradation in soil. High potential to bioconcentrate in fish with a BCF value of 12400 L/kg after 28 days. Identified as a PBT substance by the European Union.	NA	No
Poly(oxy-1,2-ethanediyl), a-hydro-w-hydroxy-, mono-C10-14-alkyl ethers, phosphates	[redacted]	1	[redacted]	ND	1000			Readily biodegradable with 80-88% degradation reached within 28 days. It hasa low potential for bioaccumulation based on BCF values of <5 to 387.5	NA	No
Poly(oxy-1,2-ethanediyl), alphahexyl-omega-hydroxy	[redacted]	1	[redacted]	3.9	614			It is considered to be readily biodegradable, reaching 90.4% degradation after 28 days. It is not expected to bioaccumulate based on an experimental log K_{ow} value of 0.81.	Chemical not considered to pose an unreasonable risk to health of workers and public health on the basis of the Tier 1 IMAP Assessment.	No
Polyethylene glycol	[redacted]	1	[redacted]	ND	25700			This chemical is readily biodegradable. The BCF is 3.162 kg/L; therefore, there not expected to bioaccumulate.	Chemical not considered to pose an unreasonable risk to health of workers and public health on the basis of the Tier 1 IMAP Assessment.	No
Polymer of 2-acrylamido-2-methylpropanesulfonic acid sodium salt and methyl acrylate	[redacted]	1	[redacted]	ND	>5000			No data is available. Not expected to be readily biodegradable or bioaccumulate due its molecular weight and low water solubility (1000 g/L). Less than 10% biodegradation after 44 days.	NA	No
Polypropylene glycol	[redacted]	1	[redacted]	ND	500			Readily biodegradable, 86.6% degradation after 28 days. It is not expected to bioaccumulate based on log K_{ow} values of <=3 and relatively high water solubility.	Chemical not considered to pose an unreasonable risk to health of workers and public health on the basis of the Tier 1 IMAP Assessment.	No
Potassium chloride	[redacted]	1	[redacted]	ND	3020		Dissociates completely	Dissociates completely in aqueous media. Will dissociate to potassium and chloride ions which are not expected to bioaccumulate.	Chemical identified as low concern to human health by application of expert validated rules	No

Chemical Name	CAS Number	Tier	Concentration in Injected Fluid (mg/L)	LC50 (mg/L)	Rat Lethal Dose (mg/kg)	Ratio of Lethal Dose to Maximum Concentration	Persistence	Environmental Fate Summary	NICNAS - Low Concern Chemical/Polymer	Dangerous Goods Code Required for Transport
Propan-2-ol	[redacted]	1	[redacted]	19000	4700			It is readily biodegradable, 49% biodegradable after 5 days. Not expected to bioaccumulate based on a log K_{ow} value of 0.05	NA	Class 3; Packing Group II; UN1219
Propylene glycol n-propyl ether	[redacted]	1	[redacted]	1725	>2000			Readily biodegradable, 91.5% degradation after 28 days. It is not expected to bioaccumulate based on a Log Kow of 0.621	Chemical not considered to pose an unreasonable risk to health of workers and public health on the basis of the Tier 1 IMAP Assessment.	Class 3; Packing Group III; UN1993
Silica dioxide	[redacted]	1	[redacted]	>0.69	>5000		Inorganic, N/A	A naturally-occurring material not expected to degrade.	Chemical identified as low concern to human health by application of expert validated rules	No
Siloxanes and silicones, dimethyl, reaction products with silica	[redacted]	1	[redacted]	0.695	>4800			It is not readily biodegradable with a half life in soil of 2.4-3.9 years. In freshwater sediments it is hydrolysed after 1 year. It is not expected to bioaccumulate	Low concern polymer	No
Sodium 4-chloro-3-methylbenzoate	[redacted]	1	[redacted]	12.2	>2000			It is expected to be readily biodegradable both aerobically and anaerobically. This chemical has low potential for bioaccumulation based on the BCF value of 4.79 L/kg and log K_{ow} value of 0.138	NA	No
Sodium bicarbonate	[redacted]	1	[redacted]	>4.74	>4000		Dissociates completely	Dissociates completely to sodium (Na+) and bicarbonate (HCO3-) ions which are both ubiquitous in the environment. It will not adsorb on particulate matter or surfaces and will not accumulate	Chemical identified as low concern to human health by application of expert validated rules	No
Sodium bisulfite	[redacted]	1	[redacted]	>5.5	1540		Dissociates completely	Dissociates in water to form (Na+) ions, bisulfite ions (HSO3-), sulfite (SO23-) ions, and sulfur dioxide (SO2) which is a gas. It is not expected to bioaccumulate in the environment because of its dissociation to ionic species and a gas.	NA	No
Sodium carbonate	[redacted]	1	[redacted]	2.3	2800		Dissociates completely	Dissociates completely to sodium (Na+) and carbonate (CO32-) ions which are both ubiquitous in the environment. It is not expected to bioaccumulate.	NA	No
Sodium Chloride	[redacted]	1	[redacted]	>42	>3550		Dissociates completely	Dissociates completely in aqueous solutions to sodium and chloride which are ubiquitous in the environment. Therefore, this chemical is not expected to bioaccumulate.	Chemical identified as low concern to human health by application of expert validated rules	No
Sodium diacetate	[redacted]	1	[redacted]	ND	5600			Readily biodegradable, 99% degradation after 28 days. It is not expected to bioaccumulate based on a log K_{ow} of -3.72	Chemical identified as low concern to human health by application of expert validated rules	No

Chemical Name	CAS Number	Tier	Concentration in Injected Fluid (mg/L)	LC50 (mg/L)	Rat Lethal Dose (mg/kg)	Ratio of Lethal Dose to Maximum Concentration	Persistence	Environmental Fate Summary	NICNAS - Low Concern Chemical/Polymer	Dangerous Goods Code Required for Transport
Sodium hydroxide	[redacted]	1	[redacted]	ND	325		Dissociates completely	Dissociates completely in the aquatic environment to ubiquitous ions (sodium and hydroxyl). It is not expected to bioaccumulate	NA	Class 8; Packing Group II; UN1824, Corrosive liquid
Sodium iodide	[redacted]	1	[redacted]	ND	2779		Inorganic, N/A	Dissociates in water to (Na+) and (I-) ions. It is not bioaccumulative	Chemical not considered to pose an unreasonable risk to health of workers and public health on the basis of the Tier 1 IMAP Assessment.	Hazard class 9; UN3077
Sodium perborate tetrahydrate	[redacted]	1	[redacted]	1.17	2567		Inorganic, N/A	Unlikely to bioaccumulate	NA	No
Sodium persulfate	[redacted]	1	[redacted]	>5.1	895		Dissociates completely	Dissociates in aqueous media to the sodium cation and persulfate anion. The persulfate anion will readily hydrolize (decompose) to sulfate ions.	NA	Class 5.1; Packing Group: III; UN1505
Sodium polyacrylate	[redacted]	1	[redacted]	ND	>5000			It is not readily biodegradable. It is not expected to bioaccumulate due to its high molecular weight	Polymer identified as low concern to human health by application of expert validated rules	No
Sodium sulfate	[redacted]	1	[redacted]	>2.4	>2000		Dissociates completely	Dissociates in aqueous media to sodium and sulfate ions, which are ubiquitous in the environment. It is not expected to bioaccumulate.	Chemical identified as low concern to human health by application of expert validated rules	No
Sodium Sulfite	[redacted]	1	[redacted]	>5.5	2610		Dissociates completely	Dissociates in water to form sodium (Na+) ions, sulphite (SO23-) ions, and bisulphite ions (HSO3-).It is not expected to bioaccumulate in the environment because of its dissociation to ionic species and a gas.	NA	No
Sodium Tetraborate Decahydrate	[redacted]	1	[redacted]	>2.01	>2500		Inorganic, N/A	It is unlikely to bioaccumulate due to its high water solubility.	NA	No
Sodium thiosulfate	[redacted]	1	[redacted]	>2500	>2000		Dissociates completely	Dissociates in aqueous media to sodium (Na+) and thiosulfate (S2O32-) ions which are ubiquitous in the environment. It is not expected to bioaccumulate.	Chemical identified as low concern for human health	No
Sodium-2-Chloro-5-fluorobenzoate	[redacted]	1	[redacted]	12.2	>2000			It is expected to be readily biodegradable both aerobically and anaerobically. This chemical has a low potential for bioaccumulation based on the BCF value of 3.98 L/kg and log K_{ow} value of -1.36.	NA	No
Sorbitan monooleate polyoxyethylene derivative	[redacted]	1	[redacted]	ND	>30			Readily biodegradable, 61% degradation after 28 days. It has a low potential for bioaccumulation	NA	No
Sorbitan, mono-9-octadecenoate, (Z)	[redacted]	1	[redacted]	>5	>15900			Readily biodegradable. It has a low potential for bioaccumulation.	NA	No

Chemical Name	CAS Number	Tier	Concentration in Injected Fluid (mg/L)	LC50 (mg/L)	Rat Lethal Dose (mg/kg)	Ratio of Lethal Dose to Maximum Concentration	Persistence	Environmental Fate Summary	NICNAS - Low Concern Chemical/Polymer	Dangerous Goods Code Required for Transport
Soybean oil	[redacted]	1	[redacted]	ND	2500			It is expected to be readily biodegradable. Estimated BCF of 255 L/kg after 28 days of exposure.	Chemical identified as low concern to human health by application of expert validated rules	No
Tetrasodium ethylenediaminetetraacetate	[redacted]	1	[redacted]	ND	1700			It is not readily biodegradable; however, it can degrade under realistic environmental surface water conditions. Therefore considered ultimately biodegradable. It is resistant to hydrolysis. It has a low potential to bioaccumulate based on BCF values of 1.8 and 1.1 from a 28 day fish test.	NA	No
Tributyl tetradecyl phosphonium chloride	[redacted]	2	[redacted]	<0.05	>10002			It is not readily biodegradable in an OECD 301 test; however, after 24 and 168 hours, degradation was >81% and >98% in a die-away (stmulation) test and in activated sludge, there was >40% degradation after 30 days. It is not expected to bioaccumulate based on a reported Log Kow of 2.45.	NA	Class 8 and 6.1; Packing Group II; UN2922
Triethanol amine	[redacted]	1	[redacted]	ND	6400			Readily biodegradable, 96% degradation after 19 days. It has a low potential to bioaccumulate based on reported BCF values <0.4 and <3.9 at concentrations of 2.5 and 0.25 mg/L.	NA	No
Ulexite	[redacted]	1	[redacted]	ND	ND		Inorganic, N/A	It is not expected to bioaccumulate based on BCF values of <0.1 to 10.5 in fish and oysters	NA	No
Urea	[redacted]	1	[redacted]	ND	1500			It is readily biodegradable, reaching 90-100% degradation after 21 days. It has a low potential to bioaccumulate with BCF values in fish reported as 1 or <10.	Chemical identified as low concern to human health by application of expert validated rules	No
Vinylidene chloride/methylacrylate copolymer	[redacted]	1	[redacted]	ND	ND			This polymer is not expected to undergo rapid degradation and bioaccumulation is expected to be minimal based on its molecular weight (>1000 g/mol)	Low concern polymer	No

Notes:
% = percent; BCF = bioconcentration factor; g/L = grams per litre; g/mol = grams per mol; K_{ow} = octanol water coefficient; LC = lethal concentration; L/kg = litres per kilogram; mg/L = milligrams per litre; mg/kg = milligrams per kilogram; QSAR = Quantitative Structure Activity Relationship

Refer to **Appendix C** for additional information on chemical.

Persistence Legend	
Colour/symbol	**Risk Level**
	Very Low
	Low
	Moderate
	High
	Very High
	Low but uncertain. Predicted risk or similar chemical tested.
	Moderate but uncertain. Predicted risk or similar chemical tested.
	High but uncertain. Predicted risk or similar chemical tested.
	Very High but uncertain. Predicted risk or similar chemical tested.
ND	No data
Inorganic, N/A	Chemical is inorganic, biodegradation assessment is not applicable.

Ratio of Lethal Dose to Maximum Concentration Key	
	No Data
	≥ 100
	10 to 100
	1 to 10
	≤ 1

2.3 Tier 2 Assessment

Of the chemicals evaluated for the four hydraulic fracturing system formulations, 9 chemicals were carried through to Tier 2 assessment. Chemicals identified in the Tier 1 assessment with a high ecotoxicity hazard assessment and therefore having a potential avian wildlife exposure to fluids stored in treatment tanks; meeting this criterion and having the requisite toxicity data for a Tier 2 assessment include:

- Chlorous acid, sodium salt (CAS number [redacted]
- Crontonaldehyde (CAS number [redacted]
- Glutaraldehyde (CAS number [redacted]
- Tributyl tetradecyl phosphonium chloride (CAS number [redacted]
- Dicoco dimethyl quaternary ammonium chloride (CAS number [redacted]
- Octamethylcyclotetrasiloxane (CAS number [redacted]
- Decamethylcylopentasiloxane (CAS number [redacted]
- Dodecamethylcyclohexasiloxane (CAS number [redacted]
- Copper (II) sulfate (CAS number [redacted]

No chemicals were identified in the Tier 1 assessment for a human health Tier 2 assessment.

2.3.1 Avian Wildlife

Potential exposure to selected chemical additives and/or flowback in treatment tanks by avian wildlife was assessed for representative avian species. **Appendix E** presents the outcomes of the Tier 2 assessment for these chemicals. The selected chemicals include:

- Chlorous acid, sodium salt (CAS number [redacted]
- Crontonaldehyde (CAS number [redacted]
- Glutaraldehyde (CAS number [redacted]
- Tributyl tetradecyl phosphonium chloride (CAS number [redacted]
- Dicoco dimethyl quaternary ammonium chloride (CAS number [redacted]
- Octamethylcyclotetrasiloxane (CAS number [redacted]
- Decamethylcylopentasiloxane (CAS number [redacted]
- Dodecamethylcyclohexasiloxane (CAS number [redacted]
- Copper (II) sulfate (CAS number [redacted]

The potential exposure pathway for avian wildlife was assessed based on the potential ingestion of waters containing the selected chemicals (including flowback) from treatment tanks that were used for storage during the hydraulic fracturing activities of approximately three weeks. If a chemical was included in multiple fluid systems (e.g., glutaraldehyde), the maximum injected concentration (present in any of the fluid systems) was used in the Tier 2 assessment. Potential dietary intake of water containing these chemicals was compared to toxicity reference values developed specifically for avian wildlife to estimate a hazard quotient; a potential hazard quotient threshold level less than 1 indicates there are no unacceptable exposures to the avian species.

The hazard quotient for all the assessed avian species was orders of magnitude less than the threshold hazard quotient level of 1 (**Appendix E**). Therefore, there were no unacceptable exposures to the avian species. In addition, as a further conservative consideration, even if the potential exposure period is expanded to one year, the hazard quotient for the assessed avian species still will be orders of magnitude less than the threshold hazard quotient level of 1.

3 Summary and Risk Management

The goal of the chemical risk assessment was to demonstrate that potential risks associated with hydraulic stimulation chemicals proposed for use by Imperial and Imperial A across their NT tenement have been eliminated or reduced as much as is reasonably practicable to potentially exposed human and ecological receptors.

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 hydraulic stimulation chemicals within the life cycle (i.e., mixing, usage and storage) may result in potential exposure to 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.

inGauge has developed and implemented a range of systems and plans to control the transportation and storage of chemicals during field development and operational activities. This includes personnel induction and training, effective traffic management and routing to minimise the potential for accidents and spill management planning and response equipment. These systems and processes are considered effective in lowering the probability of occurrence of consequence associated with transportation incidents.

The human health and ecological hazard mitigation information provided in the chemical risk assessment dossiers and SDSs primarily focuses on safe handling, transportation and worker protection.

Based on the outcomes of this assessment, no further management controls are considered necessary.

4 Limitations

EHS Support Pty Ltd ("EHS Support") has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of inGauge and only those third parties who have been authorised in writing by EHS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal email dated 18 July 2024 and subsequent emails.

The methodology adopted and sources of information used by EHS Support are outlined in this report. EHS Support has made no independent verification of this information beyond the agreed scope of works, and EHS Support assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that the information contained in this report as provided to EHS Support was false.

This report was prepared through August 2024 and October 2024 and is based on the information reviewed at the time of preparation. EHS Support disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for the use of any part of this report in any other context or for any other purpose, or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

5 References

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Tables

Table 1 Evaluation of Compiled List of Chemicals

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Mar-20	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	[redacted]	[redacted]	**PNECwater** - not derived **PNECsoil** - not derived	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low Concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Not considered persistent. PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: expected to have a low potential for bioaccumulation PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	2-Ethyl hexanol	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} Fathead minnow - 28.2 mg/L -96-hr LC_{50} Golden Orfe - 17.1 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - 39 mg/L Acute Aquatic - Algae and other aquatic plants -72-hr EC_{50} *Scenedesmus subspicatus* - 11.5 mg/L (biomass); 16.6 mg/L (growth rate) -EC_{10} *Scenedesmus subspicatus* - 3.2 mg/L (biomass); 5.3 mg/L (growth rate) Chronic Aquatic - Algae and other aquatic plants -72-hr EC_{10} *Scenedesmus subspicatus* was 3.2 mg/L (biomass) and 5.3 mg/L (growth rate) **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.012 mg/L (Acute Daphnia) **$PNEC_{soil}$** - 0.027 mg/kg soil dry weight (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Harmful to aquatic life PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: Log Kow is 2.9 No bioconcentration studies PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Acetaldehyde	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic-Fish -96-hr LC_{50} - *Pimephales promelas* - 30.8 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - 48.3 mg/L Acute Aquatic - Algae and other aquatic plants -120d EC_{50} - *Nitzscheria linearis* >237 and <249 mg/L **Chronic Aquatic** -No experimental studies are available. **Terrestrial Toxicity** -No experimental studies are available. **$PNEC_{water}$** - 0.3 mg/L (acute fish) **$PNEC_{soil}$** - 0.012 mg/kg soil dry weight (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - Eye/respiratory irritant; animal carcinogen (inhalation); suspect mutagen. Ecological Hazard - Harmful to aquatic life PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Hazard Assessment: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: log Kow is -0.17 PBT Assessment: Does not meet the screening criteria for bioaccumulation.

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Mar-20	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	[redacted]	Tier 1	PBT Assessment: The overall conclusion is that 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 is not a PBT substance Management: No additional management required, Tier 1 screening satisfied.	NA
	2-Ethyl hexanol	[redacted]	Tier 1 (Qualitative Assessment/ PBT)	PBT Assessment: The overall conclusion is that 2-ethylhexanol is not a PBT substance. Qualitative assessment indicates that this chemical is of low concern to human health. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release.	NA
	Acetaldehyde	[redacted]	Tier 1 (Qualitative/ PBT Exposure Assessment)	PBT Assessment: The overall conclusion is that acetaldehyde is not a PBT substance. Qualitative assessment indicates that this chemical may pose a hazard to human health (e.g., eye/respiratory irritant). The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. This chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT criteria for toxicity to aquatic organisms. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Mar-20	Acetic acid	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Oncorhynchus mykiss* - (test substance potassium acetate) >300.82 mg/L (as acetate ion) -96-hr LC_{50} *Danio rerio* - (test substance potassium acetate) >300.82 mg/L (as acetate ion) -96-hr LC_{50} *Oncorhynchus mykiss* - (test substance acetic acid) 64.8 mg/L (measured) -96-hr LC_{50} *Oncorhynchus mykiss* - (test substance acetic acid) 31.3 mg/L - 67.6 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - (test substance potassium acetate) >300.82 mg/L (as acetate ion) -48-hr EC_{50} *Daphnia magna* - (test substance acetic acid) 79.5 mg/L (measured) -48-hr EC_{50} *Daphnia magna* - (test substance acetic acid) 18.9 mg/L (measured) Acute Aquatic - Algae and other aquatic plants -72-hr EC_{50} *Desmodesmus subspicatus* - 486.5 mg/L Chronic Aquatic - Fish -21-day *Oncorhynchus mykiss* study - measured NOEC 57.2 mg/L (60% acetic acid) and 34.3 mg/L (100% acetic acid) Chronic Aquatic - Invertebrate -21-day *Daphnia magna* reproduction study measured NOEC 80 mg/L (60% acetic acid) and 31.4 mg/L (100% acetic acid) -21-day *Daphnia magna* reproduction study measured NOEC 22.7 mg/L (100% acetic acid) **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 3.0 mg/L (E(L)C50 test fish or *Dapnhia magna*) **$PNEC_{soil}$** - 0.04 mg/kg soil dry weight (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - Corrosive, respiratory irritant Ecological Hazard - Low Concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Hazard Assessment: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: Low Kow is -0.17 PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Acrylamide acrylate copolymer	[redacted]	[redacted]	**$PNEC_{water}$** - 0.1 mg/L (acute fish) **$PNEC_{soil}$** - not calculated	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low Concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Not biodegradable PBT Assessment: Does meet the criteria for persistence.	Environmental Fate Property: Not expected to bioaccumulate because of poor water solubility and high molecular weight PBT Assessment: Does not meet criteria for bioaccumulation
	Acrylamide, sodium acrylate polymer	[redacted]	[redacted]	**Aquatic and Terrestrial Toxicity** -No studies are available. -Expected to be low concern for toxicity to aquatic organisms. Due to poor solubility and high molecular weight not expected to be bioavailable. Does not contain any reactive functional groups. **PNECs** - not calculated	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low Concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Not biodegradable PBT Assessment: Does meet the criteria for persistence.	Environmental Fate Property: Not expected to bioaccumulate because of poor water solubility and high molecular weight PBT Assessment: Does not meet criteria for bioaccumulation

Table 1
Evaluation of Compiled List of Chemicals
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Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Mar-20	Acetic acid	[redacted]	Tier 1 (NICNAS/ PBT/ Exposure Assessment)	NICNAS Assessment (2018) Human Health - potentially harmful to public health in event of transport spill. - potentially harmful to workers health in event of industrial incident Environment -unlikely to cause harm to environment PBT Assessment: The overall conclusion is that acetic acid is not a PBT substance. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT criteria for toxicity to aquatic organisms. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA
	Acrylamide acrylate copolymer	[redacted]	Tier 1 (NICNAS/ PBT/ Exposure Assessment)	NICNAS Assessment (2018) NICNAS assessed in an IMAP Tier 1 assessment and considers it a "polymer identified as low concern to human health by application of expert validated rules" PBT Assessment: The overall conclusion is that acrylamide/sodium acrylate copolymer is not a PBT substance. The estimated injected concentration did exceed the PNECs for this chemical and is not biodegradable. However, this chemical does not bioaccumulate and does not meet the PBT criteria for toxicity to aquatic organisms. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release.	NA
	Acrylamide, sodium acrylate polymer	[redacted]	Tier 1 (NICNAS/ PBT)	NICNAS Assessment (2018) NICNAS assessed in an IMAP Tier 1 assessment and considers it a "polymer identified as low concern to human health by application of expert validated rules". PBT Assessment: The overall conclusion is that acrylamide/sodium acrylate copolymer is not a PBT substance. Management: No additional management required, Tier 1 screening satisfied.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Mar-20	Acrylonitrile	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} Oryzias latipes - 5.1 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - 2.5 mg/L Acute Aquatic - Algae and other aquatic plants -72-hr EC_{50} *Pseudokirchneriella subcapitata* - 10 mg/L (biomass) Chronic Aquatic - Algae and other aquatic plants -30-day LOEC Pimephales promelas in a fish early life stage test was 0.34 mg/L. A NOEC of 0.17 mg/L is derived by LOEC/2. -The 21-day NOEC from a Daphnia reproduction test is 0.5 mg/L (ECHA) [Kl. score = 1]. -The 72-hr NOEC to Pseudokirchneriella subcapitata is 0.95 mg/l based on growth rate (ECHA) [Kl. score = 1]. **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.017 mg/L **$PNEC_{soil}$** - 0.002 mg/kg soil dry weight	Qualitative Assessment: Human Health Hazard - High acute toxicity (oral, dermal, inhalation); skin/respiratory irritant; skin sensitizer; animal carcinogen (oral and inhalation) Ecological Hazard - Toxic to aquatic life with long lasting effects. PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Inherently biodegradable PBT Assessment: Does not meet the criteria for persistence.	Environmental Fate Property: log Kow 1.04 PBT Assessment: Does not meet criteria for bioaccumulation
	Alcohols, C10-16, ethoxylated propoxylated	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic -Fish: 3 species, 96-hr LC_{50} - 1200 to 2000 µg/L. -Invertebrate: 1 species, 48-hr EC_{50} 140 to 2840 µg/L. -Algae, 2 species, 410 to 1300 µg/L. Chronic Aquatic Freshwater fish: 2 species, 720 to 1,500 µg/L. Freshwater crustaceans: 2 species, 590 to 860 µg/L. Freshwater rotifers: 1 species, Brachionus calyciflorus, 1,300 µg/L. Freshwater algae, diatoms and blue-green algae: 6 species, 200 to 8,700 µg/L. Freshwater mesocosms: 4 NOEC data for multiple species tests were 80, 80, 320 and 330 µg/L, although replication was insufficient to meet OECD (1992) requirements. Normalised data were 380, 380, 320 and 1,520 µg/L. **Terrestrial Toxicity** -No studies are available **$PNEC_{water}$** - 0.14 mg/L (ANZECC Water Quality Guideline for alcohol ethoxyates) **$PNEC_{soil}$** - 2.2 mg/kg dry weight (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - irritating to eyes Ecological Hazard - moderate chronic toxicity to aquatic life PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: Log K_{ow} range from <5 to 387.5 PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Alcohols, C12-15, ethoxylated	[redacted]	[redacted]	**Aquatic Toxicity** Toxicity values (NOECs) utilised in development of ANZECC water quality guideline for alcohol ethoxylates: -Freshwater fish: 2 species, 720 to 1,500 µg/L -Freshwater crustaceans: 2 species, 590 to 860 µg/L. -Freshwater rotifers: 1 species, Brachionus calyciflorus, 1,300 µg/L -Freshwater algae, diatoms and blue-green algae: 6 species, 200 to 8,700 µg/L. - Freshwater mesocosms: 4 NOEC data for multiple species tests were 80, 80, 320, and 330µg/L, although replication was insufficient to meet OECD (1992) requirements. Normalised data were 380, 380, 320, and 1,520 µg/L. **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.140 mg/L (ANZECC Water Quality Guideline for alcohol ethoxyates) **$PNEC_{soil}$** - 0.9 - 5.6 (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Harmful to aquatic life with long lasting effects PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: Log Kow range from <5 to 387.5 PBT Assessment: Does not meet the screening criteria for bioaccumulation.

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Mar-20	Acrylonitrile	[redacted]	Tier 1 (PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that acrylonitrile is not a PBT substance. Qualitative Assessment indicated human health hazard of skin/respiratory irritant, acute toxicity via oral, dermal, and inhalation pathway; and, carcinogenic to animals. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is inherently biodegradable, does not bioaccumulate, and does not meet the PBT criteria for toxicity to aquatic organisms. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure.	NA
	Alcohols, C10-16, ethoxylated propoxylated	[redacted]	Tier 1 (Qualitative/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that Alcohols, C10-16, ethoxylated propoxylated is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., eye irritant). While the estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA
	Alcohols, C12-15, ethoxylated	[redacted]	Tier 1 (Qualitative/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that Alcohols, C12-15, ethoxylated is not a PBT substance. Qualitative Assessment indicated low concern to human health; however harmful effects to aquatic life. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT criteria for toxicicty. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Mar-20	Alcohols, C12-16, ethoxylated	[redacted]	[redacted]	**Aquatic Toxicity** Toxicity values (NOECs) utilised in development of ANZECC water quality guideline for alcohol ethoxylates: -Freshwater fish: 2 species, 720 to 1,500 µg/L -Freshwater crustaceans: 2 species, 590 to 860 µg/L. -Freshwater rotifers: 1 species, Brachionus calyciflorus, 1,300 µg/L -Freshwater algae, diatoms and blue-green algae: 6 species, 200 to 8,700 µg/L. - Freshwater mesocosms: 4 NOEC data for multiple species tests were 80, 80, 320, and 330µg/L, although replication was insufficient to meet OECD (1992) requirements. Normalised data were 380, 380, 320, and 1,520 µg/L **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.140 mg/L (ANZECC Water Quality Guideline for alcohol ethoxyates) **$PNEC_{soil}$** - 0.0 to 10.7 mg/kg dry weight soil (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - irritating to eyes Ecological Hazard - moderate chronic toxicity to aquatic life PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: Log Kow range from <5 to 387.5 PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Alcohols, C6-12, ethoxylated propoxylated	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic -Fish: 3 species, 96-hr LC_{50} - 1200 to 2000 µg/L. -Invertebrate: 1 species, 48-hr EC_{50} 140 to 2840 µg/L. -Algae, 2 species, 410 to 1300 µg/L. Chronic Aquatic Freshwater fish: 2 species, 720 to 1,500 µg/L. Freshwater crustaceans: 2 species, 590 to 860 µg/L. Freshwater rotifers: 1 species, Brachionus calyciflorus, 1,300 µg/L. Freshwater algae, diatoms and blue-green algae: 6 species, 200 to 8,700 µg/L. Freshwater mesocosms: 4 NOEC data for multiple species tests were 80, 80, 320 and 330 µg/L, although replication was insufficient to meet OECD (1992) requirements. Normalised data were 380, 380, 320 and 1,520 µg/L. **Terrestrial Toxicity** -No studies are available **$PNEC_{water}$** - 0.14 mg/L (ANZECC Water Quality Guideline for alcohol ethoxyates) **$PNEC_{soil}$** - 2.2 mg/kg dry weight (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - irritating to eyes Ecological Hazard - moderate chronic toxicity to aquatic life PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: Log K_{ow} range from <5 to 387.5 PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Aldol	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic -96-hr LC_{50} - Fish - 134 mg/L -48-hr EC_{50} *Daphnid* - 840 mg/L -96-hr EC_{50} *Green Algae* - 692 mg/L **Chronic Aquatic** -No experimental studies are available. **Terrestrial Toxicity** -No experimental studies are available. **$PNEC_{water}$** - 0.13 mg/L **$PNEC_{soil}$** - 0.002 mg/kg soil dry weight	Qualitative Assessment: Human Health Hazard - Expected to be eye/respiratory irritant; low concern for systemic toxicity. Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: low kow = -0.722 PBT Assessment: Does not meet the screening criteria for bioaccumulation.

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Mar-20	Alcohols, C12-16, ethoxylated	[redacted]	Tier 1 (Qualitative/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that Alcohols, C12-16, ethoxylated is not a PBT substance. Qualitative Assessment indicated low concern to human health (e.g., eye irritant).. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable and does not bioaccumulate. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA
	Alcohols, C6-12, ethoxylated propoxylated	[redacted]	Tier 1 (Qualitative/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that Alcohols, C6-12, ethoxylated propoxylated is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., eye irritant). While the estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. This chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA
	Aldol	[redacted]	Tier 1 (Qualitative Assessment/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that aldol is not a PBT substance. Qualitative assessment indicates that this chemical may pose a hazard to human health (e.g., eye/respiratory irritant). The estimated injected concentration did exceed the PNECs for this chemical. However, this chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT criteria for toxicity to aquatic organisms. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Management: Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Mar-20	Amides, tall-oil fatty, N,N-bis(hydroxyethyl)	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic -96-hr LC_{50} - Danio rerio - 5.1 mg/L -48-hr EC_{50} Daphnia magna - 3.2 mg/L -72-hr EC_{50} Desmodesmus subspicatus - 18.6 mg/L **Chronic Aquatic** -The 28-day NOEC to Oncorhynchus mykiss in a fish chronic toxicity study is 0.32 mg/L [nominal] and 0.26 mg/L [measured] (ECHA) [Kl. score =2]. -The 21-d NOEC in a Daphnia reproduction test is 0.1 mg/L [nominal] and 0.07 mg/L [measured] (ECHA) [Kl. score = 2]. -The 72-hr EC10 to Desmodesmus subspicatus is 1.4 mg/L (ECHA) [Kl. score = 2]. **Terrestrial Toxicity** -No experimental studies are available. **$PNEC_{water}$** -0.007 mg/L (Acute *Daphnia*) **$PNEC_{soil}$** - 0.16 (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard -Skin/eye irritant Ecological Hazard - Toxic to aquatic life PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Inherently biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: > 6 (experimental) PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Amine oxides, cocoalkyldimethyl	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic -96-hr LC_{50} - Salmo gairdneri - 13 mg/L -96-hr LC_{50} - Brachydanio rerio - 1.0 mg/L -96-hr LC50 - Leuciscus idus melanotus - 4.3 mg/L -48-hr EC_{50} Daphnia magna - 2.9 mg/L -72-hr EC_{50} Selenastrum capricornutum - 0.29 mg/L **Chronic Aquatic** -No studies available **Terrestrial Toxicity** -No experimental studies are available. **$PNEC_{water}$** -0.009 mg/L (Acute *Algae*) **$PNEC_{soil}$** - 0.18 mg/kg dry weight soil (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard -Skin irritant/Severe eye irritant Ecological Hazard - Moderately toxic to aquatic organisms PBT Assessment: Substance exhibits higher toxicity than that established by regulatory guidance.	Environmental Fate Property: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: log K_{ow} <2.7 PBT Assessment: Does not meet the criteria for bioaccumulation
	Benzaldehyde	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic -96-hr LC_{50} -Fathead minnow - 12.4 mg/L -96-hr LC_{50} -Rainbow trout- 11.2 mg/L -96-hr LC_{50} - Goldfish - 13.8 mg/L -96-hr LC_{50} - Channel catfish- 5.39 mg/L -96-hr LC_{50} - Bluegill - 1.07 mg/L -48-hr EC_{50} Daphnia magna - 19.7 mg/L -72-hr EC_{50} Pseudokirchneriella subcapitata - 33.1 (growth) 8.05 (yeild) **Chronic Aquatic** -7-day NOEC to 1- day Pimephales promelas larvae was 0.12 mg/L (measured) based on growth rate and mortality (ECHA) [Kl. score = 2]. -8-day NOEC to Scenedesmus quadricauda is 34 mg/L (ECHA) [Kl. score = 4]. -72-hr EC_{10} for Raphidocelis subcapitata was reported as 0.039 mg/L (ECHA) [Kl.score=1]. **Terrestrial Toxicity** -No experimental studies are available. **$PNEC_{water}$** -0.0008 mg/L (Acute *Algae*) **$PNEC_{soil}$** - 0.0003 mg/kg dry weight soil (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - Hazardous and considered harmful if swallowed. Low acute dermal toxicity and moderate acute inhalation toxicity potential. Ecological Hazard - Benzaldehyde has moderate toxicity to aquatic organisms PBT Assessment: Substance exhibits higher toxicity than that established by regulatory guidance.	Environmental Fate Property: Readily biodegradable. It has low potential to adsorb to soil or sediment. PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: Not Expected to bioaccumulate based on a log K_{ow} of 1.4 PBT Assessment: Does not meet the criteria for bioaccumulation

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Mar-20	Amides, tall-oil fatty, N,N-bis(hydroxyethyl)	[redacted]	Tier 1 (Qualitative/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that Amides, tall-oil fatty, N,N-bis(hydroxyethyl) is not a PBT substance. Qualitative Assessment indicated human health hazard of skin/eye irritant. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is inherently biodegradable, does not bioaccumulate, and does not meet the PBT criteria for toxicity to aquatic organisms. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Management: Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure.	NA
	Amine oxides, cocoalkyldimethyl	[redacted]	Tier 1 (Qualitative Assessment/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that Amine oxides, cocoalkyldimethyl is not a PBT substance. Qualitative Assessment indicated human health hazard of skin/eye irritant. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT criteria for toxicity to aquatic organisms. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release.Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA
	Benzaldehyde	[redacted]	Tier 1 (Qualitative Assessment/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that benzaldehyde is not a PBT substance. Qualitative assessment indicates that this chemical is of low to moderate concern to human health. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT criteria for toxicity to aquatic organisms. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Mar-20	Bismuth Oxide	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic -96-hr LC_{50} -Brachydanio rerio - >137 [WAF] and >100 [WAF]* mg/L -48-hr EC_{50} -Daphnia magna - >137 [WAF] and >100 [WAF]* mg/L -72-hr EC_{50} Daphnia - >137 [WAF] and >100 [WAF]* mg/L *As bismuth. The value for bismuth oxide is 223 mg/L (the molecular weight is 266 g/mol). **Chronic Aquatic** -No experimental studies are available. **Terrestrial Toxicity** -No experimental studies are available. **$PNEC_{water}$** -1.0 mg/L **$PNEC_{soil}$** - Cannot be derived using the equilibrium partitioning method.	Qualitative Assessment: Human Health Hazard -Low concern Ecological Hazard - Low concern PBT Assessment:Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Not relevant PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: slightly soluble in water PBT Assessment: Does not meet the criteria for bioaccumulation
	Butyl alcohol	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic -96-hr LC_{50} -Pimephelas promelas - 1,376 mg/L -48-hr EC_{50} -Daphnia magna - 1,328 mg/L -72-hr EC_{50} - Pseudokirchneriella subcapitata - 225 mg/L **Chronic Aquatic** -21-d NOEC from a Daphnia reproduction test is 4.1 mg/L (ECHA) [Kl. score = 2]. -96-hr EC10 to Pseudokirchneriella subcapitata is 134 mg/L (ECHA) [Kl. score = 1]. **Terrestrial Toxicity** -No experimental studies are available. **$PNEC_{water}$** -0.08 mg/L (Acute *Algae*) **$PNEC_{soil}$** - 0.004 mg/kg soil dry weight.	Qualitative Assessment: Human Health Hazard -Skin irritant/Severe eye irritant Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: log Kow = 1 PBT Assessment: Does not meet the criteria for bioaccumulation
	Crontonaldehyde	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Oncorhynchus mykiss* - 0.65 mg/L -96-hr LC_{50} *Pimephales promelas* - 0.84 mg/L -96-hr LC_{50} *Lepomis macrochirus* - 3 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - 2 mg/L Acute Aquatic - Algae and other aquatic plants -72-hr EC_{50} *Pseudokirchneriella subcapitata* - 0.597 mg/L -96-hr EC_{50} *Pseudokirchneriella subcapitata* - <0.881 mg/L Chronic Aquatic - Fish -21-day *Oryzias latipes* early stage life toxicity NOEC 0.0247 mg/L Chronic Aquatic - Algae and other aquatic plants -96-hr *Pseudokirchneriella subcapitata* study EC_{10} 0.385 mg/L **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.0005 mg/L (lowest NOEC) **$PNEC_{soil}$** - 0.00007 mg/kg soil dry weight (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard: Very high acute toxicity (dermal, inhalation); moderate-to-high acute toxicity (oral); skin/respiratory irritant; severe eye irritant; repeated inhalation exposures may cause nasal lesions; suspect mutagen. Ecological Hazard: Very toxic to aquatic life with long lasting effects. PBT Assessment: Substance exhibits higher toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: Experimental log Kow is 0.6 PBT Assessment: Does not meet the criteria for bioaccumulation.

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Mar-20	Bismuth Oxide	[redacted]	Tier 1 (Qualitative/ PBT)	PBT Assessment: The overall conclusion is that bismuth oxide is not a PBT substance. Qualitative assessment indicates that this chemical is of low concern to human health. Management: No additional management required, Tier 1 screening satisfied.	NA
	Butyl alcohol	[redacted]	Tier 1 (Qualitative/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that butyl alcohol is not a PBT substance. Qualitative Assessment indicated human health hazard of Skin irritant/Severe eye irritant. The estimated injected concentration did exceed the PNECs for this chemical. However, this chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted for aquatic receptors. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure.	NA
	Crontonaldehyde	[redacted]	Tier 2	PBT Assessment: The overall conclusion is that Crontonaldehyde is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., acute toxicity, severe eye irritant). The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted for aquatic receptors. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure. Chemicals with a high ecotoxicity hazard assessment have a potential avian wildlife exposure to chemicals stored in treatment tanks. Therefore, a Tier 2 assessment was conducted for avian receptors.	A quantitative risk characterisation was used to assess the risk to avian receptors from potential exposure to crontonaldehyde (Appendix E). There were no unacceptable potential risks to avian receptors as a result of ingestion of waters stored in treatment tanks.

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Mar-20	Chlorous acid, sodium salt	[redacted]	[redacted]	**PNECwater** -0.001 mg/L (Acute Algae) **PNECsoil** -not derived	Qualitative Assessment: Human Health Corrosive; moderate-to-high acute oral toxicity. Repeated exposures may cause blood effects Ecological Hazard - Very toxic to aquatic life. Harmful to aquatic life with long lasting effects. PBT Assessment: Substance exhibits higher toxicity than that established by regulatory guidance.	Environmental Fate Property: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	PBT Assessment: Does not meet the criteria for bioaccumulation (ionic species)
	Choline Chloride	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Oryzias latipes* - >100 mg/L (nominal and measured) -96-hr LC_{50} *Leuciscus idus* - >10,000 mg/L (78% solution of choline chloride) Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - 349 mg/L (nominal and measured) -48-hr EC_{50} *Daphnia magna* - >500 mg/L (78% solution of choline chloride) Acute Aquatic - Algae and other aquatic plants -72-hr EC_{50} *Pseudokirchneriella subcapitata* - >1,000 (nominal and measured) Chronic Aquatic - Invertebrate -21-day *Daphnia magna* reproduction test NOEC 30.2 mg/L (nominal and measured) Chronic Aquatic - Algae and other aquatic plants -72-hr *Pseudokirchneriella subcapitata* study NOEC 30.2 mg/L **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.3 mg/L **$PNEC_{soil}$** - 0.007 mg/kg soil dry weight (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard -Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: Experimental log Kow is -3.77 PBT Assessment: Does not meet the criteria for bioaccumulation.
	Cinnamaldehyde	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Brachydanio rerio* - 4.15 mg/L -96-hr LC_{50} *Poecilia reticulata* - >3.5 Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - 3.21 mg/L Acute Aquatic - Algae and other aquatic plants -72-hr EC_{50} *Desmodesmus subspicatus* - 31.6 mg/L -72-hr EC_{50} *Chlorella vulgaris* - 16.09 mg/L Chronic Aquatic - Fish -28-day LOEC *Oryzias latipes* 66.08 mg/L **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.04 mg/L (Acute Fish) **$PNEC_{soil}$** - 0.02 mg/kg dry weight soil (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard -Skin/eye irritant; skin sensitizer Ecological Hazard - Toxic to aquatic life PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable. PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: log Kow is 2.107 PBT Assessment: Does not meet the screening criteria for bioaccumulation.

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Mar-20	Chlorous acid, sodium salt	[redacted]	Tier 2	PBT Assessment: The overall conclusion is that butyl alcohol is not a PBT substance. Qualitative Assessment indicated human health hazard of Skin irritant/Severe eye irritant. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure. Chemicals with a high ecotoxicity hazard assessment have a potential avian wildlife exposure to chemicals stored in treatment tanks. Therefore, a Tier 2 assessment was conducted for avian receptors.	A quantitative risk characterisation was used to assess the risk to avian receptors from potential exposure to chlorous acid, sodium salt (Appendix E). There were no unacceptable potential risks to avian receptors as a result of ingestion of waters stored in treatment tanks.
	Choline Chloride	[redacted]	NA	NICNAS: Identified as chemical of low concern for human health in National assessment of chemicals associated with coal seam gas extraction in Australia, Tech Report Number 11 (NICNAS, 2017) PBT Assessment: The overall conclusion is that choline chloride is not a PBT substance. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. This chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: No additional management required, Tier 1 screening satisfied.	NA
	Cinnamaldehyde	[redacted]	Tier 1 (Qualitative Assessment/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that cinnamaldehyde is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., skin irritant). The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. This chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Mar-20	Citric acid	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -48-hr LC50 Leuciscus idus melanotus (golden orfe) - 440 mg/L and 760 mg/L -96-hr LC50 Lepomis macrochirus (fathead minnow)- >100 mg/L Acute Aquatic - Invertebrate -24-hr EC50 Daphnia magna - 85 mg/L (un-neutralised test solution) 1,535 mg/L in neutralised solution Acute Aquatic - Algae and other aquatic plants -8-day EC_0 Scenedesmus quadricauda - 640 mg/L Chronic Aquatic -No chronic studies available **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.44 mg/L (Acute Daphnia) **$PNEC_{soil}$** - 0.002 mg/kg soil dry weight (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard -Eye irritant Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: log Kow is -1.61 to -1.80 PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Cocobetaine	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic The lowest acute LC/EC50 values for fish, Daphnia, and algae are all in the range of 1.3 – 2 mg active substance/L **Chronic Aquatic** -72-hr NOEC Daphnia - 0.932 mg active substance/L -72-hr NOEC algae 3.55 active substance/L -72-hr EC50 algae - 9.86 mg active substance/L **Terrestrial Toxicity** Two studies (without analytical monitoring) of effects on earthworms and higher plants showed low toxicity (no data provided). Refer to toxicity profile for additional information **$PNEC_{water}$** - 0.0032 mg/L (chronic fish) **$PNEC_{soil}$** - 0.028 mg/kg soil dry weight (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard -Skin irritant; skin sensitizer Ecological Hazard - Harmful to aquatic life with long lasting effects PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: BCF between 3 and 71 PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Crystalline silica, quartz	[redacted]	[redacted]	**Aquatic and Terrestrial Toxicity** -No studies are available. -Expected to be low concern for toxicity to aquatic organisms. **$PNEC_{water}$** - not derived **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Hazard: Inhalation: silicosis and lung cancer in humans. Oral/dermal: low concern. Ecological Hazard: Low concern PBT Assessment: Substance exhibits higher toxicity than that established by regulatory guidance.	Environmental Fate Properties: Not relevant PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: water-insoluble mineral; not bioavailable PBT Assessment: Does not meet the screening criteria for bioaccumulation.

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Mar-20	Citric acid	[redacted]	Tier 1 (NICNAS/ PBT/ Exposure Assessment)	NICNAS: Identified as chemical of low concern for human health in National assessment of chemicals associated with coal seam gas extraction in Australia, Tech Report Number 11 (NICNAS, 2017) Qualitative Assessment indicated potential hazard to human health (e.g., eye irritant). PBT Assessment: The overall conclusion is that citric acid is not a PBT substance. The estimated injected concentration did exceed the PNECs for this chemical. This chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure.	NA
	Cocobetaine	[redacted]	Tier 1 (Qualitative/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that cocobetaine is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., skin irritant). The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. This chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure.	NA
	Crystalline silica, quartz	[redacted]	Tier 1 (Qualitative Assessment/ PBT)	PBT Assessment: The overall conclusion is that Crystalline silica, quartz is not a PBT substance. Qualitative Assessment indicated hazardous to human health by the inhalation pathway; not hazardous by the oral/dermal route. Management: Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure. Therefore a Tier 2 Assessment is not warranted.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Mar-20	Diethanolamine	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Oncorhynchus mykiss* - 460 mg/L -96-hr LC_{50} *Pimephales promelas* - 1,460 mg/L (geometric mean of 96-h LC_{50} values of fry, juvenile, and subadult fish. not neutralised) -96-hr LC_{50} *Pimephales promelas* - 1,664 mg/L -48-hr LC_{50} *Lepomis macrochiru* s - 1,850 mg/L -24-hr LC_{50} *Carassius auratus* - >5,000 mg/L (neutralised) 800 (non-neutralised) Acute Aquatic - Invertebrate -48-hr EC_{50} *Ceriodaphnia dubia* - 30.1 mg/L (24°C), 89.9 (20°C) -48-hr EC_{50} *Daphnia magna* - 55 mg/L -48-hr EC_{50} *Daphnia magna* - 171 mg/L Acute Aquatic - Algae and other aquatic plants -72-hr EC_{50} *Pseudokirchneriella subcapitata* - 9.5 mg/L (growth rate; Test 1), 19 (growth rate; Test 2) -72-hr EC_{50} *Desmodesmus subspicatus* - 14.9 mg/L (growth rate), 6.2 (biomass) -72-hr EC_{50} *Desmodesmus subspicatus* - 107.3 mg/L (growth rate), 74.5 (biomass) -72-hr EC_{50} *Chlorella vulgaris* - 778 mg/L (growth rate) Chronic Aquatic - Invertebrate -EC_{10} *Daphnia magna* 1.05 mg/L -NOEC *Daphnia magna* 0.76 mg/L Chronic Aquatic - Algae and other aquatic plants -EC_{10} *Pseudokirchneriella subcapitata* - 1.4 mg/L (growth rate, Test 1), 1.1 (growth rate, Test 2) -EC_{10} *Desmodesmus subspicatus* - 2.4 mg/L (growth rate), 2.0 (biomass) -EC_{10} (non-neutralised) *Desmodesmus subspicatus* - 85.7 mg/L (growth rate), 41.3 (biomass) -7-d NOEC *Pseudokirchneriella subcapitata* - 10 mg/L **Terrestrial Toxicity** -35-day LC_{50} earthworm (*Eisenia Andrei, Eisenia fetida, or Lumbricus terrestris*) - 4,141 mg/kg (mortality) -63-day EC_{50} earthworm - 776 mg/kg (reproduction) -63-day EC_{25} earthworm - 171 mg/kg (reproduction) -28-day LC_{50} springtails (*Folsomia candida*) 8,301 mg/kg (reproduction) -28-day EC_{50} earthworm - 4,205 mg/kg (reproduction) -28-day EC_{25} earthworm - 2,102 mg/kg (reproduction) **$PNEC_{water}$** - 0.02 mg/L (Chronic algea) **$PNEC_{soil}$** - 0.027 mg/kg soil dry weight (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard -Skin irritant/Severe eye irritant. Repeated exposure may cause liver, kidney and blood toxicity Ecological Hazard - Harmful to aquatic life PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: Estimated BCF 2.3 PBT Assessment: Does not meet the criteria for bioaccumulation.

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Mar-20	Diethanolamine	[redacted]	Tier 1 (Qualitative Assessment/ PBT)	PBT Assessment: The overall conclusion is that diethanolamine is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., skin irritant). The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Mar-20	Diethylene glycol	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-h LC_{50} *Pimephales promelas* - 75,200 mg/L -96-h LC_{50} *Oncorhynchus mykiss* - 66,000 Acute Aquatic - Invertebrate -24-h EC_{50} *Daphnia magna* ->10,000 mg/L -48-hr EC_{50} *Daphnia magna* - 65,980 mg/L -48-hr EC_{50} *Daphnia magna* - 62,630 mg/L Chronic Aquatic - Fish -7-day NOEC *Pimephales promelas* - 15,380 mg/L (for ethylene glycol) Chronic Aquatic - Invertebrate -7-day NOEC *Ceriodaphnia dubia* - 8,590 mg/L (for ethylene glycol) -21 day - *Daphnia magna* - > 15,000 mg/L (for triethylene glycol) Chronic Aquatic - Algae -8-day TGK to algae *Scenedesmus quadricauda* 2,700 mg/L **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 27 mg/L **$PNEC_{soil}$** - 0.36 mg/kg dry weight soil	Qualitative Assessment: Human Health Hazard -Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: log Kow = -1.98 (calculated) PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Disodium octaborate tetrahydrate	[redacted]	[redacted]	**Aquatic Toxicity:** Following utilised by ANZECC to develop water quality guideline for boron Chronic Aquatic - Fish 32-day LOEC *O mykiss* - 0.04 mg/L 32-day LOEC *O mykiss* - 27.6 mg/L Chronic Aquatic - Invertebrates - 21-day LC_{50} *Daphnia magna* 4.665 mg/L - 21-day LC_{50} *Daphnia magna* 54.2 mg/L - NOEC 6.0 mg/L (reproduction) Chronic Aquatic - Algae and other aquatic plants -14-day NOEC *Chlorella pyrenoidosa* 0.4 mg/L -NOEC *Chlorella vulgaris* 5.2 mg/L. **$PNEC_{water}$** - 0.37 mg/L (ANZECC water quality guideline for boron) **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard -Known or presumed human reproductive toxicant. Ecological Hazard - Moderate concern PBT Assessment: Substance exhibits higher toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Not applicable.	Environmental Fate Property: Water soluble and not expected to bioaccumulate PBT Assessment: Does not meet the screening criteria for bioaccumulation.

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Mar-20	Diethylene glycol	[redacted]	Tier 1 (Qualitative Assessment/PBT)	PBT Assessment: The overall conclusion is that Diethylene glycol is not a PBT substance. Qualitative assessment indicated low concern to human health The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: No additional management required, Tier 1 screening satisfied.	NA
	Disodium octaborate tetrahydrate	[redacted]	Tier 1 (Qualitative/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that Disodium octaborate tetrahydrate is not a PBT substance. Qualitative assessment indicated known or presumed human reproductive toxicant. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical dissociates completely in aqueous media, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Mar-20	Ethanol	[redacted]	[redacted]	**Aquatic Toxicity:** Acute Toxicity Algae (most sensitive) 96-hr EC_{50} for *Chlorella vulgaris* 1,000 mg/L Chronic Aquatic - Invertebrates - lowest NOEC *Cerodaphnia sp.* 9.6 mg/L Chronic Aquatic - Algae and other aquatic plants - 5-day NOEC *Skeletonema costatum* 3,240 to 5,400 mg/L (cell count) -5-day EC_{50} *Skeletonema costatum* 10,943 - 11,619 mg/L. **Terrestrial Toxicity:** Toxicity to Terrestrial Plants The 7-d NOEC values of higher (vascular) plants Lemna gibba and L. minor were 280 and 778 mg/L, respectively. The EC50 values for both plants were 4,432 mg/L (Cowgill, 1991). Toxicity to Terrestrial Organisms -48-hr LC_{50} oligochaete worm (*Eisenia foetida*) 0.1-1.0 mg/cm^2 (200-2000 mg/L). **$PNEC_{water}$** - 1.0 mg/L (chronic *Daphnia*) **$PNEC_{soil}$** - 0.013 mg/kg soil dry weight (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard -Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: BCF - estimated 3.16 L/kg PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Ethoxylated branched C13 alcohol	[redacted]	[redacted]	**Aquatic Toxicity** Freshwater fish: 2 species, 720 to 1,500 µg/L. Freshwater crustaceans: 2 species, 590 to 860 µg/L. Freshwater rotifers: 1 species, Brachionus calyciflorus, 1,300 µg/L Freshwater algae, diatoms and blue-green algae: 6 species, 200 to 8,700 µg/L. Freshwater mesocosms: 4 NOEC data for multiple species tests were 80, 80, 320, and 330 µg/L, although replication was insufficient to meet OECD (1992) requirements. Normalised data were 380, 380, 320, and 1,520 µg/L. **Chronic Toxicity** -No studies available **Terrestrial Toxicity** -No studies are available **$PNEC_{water}$** - 0.14 mg/L **$PNEC_{soil}$** - 0.56 mg/kg soil dry weight	Qualitative Assessment: Human Health Hazard -Low concern Ecological Hazard - Harmful to aquatic life with long lasting effects PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: 4.9 PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Ethylene glycol	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Pimephales promelas* - >72,860 mg/L -96-hr LC_{50} *Oncorhynchus mykiss* - 22,810 mg/L and 24,591 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - >100 mg/L, 46,300 mg/L (20°C), 51,000 mg/L (24°C) -48-hr EC50 *Ceriodaphnia dubia-affinis* - 25,800 mg/L (20°C), 10,000 mg/L (24°C) Acute Aquatic - Algae and other aquatic plants -96-hr IC_{50} *Selenastrum capricornutum* - 10,940 mg/L -96-hr NOEC *Selenastrum capricornutum* - 10,000 mg/L Chronic Aquatic - Fish -7-day NOEC *Pimephales promelas* - 15,380 mg/L Chronic Aquatic - Invertebrate -7-day NOEC *Ceriodaphnia dubia* - 8,590 mg/L Chronic Aquatic - Algae -72-hr NOEC *Pseudokirchneriella subcapitata* - >100 mg/L **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 10 mg/L **$PNEC_{soil}$** - 0.13 mg/kg soil dry weight (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - Repeated exposures may cause kidney toxicity Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Readily biodegradable. PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: -Calculated log Kow is -1.36 -BCF in golden ide (*Leuciscus idus melanotus*) after 3 days exposure was 10 PBT Assessment: Does not meet the criteria for bioaccumulation.

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Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Mar-20	Ethanol	[redacted]	Tier 1 (NICNAS/ PBT)	NICNAS Assessment (2018) Human Health - potentially harmful to public health in event of transport spill. - potentially harmful to workers health in event of industrial incident Environment -Limited assessment - detailed information unavailable therefore, chemical assessed at earliest most conservative level of testing, which overestimates risk. Therefore, classified as potentially harmful at this level, but further information and testing wold be required to determine actual level of risk PBT Assessment: The overall conclusion is that ethanol is not a PBT substance. PBT assessment indicated criteria for persistence, bioaccumulation, and toxicity not met. Additionally, concentration injected did not exceed ecotoxicity and PNEC screening values and potential aquatic exposure pathway incomplete (refer to text). Qualitative Assessment indicated potential hazard to human health (e.g., skin irritant). Management: Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA
	Ethoxylated branched C13 alcohol	[redacted]	Tier 1 (PBT/Exposure Assessment)	PBT Assessment: The overall conclusion is that Ethoxylated branched C13 alcohol is not a PBT substance. Qualitative Assessment indicated low concern to human health. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable and does not bioaccumulate. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Therefore, a Tier 2 assessment was not warranted.	NA
	Ethylene glycol	[redacted]	Tier 1 (Qualitative Assessment/ PBT)	PBT Assessment: The overall conclusion is that ethylene glycol is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., kidney toxicity). The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Mar-20	Fatty acids, C8-C16, ethylhexyl ester	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} Bluegill Sunfish - 13 mg/L -96-hr LC_{50} *Oncorhynchus mykiss* - 10 mg/L Acute Aquatic - Invertebrate -48-hr LC_{50} *Daphnia magna* - 14.87 mg/L -48-hr LC_{50} *Daphnia magna* - 14 mg/L **Acute Aquatic Toxicity** -96-hr LC_{50} *Brachydanio rerio ->100 [WAF]* mg/L (biomass), 0.6 (growth rate), 0.025 (NOEC) -48-hr EL_{50} *Daphnia magna* - 12.41 mg/L -72-hr EL_{50} *Pseudokirchneriella subcapitata* - 39.7 [WAF] mg/L -72-day EL_{50} *Pseudokirchneriella subcapitata* -7.08 [WAF] mg/L **Chronic Toxicity** -No studies available **Terrestrial Toxicity** -No studies available **$PNEC_{water}$** - 0.001 mg/L **$PNEC_{soil}$** - 11 mg/kg soil dry weight	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Readily biodegradable. PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: 6.68 to 8.65 PBT Assessment: Does not meet the criteria for bioaccumulation.
	Fatty acids, tall-oil, ethoxylated	[redacted]	[redacted]	**Aquatic Toxicity** -96-hr LL_{50} *Brachydanio rerio ->100 [WAF]* mg/L -48-hr EL_{50} *Daphnia magna* - 12.41 mg/L -72-hr EL_{50} *Pseudokirchneriella subcapitata* - 39.7 [WAF] mg/L -72-day EL_{50} *Pseudokirchneriella subcapitata* -7.08 [WAF] mg/L **Chronic Toxicity** -No studies available **Terrestrial Toxicity** -No studies available **$PNEC_{water}$** - 0.12 mg/L **$PNEC_{soil}$** - 39 to > 683 mg/kg soil dry weight (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - Skin sensitizer Ecological Hazard - Harmful to aquatic life. Harmful to aquatic life with long lasting effects. PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Readily biodegradable. PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: PBT Assessment: Does not meet the criteria for bioaccumulation.

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Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Mar-20	Fatty acids, C8-C16, ethylhexyl ester	[redacted]	Tier 1 (Qualitative Assessment/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that Fatty acids, C8-C16, ethylhexyl ester is not a PBT substance. Qualitative assessment indicated low concern to human health The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release.	NA
	Fatty acids, tall-oil, ethoxylated	[redacted]	Tier 1 (Qualitative Assessment/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that Fatty acids, tall-oil, ethoxylated is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., skin irritant). The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Mar-20	Glutaraldehyde	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} Bluegill Sunfish - 13 mg/L -96-hr LC_{50} *Oncorhynchus mykiss* - 10 mg/L Acute Aquatic - Invertebrate -48-hr LC_{50} *Daphnia magna* - 14.87 mg/L -48-hr LC_{50} *Daphnia magna* - 14 mg/L Acute Aquatic - Algae and other aquatic plants -72-hr EC_{50} *Scenedesmus subspicatus* - 0.375 mg/L (biomass), 0.6 (growth rate), 0.025 (NOEC) -72-hr EC_{50} *Scenedesmus subspicatus* - 0.92 mg/L (biomass), 0.61 (growth rate), 0.33 (NOEC) -72-hr EC_{50} *Scenedesmus subspicatus* - 0.61 mg/L (growth rate) Chronic Aquatic - Fish -97-day LOEC *Oncorhynchus mykiss* - 5 mg/L -97-day NOEC *Oncorhynchus mykiss* - 1.6 mg/L Chronic Aquatic - Invertebrate -21-day NOEC *Daphnia magna* - 5 mg/L **Terrestrial Toxicity** Earthworms -14-day LC50 - 500 mg/kg soil dry weight Soil microoganisms -28-day EC50 - 360 mg/kg soil dry weight - > 593 mg/kg soil dry weight -28-day EC10 - 1.5 mg/kg soil dry weight - 11.5 mg/kg soil dry weight	Qualitative Assessment: Human Health Hazard - Corrosive; skin/respiratory sensitizer Ecological Hazard - Very toxic to aquatic life with long lasting effects. Low concern to terrestrial organisms. PBT Assessment: Substance exhibits higher toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable. PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: expected to have a low potential for bioaccumulation PBT Assessment: Does not meet the screening criteria for bioaccumulation.
				Avian -single dose (oral gavage) LC50 Mallard duck - 206 mg/kg -5-day dietary NOEC - Mallard duck - >2500 ppm Terrestrial Plants: -19-day EC_{50} - *Avena sativa* (oats) - >1,000 mg/kg soil dry weight; NOEC - >1000 (emergence rate, dry matter, shoot length) -19-day EC_{50} - *Brassica napus* (rapeseed) - >1,000 mg/kg soil dry weight; NOEC - >1000 (emergence rate), 500 (dry matter), 250 (shoot length) -19-day EC_{50} - *Vicia sativa* (vetch) - >1,000 mg/kg soil dry weight; NOEC - >1000 (emergence rate), 125 (dry matter), 125 (shoot length) **$PNEC_{water}$** - 0.0025 mg/L (Chronic algae) **$PNEC_{soil}$** -0.02 mg/kg soil dry weight (lChronic soil organisms)			
	Glycerine	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Oncorhynchus mykiss* - 54,000 mg/L -96-hr LC_{50} sheepshead minnow- >11,000 mg/L Acute Aquatic - Invertebrate -24-hr EC_{50} *Daphnia magna* - >10,000 mg/L Acute Aquatic - Algae and other aquatic plants -8-day EC_0 *Scenedesmus quadricauda* - >10,000 mg/L Chronic Aquatic -No chronic studies available **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 100 mg/L (Acute *Daphnia*) **$PNEC_{soil}$** - 1.3 mg/kg soil dry weight (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: -No bioconcentration studies conducted -Experimental log Kow of -1.75 PBT Assessment: Does not meet the screening criteria for bioaccumulation.

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Mar-20	Glutaraldehyde	[redacted]	Tier 2	NICNAS Assessment (2018) Human Health - potentially harmful to public health in event of transport spill. - potentially harmful to workers health in event of industrial incident Environment -Potentially harmful to the environment in the event of transport spill PBT Assessment: The overall conclusion is that glutaraldehyde is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., skin irritant). The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical and does meet the screening criteria for toxicity. This chemical is readily biodegradable and does not bioaccumulate. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted for aquatic receptors. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted for human receptors.	A quantitative risk characterisation was used to assess the risk to avian receptors from potential exposure to gluteraldehyde (Appendix E). There were no unacceptable potential risks to avian receptors as a result of ingestion of waters stored in treatment tanks.
				Chemicals with a high ecotoxicity hazard assessment have a potential avian wildlife exposure to chemicals stored in treatment tanks. Therefore a Tier 2 assessment was conducted for avian receptors.	
	Glycerine	[redacted]	Tier 1 (Qualitative Assessment/ PBT)	PBT Assessment: The overall conclusion is that glycerine is not a PBT substance. Qualitative assessment indicated low concern to human health Management: No additional management required, Tier 1 screening satisfied.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Mar-20	Guar gum	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Oncorhynchus mykiss* - 218 mg/L Acute Aquatic - Invertebrate -48-hr LC_{50} *Daphnia magna* - 42 mg/L -96-hr LC_{50} *Daphnia magna* - <6.2 mg/L Chronic Aquatic -No chronic studies available **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.006 mg/L (Acute *Daphnia*) **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern to fish, moderate acute toxicity to invertebrates PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable. PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: Expected to not bioaccumulate. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Hydrochloric acid	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Lepomis macrochirus* - pH 3.25-3.5 (20 mg/L) Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - pH 4.92 (0.45 mg/L) Acute Aquatic - Algae and other aquatic plants -72-hr EC_{50} *Chlorella vulgaris* - pH 4.7 (growth rate) (0.73 m/L), pH 4.7 (0.364 mg/L) Chronic Aquatic -No chronic studies available **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - not derived **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Corrosive; respiratory irritant Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely PBT Assessment: Not applicable.	Environmental Fate Property: Expected to not bioaccumulate. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Hydrotreated light petroleum distillate	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Oncorhynchus mykiss* - 2-5 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - 1.4 mg/L Acute Aquatic - Algae and other aquatic plants -72-hr EC_{50} *Raphidocelis subcapitata* - <1-3 mg/L -72-hr EC50 *Selenastrum capricornutum* - 3.7 mg/L Chronic Aquatic -No chronic studies available for fish -21-d EL_{50} - *Daphnia magna* 0.89 mg/L **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.005 mg/L **$PNEC_{soil}$** - 0.32 mg/kg dry weight	Qualitative Assessment: Human Health Hazard - skin sensitizer Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence	Environmental Fate Properties: BCF = 3.162 L/kg PBT Assessment: Does not meet the screening criteria for bioaccumulation.

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Mar-20	Guar gum	[redacted]	Tier 1 (NICNAS/ PBT/ Exposure Assessment)	NICNAS Assessment (2018) Human Health - unlikely to cause harm to public - unlikely to cause harm to workers Environment -Potentially harmful to the environment in the event of transport spill NICNAS: Identified as chemical of low concern for human health in National assessment of chemicals associated with coal seam gas extraction in Australia, Tech Report Number 11 (NICNAS, 2017) Qualitative assessment indicated low concern to human health. PBT Assessment - The overall conclusion is that guar gum is not a PBT substance. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT criteria for toxicicty. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Therefore, a Tier 2 assessment was not warranted.	NA
	Hydrochloric acid	[redacted]	Tier 1 (NICNAS/ Qualitative Assessment/ PBT)	NICNAS Assessment (2018) Human Health - unlikely to cause harm to public - potentially harmful to workers health in event of industrial incident Environment -Potentially harmful to the environment in the event of transport spill PBT Assessment - The overall conclusion is that hydrochloric acid is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., corrosive). Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA
	Hydrotreated light petroleum distillate	[redacted]	Tier 1 (Qualitative/PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that hydrotreated light petroleum distillate is not a PBT substance. Qualitative assessment indicated low concern for human and ecological hazards. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. This chemical is inherently biodegradable and does not meet the PBT assessment criteria for toxicity or bioaccumulation. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Australia SafeWork Place and Condor Occupational Safety Guidance will be used to minimise human health exposure. Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Therefore, a Tier 2 assessment was not warranted.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Mar-20	Hydroxylpropyl guar	[redacted]	[redacted]	**Aquatic Toxicity** - no studies available **$PNEC_{water}$** - not derived **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Not determined	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence	Environmental Fate Properties: not expected to bioaccumulate based on it's large molecular weight PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Iron gluconate	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Iron Gluconate (Seawater Species) -96-hr LC50 Scophthalmus mamimus - >1,000 mg/L -48-hr EC50 Acartia tonsa -296.2 mg/L -72-hr EC50 Skeletonema costatum - 265.7 mg/L Acute Aquatic - Sodium Gluconate -96-hr LC50 Oryzias latipes - >100 mg/L -48-hr EC50 Daphnia magna - >1,000 mg/L -72-hr EC50 Desmodesmus subspicatus - >1,000 mg/L **Chronic Toxicity** -No studies are available **Terrestrial Toxicity** -No studies are available PNECwater - 2.7 mg/L PNECsoil - 0.7 mg/kg soil dry weight	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence	Environmental Fate Properties: log Kow = -7.7 PBT Assessment: Does not meet the screening criteria for bioaccumulation.

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Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Mar-20	Hydroxylpropyl guar	[redacted]	Tier 1 (Qualitative Assessment/ PBT)	PBT Assessment - The overall conclusion is that hydroxylpropyl guar is unlikely to be a PBT substance because of physio-chemical properties. Qualitative assessment indicated low concern to human health Management: No additional management required, Tier 1 screening satisfied.	NA
	Iron gluconate	[redacted]	Tier 1 (Qualitative Assessment/PBT)	PBT Assessment - The overall conclusion is that hydrochloric acid is not a PBT substance. Qualitative assessment indicated low concern to human health Management: No additional management required, Tier 1 screening satisfied.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Mar-20	Methanol	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} Bluegill - 15,400 mg/L -96-hr LC_{50} *Salmo gairdneri* - 20,100 mg/L -96-hr LC_{50} *Pimphales promelas* - 28,100 mg/L Acute Aquatic - Invertebrate -96-hr EC_{50} *Daphnia magna* - 18,620 mg/L -48-hr EC_{50} *Daphnia magna* - >10,620 mg/L Acute Aquatic - Algae and other aquatic plants -96-hr EC_{50} *Selenastrum capricornutum* -~22,000 mg/L -10-14 d EC_{50} *Chlorella pyrenoidosa* - 28,400 mg/L Chronic Aquatic -No chronic studies available **Terrestrial Toxicity** 35-d EC_{50} Earthworm *Eisenia fetida* - 17,199 mg/kg soil dw 63-d EC_{50} Earthworm *Eisenia fetida* - 26,646 mg/kg soil dw 28-d EC_{25} *Folsomia candida* - 2,842 mg/kg soil dw (test results) 28-d NOEC (reproduction) *Folsomia candida* - 1,000 mg/kg soil dw (derived graphically) 14-d EC_{50} *Hordeum vulgare* - 15,492 mg/kg soil dw 14-d NOEC (seedline emergence) *Hordeum vulgare* - 12,000 mg/kg soil dw (derived graphically) 14-d EC_{25} *Hordeum vulgare* - 2,538 mg/kg soil dw (test results) 14-d NOEC (shoot dry mass) *Hordeum vulgare* - 1,555 mg/kg soil dw (derived graphically) 14-d EC_{25} *Hordeum vulgare* - 2,823 mg/kg soil dw (test results) 14-d NOEC (root dry mass) *Hordeum vulgare* - 2,592 mg/kg soil dw (derived graphically) 14-d EC_{25} *Hordeum vulgare* - 4,885 mg/kg soil dw (test results) 14-d NOEC (shoot length) *Hordeum vulgare* - 2,592 mg/kg soil dw (derived graphically) 14-d EC_{25} *Hordeum vulgare* - 5,752 mg/kg soil dw (test results) 14-d NOEC (rott length length) *Hordeum vulgare* - 4,320 mg/kg soil dw (derived graphically) **$PNEC_{water}$** - 10 mg/L (Acute *Daphnia)* **$PNEC_{soil}$** - 6.3 mg/kg soil dry weight (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - Low concern if used at <3% Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: -Calculated log Kow -1.36 -BCF in *Cyprinus carpio* 1.0, BCF *Leuciscus idus* <10 PBT Assessment: Does not meet the criteria for bioaccumulation.

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Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Mar-20	Methanol	[redacted]	Tier 1 (NICNAS/ Qualitative Assessment/ PBT)	NICNAS Assessment (2018) Human Health - potentially harmful to public in event of transport spill or pond leak - potentially harmful to workers when mixing and/or cleaning or in event of industrial accident Environment -unlikely to cause harm to environment PBT Assessment: The overall conclusion is that methanol is not a PBT substance. Qualitative assessment indicated low concern to human health Management: Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA

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Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Mar-20	Polyethylene glycol	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Poecilia reticulata* - >100 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - > 100 mg/L Acute Aquatic - Algae and other aquatic plants -96-hr EC_{50} *Selenastrum subspicatus* - >100 mg/L Chronic Aquatic -28 d modelled NOEC fish - 13,671.586 mg/L -7-d LC_{50} *Poeciliia reticulata* (guppy fish) - 1150 mg/L -21-d modelled NOEC invertebrate - 17475.27 mg/L -8-d EC_{50} *Scenedesmus quadricauda* (algae) - diethylene glycol mono-butyl ehter (CAS No. [redacted] 1000 mg/L **Terrestrial Toxicity** No terrestrial toxicity studies. Not needed because little to no adsorption is expcted in soil compartment. **$PNEC_{water}$** - 100 mg/L (chronic algae) **$PNEC_{soil}$** - 13 mg/kg soil dw (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable. PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: -Estimated BCF is 3.162 PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Polypropylene glycol	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Danio rerio* - >100 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - 105.8 mg/L Acute Aquatic - Algae and other aquatic plants -72-hr EC_{50} *Desmodesmus subspicatus* ->100 mg/L Chronic Aquatic -No chronic studies available **Terrestrial Toxicity** No terrestrial toxicity studies **$PNEC_{water}$** - 0.1 mg/L (NOEC for Dapnia) **$PNEC_{soil}$** - 0.0067 mg/kg soil dry weight (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - Low to moderately toxic, depending on molecular weight Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence	Environmental Fate Properties: log Kow <= 3 PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Potassium chloride	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Pimpephelas promelas* - 880 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* 660 mg/L -48-hr EC_{50} *Ceriodaphnia dubia* - 630 mg/L Acute Aquatic - Algae and other plants -72-hr EC_{50} *Scenedesmus subspicatus* - >100 mg/L **Chronic Aquatic - Invertebrate** -7-day NOEC in a fathead minnow is 500 mg/L **Terrestrial Toxicity** -No data available. **$PNEC_{water}$** - 1 mg/L (algae) **$PNEC_{soil}$** -not derived	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Does not meet the screening criteria for persistence	Environmental Fate Properties: Will dissociate to potassium and chloride ions which are not expected to bioaccumulate. PBT Assessment: Does not meet the screening criteria for bioaccumulation.

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Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Mar-20	Polyethylene glycol	[redacted]	Tier 1 (Qualitative Assessment/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that Polyethylene glycol is not a PBT substance. Qualitative assessment indicated low concern to human health. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is inherently biodegradable, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Therefore, a Tier 2 assessment was not warranted.	NA
	Polypropylene glycol	[redacted]	Tier 1 (Qualitative Assessment/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that Polypropylene glycol is not a PBT substance. Qualitative assessment indicated low concern to human health. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is inherently biodegradable, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Therefore, a Tier 2 assessment was not warranted.	NA
	Potassium chloride	[redacted]	Tier 1	PBT Assessment: The overall conclusion is that Potassium chloride is not a PBT substance. Qualitative assessment indicated low concern to human health. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical dissociates completely in aqueous media, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Therefore, a Tier 2 assessment was not warranted.	NA

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Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Mar-20	Propylene glycol n-propyl ether	[redacted]	[redacted]	**Aquatic Toxicity** -96-hr LC_{50} *Oncorhynchus mykiss* - >100 mg/L -48-hr EC_{50} *Daphnia magna* - >100 mg/L -72-hr EC_{50} *Pseudokirchnierella subcapitata* - 3,440 mg/L **Chronic Toxicity** -No data available **Terrestrial Toxicity** -No data available **$PNEC_{water}$** - 1.0 mg/L **$PNEC_{soil}$** - 0.03 mg/kg soil dry weight	Qualitative Assessment: Human Health Hazard - Eye irritant Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable. PBT Assessment: Does meet the screening criteria for persistence.	Environmental Fate Properties: 0.621 (calculated) PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Silica dioxide	[redacted]	[redacted]	**$PNEC_{water}$** - not derived **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Not relevant PBT Assessment: Does not meet the screening criteria for persistence	Environmental Fate Properties: bioaccumulation unlikely to occur PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Sodium bicarbonate	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Oncorhynchus mykiss* - 7,700 mg/L -96-hr LC_{50} *Lepomis macrochirus* - 7,100 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - 4,100 mg/L -48-hr EC_{50} *Daphnia magna* - 1,640 mg/L -48-hr EC_{50} *Daphnia magna* - 1,020 mg/L Chronic Aquatic - Invertebrate -21-day NOEC Dapnia (reproduction) - >576 mg/L **Terrestrial Toxicity** -48-hr LC50 - acute honeybee test >24 µg/bee -48 hr NOEC - acute honeybee test 24µg/bee **$PNEC_{water}$** - not derived **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Not applicable	Environmental Fate Properties: Na+ and HCO3- ions will not adsorb on particulate matter or surfaces and will not accumulate in living tissues. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Sodium bisulfite	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} (Potassium sulfite) *Leuciscus idus* - 316 mg/L -96-hr LC_{50} (Sodium pyrosulfite) *Salmo gairdneri* - 147-215 mg/L -96-hr LC_{50} (Potassium metabisulfite) *Brachydanio rerio* - 147-215 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} (Sodium disulfite) *Daphnia magna* - 88.8 mg/L Acute Aquatic - Algae and other aquatic plants -96-hr EC_{50} (Sodium disulfite) *S. subspicatus* - 43.9 mg/L -72-hr EC_{10} (Sodium disulfite) *S. subspicatus* - 33.3 mg/L Chronic Aquatic - fish -34-day NOEC (Sodium sulfite) *Danio rerio* - >316 mg/L Chronic Aquatic - Invertebrate -21-day NOEC (Sodium sulfite) *Dapnia magna* - >10 mg/L **Terrestrial Toxicity** No terrestrial studies located. **$PNEC_{water}$** - 0.8 mg/L (Chronic Daphnia) **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Harmful to aquatic life. PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Not applicable	Environmental Fate Properties: Sodium bisulfite is not expected to bioaccumulate in the environment because of its dissociation to ionic species and a gas. PBT Assessment: Does not meet the screening criteria for bioaccumulation.

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Mar-20	Propylene glycol n-propyl ether	[redacted]	Tier 1 (Qualitative Assessment/ PBT)	PBT Assessment: The overall conclusion is that Propylene glycol n-propyl ether is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., eye irritant). Management: Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA
	Silica dioxide	[redacted]	Tier 1 (NICNAS/ Qualitative Assessment/ PBT)	NICNAS Assessment (2018) Human Health - unlikely to cause harm to public - unlikely to cause harm to workers Environment -unlikely to cause harm to environment PBT Assessment: The overall conclusion is that silica dioxide n-propyl ether is not a PBT substance. Qualitative assessment indicated low concern to human health. Management: No additional management required, Tier 1 screening satisfied.	NA
	Sodium bicarbonate	[redacted]	Tier 1 (NICNAS/PBT)	NICNAS: Identified as chemical of low concern for human health in National assessment of chemicals associated with coal seam gas extraction in Australia, Tech Report Number 11 (NICNAS, 2017) PBT Assessment: The overall conclusion is that sodium bicarbonate is not a PBT substance. Qualitative assessment indicated low concern to human health. Management: No additional management required, Tier 1 screening satisfied.	NA
	Sodium bisulfite	[redacted]	Tier 1 (PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that sodium bisulfite is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., corrosive). The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is dissociates completely in aqueous media, does not bioaccumulate, and does not meet the PBT criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Mar-20	Sodium carbonate	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} Bluegill sunfish - 300 mg/L -96-hr LC_{50} Mosquitofish - 740 mg/L -24-hr LC_{50} Bluegill sunfish - 385 mg/L -50-hr LC_{50} Molly - 297 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} *Ceriodaphnia dubia* - 200 - 227 mg/L **Terrestrial Toxicity** No terrestrial toxicity studies identified. **$PNEC_{water}$** - not derived **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Eye irritant Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Not applicable	Environmental Fate Properties: Sodium carbonate is not expected to bioaccumulate in the environment. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Sodium Chloride	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC50 *Lepomis macrochirus* - 5,840 mg/L Acute Aquatic - Invertebrate -48-hr EC50 *Daphnia magna* - 1,900 mg/L Acute Aquatic - Algae and other aquatic plants -96-hr NOEC *Lemna* - 6,780 mg/L **Chronic Toxicity** Chronic Aquatic - Fish 33-day NOEC - *Pimephales promelas* - 232 mg/L Chronic Aquatic - Invertebrate 21-day NOEC - *Daphnia pulex* - 314 mg/L **Terrestrial Toxicity** -14-day LC50 *E. fetida* - 3296 mg/kg soil dw -10-week NOEC *E. fetida* - 3,507 mg/kg soil -7-day EC50 - red fescue grass - 500.8 mg/kg soil -12-hr LD50 - wild house sparrow - 3,000 - 3,500 mg/kg **$PNEC_{water}$** - not derived **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - low concern Ecological Hazard - low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Not applicable	Environmental Fate Properties: Essential ions to biological systems. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Sodium diacetate	[redacted]	[redacted]	**Aquatic Toxicity** - on Sodium Acetate and Potassium Acetate -96-hr LC_{50} Brachydanio rerio - >100 mg/L -48-hr EC_{50} *Daphnia magna* - Sodium acetate - >1,000 and 1,730* mg/L. *Values converted to sodium diacetate using the molecular weights of sodium acetate (82.03 g/mol), potassium acetate (98.15 g/mol), and sodium diacetate (142.09g/mol). -48-hr EC50 Daphnia magna - Potassium acetate - >459.5 and 665* mg/L. *Values converted to sodium diacetate using the molecular weights of sodium acetate (82.03 g/mol), potassium acetate (98.15 g/mol), and sodium diacetate (142.09 g/mol). -72-hr EC_{50} *Skeletonema costatum* - >500 and 724* mg/L *Values converted to sodium diacetate using the molecular weights of sodium acetate (82.03 g/mol), potassium acetate (98.15 g/mol), and sodium diacetate (142.09 g/mol). **Chronic Aquatic - Algae and other aquatic plants** No studies are available. **Terrestrial Toxicity** No studies are available. **$PNEC_{water}$** - 1.7 mg/L **$PNEC_{soil}$** - 0.02 mg/kg soil dry weight	Qualitative Assessment: Human Health Hazard - Severe eye irritant Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Not applicable	Environmental Fate Properties: log Kow = -3.72 PBT Assessment: Does not meet the screening criteria for bioaccumulation.

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Mar-20	Sodium carbonate	[redacted]	Tier 1 (NICNAS/PBT)	NICNAS Assessment (2018) Human Health - unlikely to cause harm to public - potentially harmful to workers in event of industrial accident Environment -unlikely to cause harm to environment PBT Assessment: The overall conclusion is that sodium carbonate is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., irritant). Management: Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA
	Sodium Chloride	[redacted]	Tier 1 (NICNAS/Qualitative Assessment/PBT)	NICNAS: Identified as chemical of low concern for human health in National assessment of chemicals associated with coal seam gas extraction in Australia, Technical report number 11 (NICNAS, 2017). In Technical report number 14, releases to surface waters were found to have limited long-term environmetnal effects because sodium chloride is ubiquitous and present in most water, soil, and sediment. Management: No additional management required, Tier 1 screening satisfied.	NA
	Sodium diacetate	[redacted]	Tier 1 (Qualitative/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that sodium bicarbonate is not a PBT substance. Qualitative assessment indicated low concern to human health. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical dissociates completely in aqueous media, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Therefore, a Tier 2 assessment was not warranted.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Mar-20	Sodium hydroxide	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -24-hr LC50 *Carassius auratus* - 160 mg/L -48-hr LC50 *Leuciscus idus melanotus* - 189 mg/L -96-hr LC50 *Gambusia affinis* - 125 mg/L Acute Aquatic - Invertebrate -48-hr EC50 *Ceriodaphnia cf. dubia* - 40 mg/L -toxicity threshold of sodium hydroxide for Daphnia magna - 40 mg/L ot 240 mg/L **Terrestrial Toxicity** No terrestrial toxicity studies identified. **$PNEC_{water}$** - not derived **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Corrosive Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Not applicable	Environmental Fate Properties: Sodium hydroxide is not expected to bioaccumulate in the environment. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
Mar-20	Sodium iodide	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic -48-hr EC_{50} *Daphnia magna* - 0.17 mg/L -96-hr LC_{50} *Danio rerio* - >100 mg/L -96-hr LC_{50} *Oncorhynchus mykiss* 3780 mg/L -72-hr EC_{50} *Pseudokirchneriella subcapitata* >37.26 mg/L (growth) **Chronic Toxicity** - -35-day NOEC *Danio rerio* >10 mg/L -21-day NOEC Dapnia 0.153 mg/L (reproduction test) -72 hr NOEC to green algae *Pseudokirchneriella subcapitata* was >37.26 mg/L **Terrestrial Toxicity** No studies are available **$PNEC_{water}$** - 0.0153 mg/L **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Repeated exposures may cause thyroid gland toxicity. Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Not applicable	Environmental Fate Properties: the low log K_{ow} (-1.301) suggetss sodium iodide will not bioaccumulate PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Sodium perborate tetrahydrate	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Brachydanio rerio* - 5.5 mg Boron/L Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - 2.1 mg Boron/L Acute Aquatic - Alga -72-hr EC_{50} *Pseudokirchneriella subcapitata* - 0.36 mg Boron/L Chronic Aquatic - Fish -32-day NOEC - *Danio rerio* 1.8 mg Boron/L -32-day NOEC - *Pimpephales promelas* 11 mg Boron/L Chronic Aquatic - Invertebrate -14-day NOEC - *Daphnia magna* 2.4 mg Boron/L Chronic Aquatic - Algae and other aquatic plants -4-day NOEC- *Pseudokirchneriella subcapitata* 2.8 mg Boron/L **PNECwater** - 0.94 mg/L (ANZECC water quality guideline for boron) **PNECsoil** - 5.7 mg/kg soil (derived using boron species sensitivity distribution method and assessment factor of 2)	Qualitative Assessment: Human Health Hazard - Slight to moderate toxicity by inhalation route; severe eye irritant; known or presumed human reproductive toxicant. Ecological Hazard - low chronic aquatic toxicity concern. PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Persistence criteria are not applicable.	Environmental Fate Properties: unlikely to bioaccumulate to any signifcant degree; BCF for boron < 0.1 PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Sodium persulfate	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} - *Oncorhynchus mykiss* 163 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} - *Daphnia magna* 133 mg/L Acute Aquatic - Algae and other aquatic plants *2-hr LC50 - Selenastrum capricornutum* 116 mg/L No chronic studies available. **PNECwater** - 1.2 mg/L (acute algae) **PNECsoil** - not derived	Qualitative Assessment: Human Health Hazard - Skin and respiratory sensitizer; irritant Ecological Hazard -low concern. PBT Assessment: Substance exhibits higher toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Persistence criteria are not applicable.	Environmental Fate Properties: Dissociates to ions that are ubiquitous in environment PBT Assessment: Does not meet the screening criteria for bioaccumulation.

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Mar-20	Sodium hydroxide	[redacted]	Tier 1 (Qualitative/PBT)	PBT Assessment: The overall conclusion is that sodium hydroxide is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., corrosive). The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical dissociates completely in aqueous media and does not bioaccumulate. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA
Mar-20	Sodium iodide	[redacted]	Tier 1 (Qualitative/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that sodium iodide is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., corrosive). The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical dissociates completely in aqueous media and does not bioaccumulate. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA
	Sodium perborate tetrahydrate	[redacted]	Tier 1 (Qualitative/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that Sodium perborate tetrahydrate is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., severe eye irritant, moderate toxicity via inhalation route). The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical dissociates completely in aqueous media, does not bioaccumulate, and does not meet the PBT toxicity criteria. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA
	Sodium persulfate	[redacted]	Tier 1 (Qualitative/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that Sodium persulfateis not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., corrosive). The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical dissociates completely in aqueous media and does not bioaccumulate. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Mar-20	Sodium polyacrylate	[redacted]	[redacted]	**Aquatic Toxicity** toxicity studies for MW 4,500 shown because these MW polymers are most commonly used for detergents. For additional toxicity studies, refer to the dossier. Acute Aquatic - Fish -96-hr LC_{50} - *Lepomis macrochirus* >1,000 mg/L -96-hr LC_{50} - *Lepomis macrochirus* >1,000 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} - *Daphnia magna* >200 mg/L -48-hr EC_{50} - *Daphnia magna* >1,000 mg/L Chronic Aquatic - Fish -32-d NOEC - *Pimephales promelas* 56 mg/L -28-d NOEC - *Brachydanio rerio* >450 mg/L Chronic Aquatic - Invertebrate -21-d NOEC - *Daphnia magna* >450 mg/L -21-d NOEC - *Daphnia magna* 58 mg/L -21-d NOEC - *Daphnia magna* 12 mg/L Chronic Aquatic - Algae and other aquatic plants -96-hr NOEC *Scenedesmus. subspicatus* - 480 mg/L **Terrestrial Toxicity** -14-d EC0 - (4,500 Mean MW sodium polyacrylate) Eisenia foetida foetida 1,000 mg/L -28-d EC10 - (4,500 Mean MW sodium polyacrylate) Nitrogen transformation (soil microorganisms) >2,500 mg/L -28-d EC10 - (4,500 Mean MW sodium polyacrylate) Carbon transformation (soil microorganisms) >2,500 mg/L **$PNEC_{water}$** - 1.2 mg/L (lChronic Daphnia) **$PNEC_{soil}$** - 25 mg/kg soil dry weight (lChronic soil microogranisms)	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Not biodegradable. PBT Assessment: Does meet the screening criteria for persistence.	Environmental Fate Properties: Due to their high molecular weights, sodium polyacrylates are not expected to bioaccumulate. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Sodium Sulfate	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} Pimephales promelas 7,960 mg/L Acute Aquatic - Invertebrate -48-hr EC50 - *Daphnia magna* - 4,736 mg/L Chronic Aquatic - Invertebrate -7-day - $LOEC_{50}$ - *Ceriodapnia dubia* 1,329 mg/l **Terrestrial Toxicity** No data available **$PNEC_{water}$** - 11 mg/L **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Does not meet the criteria for biodegradation.	Environmental Fate Properties: Dissociates to ions that are ubiquitous in environment PBT Assessment: Does not meet the screening criteria for bioaccumulation.

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Mar-20	Sodium polyacrylate	[redacted]	Tier 1 (NICNAS/PBT)	NICNAS: Identified as chemical of low concern for human health in National assessment of chemicals associated with coal seam gas extraction in Australia, Tech Report Number 11 (NICNAS, 2017) PBT Assessment: The overall conclusion is that sodium polyacrylates are not PBT substances. Qualitative assessment indicated low concern to human health. Management: No additional management required, Tier 1 screening satisfied.	NA
	Sodium Sulfate	[redacted]	Tier 1 (PBT)	PBT Assessment: The overall conclusion is that Sodium Sulfate not a PBT substance. Qualitative assessment indicated low concern to human health. Management: No additional management required, Tier 1 screening satisfied.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Mar-20	Sodium Sulfite	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} Golden Orfe - 316 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - 89* (59) mg/L -72-hr LC_{50} *Desmodesmus subspicatus* - 43.8* (29)mg/L * test substance sodium disulfite; adjusted concentration for sodium sulfite in parentheses **Chronic Toxicity** -34-day NOEC zebra fish >316 mg/L. -21-day NOEC *Daphnia magna* >10* (6.6) mg/L EC_{10} *Desmodesmus subspicatus* 33.3* (22) mg/L * test substance sodium disulfite; adjusted concentration for sodium sulfite in parentheses **Terrestrial Toxicity** No adequate studies were located. **$PNEC_{water}$** - 0.7 mg/L (NOEC for invertebrates) **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Harmful to aquatic life. PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Does not meet the criteria for biodegradation.	Environmental Fate Properties: Dissociates to ions that are ubiquitous in environment PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Sodium thiosulfate	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic -96-hr LC_{50} *Lepomis macrochirus* - 510 mg/L -96-hr LC_{50} *Salmo gairdneri* - 770 mg/L -72-hr EC_{50} Pseudokirchneriella subcapitata - >100 mg/L -48-hr EC_{50} *Daphnia magna* - 230 mg/L **Chronic Studies** - No data are available. **Terrestrial Toxicity** - No studies are available **$PNEC_{water}$** - 1.0 mg/L **$PNEC_{soil}$** - No data available	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Does not meet the criteria for biodegradation.	Environmental Fate Properties: Dissociates to ions that are ubiquitous in environment PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Sorbitan, mono-9-octadecenoate, (Z)	[redacted]	[redacted]	**Aquatic Toxicity** -96-hr LL_{50} *Salmo gairdneri* - >1,000 [WAF] mg/L -96-hr LL_{50} *Oryzias latipes* - >1,000 [WAF] mg/L -48-hr EL_{50} *Daphnia magna* - >1,000 [WAF] mg/L -72-hr EL_{50} *Pseudokirchneriella subcapitata* - >1,000 [WAF] mg/L **Chronic Aquatic - Invertebrate** -21-day NOELR (no-observed-effect-loading-rate) in a *Daphnia* reproduction test for sorbitan stearate (CAS No. [redacted] is 16 mg/L WAFA (ECHA) [Kl. score = 2]. -72-hr NOELR (no-observed-effect-loading-rate) to *Pseudokirschneriella subcapitata* for sorbitan stearate was 560 mg/L [WAF] (ECHA) [Kl. score = 1]. **Terrestrial Toxicity** -No data available. **$PNEC_{water}$** - 0.32 mg/L WAF **$PNEC_{soil}$** -10 mg/kg soil dry weight	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence	Environmental Fate Properties: modeled BCF values ranged from 36 to 92 L.kg PBT Assessment: Does not meet the screening criteria for bioaccumulation.

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Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Mar-20	Sodium Sulfite	[redacted]	Tier 1 (Qualitative/PBT)	PBT Assessment: The overall conclusion is that Sodium Sulfite not a PBT substance. Qualitative assessment indicated low concern to human health. Management: No additional management required, Tier 1 screening satisfied.	NA
	Sodium thiosulfate	[redacted]	Tier 1 (Qualitative/PBT)	PBT Assessment: The overall conclusion is that Sodium thiosulfate not a PBT substance. Qualitative assessment indicated low concern to human health. Management: No additional management required, Tier 1 screening satisfied.	NA
	Sorbitan, mono-9-octadecenoate, (Z)	[redacted]	Tier 1 (Qualitative Assessment/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that Sorbitan monooleate polyoxyethylene derivative is not a PBT substance. Qualitative assessment indicated low concern to human health. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Therefore, a Tier 2 assessment was not warranted.	NA

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Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Mar-20	Sorbitan monooleate polyoxyethylene derivative	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic -72-hr EL_{50} *Pseudokirchneriella subcapitata* - 58.84 [WAF] mg/L -96-hr LL_{50} Brachydanio rerio - >100 [WAF] mg/L **Chronic Toxicity -** -21-day NOELR (No-Observed-Effect-Loading-Rate) for sorbitan monolaurate, ethoxylated (1-6.5 moles ethoxylated) [CAS No. [redacted] in a Daphnia reproduction test was 10 mg/L WAF (ECHA) [Kl. score = 2]. -72-hr EL10 for sorbitan monolaurate, ethoxylated (1-6.5 moles ethoxylated) [CAS No. [redacted] to Pseudokirchneriella subcapitata is 19.05 mg/L WAF (ECHA) [Kl. score = 2]. **Terrestrial Toxicity** No studies are available **$PNEC_{water}$** - 0.2 mg/L **$PNEC_{soil}$** - 3.4 mg/kg soil dry weight.	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: BCF in fish ranges from 12.6 to 14.6 L/kg PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Tributyl tetradecyl phosphonium chloride	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} Bluegill sunfish - 58.6 mg/L -96-hr LC_{50} Common carp - 87 mg/L -96-hr LC_{50} Rainbow trout - 490 mg/L -96-hr LC_{50} Rainbow trout - 200 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - 25.2 mg/L Acute Aquatic - Algae and other aquatic plants -72-hr EC_{50} *Selenastrum capricornutum* - 19 mg/L **Terrestrial Toxicity** -8-d dietary LC_{50} Bobwhite Quail 4,215 ppm -8-d dietary NOEC Bobwhite Quail 1,980 ppm -8-d dietary LC50 Mallard Duck 3,663 ppm -8-d dietary NOEL Mallard Duck 1,780 ppm -14-d oral gavage LD50 Mallard Duck 232 mg/kg -14-d oral gavage NOEL Mallard Duck <178 mg/kg **$PNEC_{water}$** -0.000019 mg/L (Acute algae) **$PNEC_{soil}$** - 6.49 mg/kg soil dry weight (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - Corrosive; acute toxicity by oral route, very high acute inhalation toxicity Ecological Hazard - Very toxic to aquatic life. PBT Assessment: Substance exhibits higher toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: No bioaccumulation studies are available on TTPC. Log Kow = 2.45 PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Triethanol amine	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Pimephales promelas* - 11,800 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} *Ceriodaphnia dubia* - 610 mg/L Acute Aquatic - Algae and other aquatic plants -72-hr EC_{50} *Desmodesmus subspicatus* - 512 mg/L (neutralised), 216 (un-neutralised) -EC_{10} - *Desmodesmus subspicatus* 26 mg/L (neutralised) Chronic Aquatic -21 day NOEC Daphnia 16 mg/L (mortality), 125 mg/L (reproduction rate), 250 mg/L (reproduction on appearance of first offspring) **Terrestrial Toxicity** No studies available **PNECwater** -0.32 mg/L (lowest EC_{10} daphnia) **PNECsoil** - 0.04 mg/kg soil dry weight (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: log Kow = -1.9 (experimental) PBT Assessment: Does meet the screening criteria for bioaccumulation.

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Mar-20	Sorbitan monooleate polyoxyethylene derivative	[redacted]	Tier 1 (Qualitative/PBT)	PBT Assessment: The overall conclusion is that sorbitan monooleate polyoxyethylene derivative is not a PBT substance. Qualitative assessment indicated low concern to human health. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted for aquatic receptors. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Therefore, a Tier 2 assessment was not warranted.	NA
	Tributyl tetradecyl phosphonium chloride	[redacted]	Tier 2	NICNAS Assessment (2018) Human Health - potentially harmful to public health in event of transport spill. - potentially harmful to workers health in event of industrial incident Environment -Limited assessment - detailed information unavailable therefore, chemical assessed at earliest most conservative level of testing, which overestimates risk. Therefore, classified as potentially harmful at this level, but further information and testing wold be required to determine actual level of risk PBT Assessment: The overall conclusion is that TTPC is not a PBT substance. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is inherently biodegradable and does not bioaccumulate. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted for aquatic receptors. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Chemicals with a high ecotoxicity hazard assessment have a potential avian wildlife exposure to chemicals stored in treatment tanks. Therefore a Tier 2 assessment was conducted for avian receptors.	A quantitative risk characterisation was used to assess the risk to avian receptors from potential exposure to Tributyl tetradecyl phosphonium chloride (Appendix E). There were no unacceptable potential risks to avian receptors as a result of ingestion of waters stored in treatment tanks.
	Triethanol amine	[redacted]	Tier 1 (Qualitative/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that Triethanol amine is not a PBT substance. Qualitative assessment indicated low concern to human health. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted for aquatic receptors. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. A Tier 2 assessment is not warranted.	NA

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Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Mar-20	Ulexite	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC50 Fathead minnow 79.7 mg B/L Aquatic Invertebrate -48-hr Freshwater invertebrates 64 - > 544 mg B/L Aquatic Algae -72-hr EC50 *Pseudokirchneriella subcapitata* 52.4 mg B/L Chronic Aquatic - Fish -4-day EC10 *Microp salmoides 36.8* mg B/L -long term NOEC-LOEC *Pimephales promelas* 21.3 mg B/L -long term NOEC-LOEC Brachydanio rerio - 36 mg/L Chronic Aquatic - Invertebrate -NOEC *Daphnia magna* - 13.9 mg B/L -NOEC Hyalella azteca - 6.3 mg B/L Chronic Aquatic - Algae and aquatic plants -NOEC *Brachionus calyciflorus* 24.6 mg B/L -NOEC *Lampsilis siliquoidea* - 30 mg B/L **Terrestrial Toxicity** -NOEC ranging from 7.2 mgB/kg dw to 86.7 mg B/kg **$PNEC_{water}$** - not derived **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Envrionmental Fate Properties: naturally occuring mineral; not expected to bioaccumulate PBT Assessment: Does not meet the screening criteria for bioaccumulation.

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Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Mar-20	Ulexite	[redacted]	Tier 1	PBT Assessment: The overall conclusion is that Ulexite is not a PBT substance. Qualitative assessment indicated low concern to human health. Management: No additional management required, Tier 1 screening satisfied.	NA

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Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
May-21	Ceramic Materials and wares, chemicals	[redacted]	[redacted]	No ecotoxicity data available. **$PNEC_{water}$** - not derived **$PNEC_{soil}$ -** not derived	Qualitative Assessment: Human Hazard: low concern Ecological Hazard: low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Not relevant as substance is inorganic PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: Not relevant as substance is inorganic PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Crystalline silica, quartz	[redacted]	[redacted]	**Aquatic and Terrestrial Toxicity** -No studies are available. -Expected to be low concern for toxicity to aquatic organisms. **$PNEC_{water}$** - not derived **$PNEC_{soil}$ -** not derived	Qualitative Assessment: Human Hazard: Inhalation: silicosis and lung cancer in humans. Oral/dermal: low concern. Ecological Hazard: Low concern PBT Assessment: Substance exhibits higher toxicity than that established by regulatory guidance.	Environmental Fate Properties: Not relevant PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: inorganic complex not expected to bioaccumulate PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Guar gum	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Oncorhynchus mykiss* - 218 mg/L Acute Aquatic - Invertebrate -48-hr LC_{50} *Daphnia magna* - 42 mg/L -96-hr LC_{50} *Daphnia magna* - <6.2 mg/L Chronic Aquatic -No chronic studies available **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.006 mg/L (Acute *Daphnia*) **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern to fish, moderate acute toxicity to invertebrates PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable. PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: Expected to not bioaccumulate. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Choline Chloride (2-hydroxy-N,N,N-trimethylethanaminium chloride)	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Oryzias latipes* - >100 mg/L (nominal and measured) -96-hr LC_{50} *Leuciscus idus* - >10,000 mg/L (78% solution of choline chloride) Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - 349 mg/L (nominal and measured) -48-hr EC_{50} *Daphnia magna* - >500 mg/L (78% solution of choline chloride) Acute Aquatic - Algae and other aquatic plants -72-hr EC_{50} *Pseudokirchneriella subcapitata* - >1,000 (nominal and measured) Chronic Aquatic - Invertebrate -21-day *Daphnia magna* reproduction test NOEC 30.2 mg/L (nominal and measured) Chronic Aquatic - Algae and other aquatic plants -72-hr *Pseudokirchneriella subcapitata* study NOEC 30.2 mg/L **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.3 mg/L **$PNEC_{soil}$** - 0.007 mg/kg soil dry weight (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard -Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: Experimental log Kow is -3.77 PBT Assessment: Does not meet the criteria for bioaccumulation.

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Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
May-21	Ceramic Materials and wares, chemicals	[redacted]	Tier 1 (Qualitative Assesment/PBT)	PBT Assessment: The overall conclusion is that Ceramic Materials and wares, chemicals is not a PBT substance. Qualitative assessment indicated low concern to human health. Management: No additional management required, Tier 1 screening satisfied.	NA
	Crystalline silica, quartz	[redacted]	Tier 1 (Qualitative Assessment/ PBT)	PBT Assessment: The overall conclusion is that Crystalline silica, quartz is not a PBT substance. Qualitative Assessment indicated hazardous to human health by the inhalation pathway; not hazardous by the oral/dermal route. Management: Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure. Therefore a Tier 2 Assessment is not warranted.	NA
	Guar gum	[redacted]	Tier 1 (NICNAS/ PBT/ Exposure Assessment)	NICNAS Assessment (2018) Human Health - unlikely to cause harm to public - unlikely to cause harm to workers Environment -Potentially harmful to the environment in the event of transport spill NICNAS: Identified as chemical of low concern for human health in National assessment of chemicals associated with coal seam gas extraction in Australia, Tech Report Number 11 (NICNAS, 2017) Qualitative assessment indicated low concern to human health. PBT Assessment - The overall conclusion is that guar gum is not a PBT substance. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT criteria for toxicicty. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Therefore, a Tier 2 assessment was not warranted.	NA
	Choline Chloride (2-hydroxy-N,N,N-trimethylethanaminium chloride)	[redacted]	Tier 1 (NICNAS/ PBT/ Exposure Assessment)	NICNAS: Identified as chemical of low concern for human health in National assessment of chemicals associated with coal seam gas extraction in Australia, Tech Report Number 11 (NICNAS, 2017) PBT Assessment: The overall conclusion is that choline chloride is not a PBT substance. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. This chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: No additional management required, Tier 1 screening satisfied.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
May-21	Acrylamide/ammonium acrylate copolymer	[redacted]	[redacted]	No ecotoxicity data available. **$PNEC_{water}$** - not derived **$PNEC_{soil}$ -** not derived	Qualitative Assessment: Human Health Hazard -Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: Not expected to bioaccumulate because of poor water solubility and high molecular weight PBT Assessment: Does not meet criteria for bioaccumulation
	Ethylene glycol	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Pimephales promelas* - >72,860 mg/L -96-hr LC_{50} *Oncorhynchus mykiss* - 22,810 mg/L and 24,591 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - >100 mg/L, 46,300 mg/L (20°C), 51,000 mg/L (24°C) -48-hr EC50 *Ceriodaphnia dubia-affinis* - 25,800 mg/L (20°C), 10,000 mg/L (24°C) Acute Aquatic - Algae and other aquatic plants -96-hr IC_{50} *Selenastrum capricornutum* - 10,940 mg/L -96-hr NOEC *Selenastrum capricornutum* - 10,000 mg/L Chronic Aquatic - Fish -7-day NOEC *Pimephales promelas* - 15,380 mg/L Chronic Aquatic - Invertebrate -7-day NOEC *Ceriodaphnia dubia* - 8,590 mg/L Chronic Aquatic - Algae -72-hr NOEC *Pseudokirchneriella subcapitata* - >100 mg/L **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 10 mg/L **$PNEC_{soil}$** - 0.13 mg/kg soil dry weight (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - Repeated exposures may cause kidney toxicity Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Readily biodegradable. PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: -Calculated log Kow is -1.36 -BCF in golden ide (*Leuciscus idus melanotus*) after 3 days exposure was 10 PBT Assessment: Does not meet the criteria for bioaccumulation.
	Hydrochloric acid	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Oncorhynchus mykiss* - pH 4.12 (hard water), pH 3.98 (soft water) -96-hr LC_{50} *Lepomis macrochirus* - pH 3.25-3.5 Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - pH 4.92 Acute Aquatic - Algae and other aquatic plants -72-hr EC_{50} *Chlorella vulgaris* - pH 4.7 (growth rate), pH 4.82 (biomass), pH 5 (yield/growth rate) Chronic Aquatic -No chronic studies available **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - not derived **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Corrosive; respiratory irritant Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely PBT Assessment: Not applicable.	Environmental Fate Property: Expected to not bioaccumulate. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Hydrotreated light petroleum distillate	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Oncorhynchus mykiss* - 2-5 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - 1.4 mg/L Acute Aquatic - Algae and other aquatic plants -72-hr EC_{50} *Raphidocelis subcapitata* - <1-3 mg/L -72-hr EC50 *Selenastrum capricornutum* - 3.7 mg/L Chronic Aquatic -No chronic studies available for fish -21-d EL_{50} - *Daphnia magna* 0.89 mg/L **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.005 mg/L **$PNEC_{soil}$** - 0.32 mg/kg dry weight	Qualitative Assessment: Human Health Hazard - skin sensitizer Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence	Environmental Fate Properties: BCF = 3.162 L/kg PBT Assessment: Does not meet the screening criteria for bioaccumulation.

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Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
May-21	Acrylamide/ammonium acrylate copolymer	[redacted]	Tier 1 (NICNAS/Qualitative Assessment/PBT)	NICNAS: Identified as chemical of low concern for human health in National assessment of chemicals associated with coal seam gas extraction in Australia, Tech Report Number 11 (NICNAS, 2017) PBT Assessment: The overall conclusion is that choline chloride is not a PBT substance. Management: No additional management required, Tier 1 screening satisfied.	NA
	Ethylene glycol	[redacted]	Tier 1 (Qualitative Assessment/ PBT)	PBT Assessment: The overall conclusion is that ethylene glycol is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., kidney toxicity). Management: Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA
	Hydrochloric acid	[redacted]	Tier 1 (NICNAS/ Qualitative Assessment/ PBT)	NICNAS Assessment (2018) Human Health - unlikely to cause harm to public - potentially harmful to workers health in event of industrial incident Environment -Potentially harmful to the environment in the event of transport spill PBT Assessment - The overall conclusion is that hydrochloric acid is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., corrosive). Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA
	Hydrotreated light petroleum distillate	[redacted]	Tier 1 (Qualitative/PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that hydrotreated light petroleum distillate is not a PBT substance. Qualitative assessment indicated low concern for human and ecological hazards. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. This chemical is inherently biodegradable and does not meet the PBT assessment criteria for toxicity or bioaccumulation. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Australia SafeWork Place and Condor Occupational Safety Guidance will be used to minimise human health exposure. Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Therefore, a Tier 2 assessment was not warranted.	NA

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Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
May-21	Ulexite	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC50 Fathead minnow 79.7 mg B/L Aquatic Invertebrate -48-hr Freshwater invertebrates 64 - > 544 mg B/L Aquatic Algae -72-hr EC50 *Pseudokirchneriella subcapitata* 52.4 mg B/L Chronic Aquatic - Fish -4-day EC10 *Microp salmoides 36.8* mg B/L -long term NOEC-LOEC *Pimephales promelas* 21.3 mg B/L -long term NOEC-LOEC Brachydanio rerio - 36 mg/L Chronic Aquatic - Invertebrate -NOEC *Daphnia magna* - 13.9 mg B/L -NOEC Hyalella azteca - 6.3 mg B/L Chronic Aquatic - Algae and aquatic plants -NOEC *Brachionus calyciflorus* 24.6 mg B/L -NOEC *Lampsilis siliquoidea* - 30 mg B/L **Terrestrial Toxicity** -NOEC ranging from 7.2 mgB/kg dw to 86.7 mg B/kg **$PNEC_{water}$** - not derived **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Envrionmental Fate Property: Naturally occuring mineral; not expected to bioaccumulate PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Poly(oxy-1,2-ethanediyl), alphahexyl-omega-hydroxy	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} Oncorhynchus mykiss - 1,464 mg/L -96-hr LC_{50} *Pimephales promelas* - range from 1,580 mmg/L - 2,137 mg/L -96 hr LC_{50} - Lepomis machrochirus - 1,490 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - range from - 881 mg/L - 2,650 mg/L Acute Aquatic - Algae and other aquatic plants -72-hr EC_{50} *Pseudokirchneriella subcapitata* - 911 mg/L (biomass); 88 mg/L -72-hr EC_{50} *Selenastrum capricornutum* - 720 mg/L (biomass); 280 mg/L **Chronic Toxicity** Chronic Aquatic - Fish -21-day NOEC *Brachydanio rerio* - > 100 mg/L Chronic Aquatic - Invertebrate - 21-day NOEC *Daphnia magna* - 100 mg/L **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 8.8 mg/L **$PNEC_{soil}$** - 0.9 mg/kg soil dry weight	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Harmful to aquatic life PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: Log Kow is 2.9 No bioconcentration studies PBT Assessment: Does not meet the screening criteria for bioaccumulation.

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Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
May-21	Ulexite	[redacted]	Tier 1 (Qualitative/PBT)	PBT Assessment: The overall conclusion is that ulexite is not a PBT substance. Qualitative assessment indicated low concern to human health. Management: No additional management required, Tier 1 screening satisfied.	NA
	Poly(oxy-1,2-ethanediyl), alphahexyl-omega-hydroxy	[redacted]	Tier 1 (Qualitative/PBT)	PBT Assessment: The overall conclusion is that poly(oxy-1,2-ethanediyl), alphahexyl-omega-hydroxy is not a PBT substance. Qualitative assessment indicated low concern to human health. The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: No additional management required, Tier 1 screening satisfied.	NA

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Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
May-21	2-Propenoic acid, polymer with sodium phosphinate (1:1), sodium salt	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} Rianbow Trout - >1,000 mg/L -96-hr LC_{50} Zebra Fish - >1,000 mg/L Acute Aquatic - Invertebrate -24-hr EC_{50} Daphnia - 320 mg/L -72-hr EC_{50} - 130 mg/L **Terrestrial Toxicity** No terrestrial toxicity studies identified. **$PNEC_{water}$** - 0.13 mg/L **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - low concern Ecological Hazard - Low toxicity concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Meets 150 day critierion for ultimate biodegradability. PBT Assessment: Meets the screening criteria for persistence	Environmental Fate Property: Not expected to bioaccumulate in the environment. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Sodium hydroxide	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -24-hr LC50 *Carassius auratus* - 160 mg/L -48-hr LC50 *Leuciscus idus melanotus* - 189 mg/L -96-hr LC50 *Gambusia affinis* - 125 mg/L Acute Aquatic - Invertebrate -48-hr EC50 *Ceriodaphnia cf. dubia* - 40 mg/L -toxicity threshold of sodium hydroxide for Daphnia magna - 40 mg/L ot 240 mg/L **Terrestrial Toxicity** No terrestrial toxicity studies identified. **$PNEC_{water}$** - not derived **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Corrosive Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Not applicable	Environmental Fate Property: Sodium hydroxide is not expected to bioaccumulate in the environment. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Distillates (petroleum), solvent-dewaxed heavy paraffinic	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic Fish - 96 hour LC_{50} fish > 100 mg/L Acute Aquatic Invertebrate - 48 hour LC_{50} >10,000 mg/L Acute Aquatic Algae -72-hour NOEL ≥ 100 mg/L **Chronic Toxicity** Chronic Aquatic - Infertebrates -21 day NOEL - *Daphnia magna* - 100 mg/L [WAF] -21-day - NOEL - *Daphnia magna* - >1000 mg/L -21 day - NOEL - *Daphnia magna* - 10 mg/L **Terrestrial Toxicity** No terrestrial data found **$PNEC_{water}$** - 1 mg/L **$PNEC_{soil}$** - 4000 mg/kg	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Inherently biodegradable PBT Assessment: Does meet the screening criteria for persistence	Environmental Fate Property: Not available because UVCB Substance PBT Assessment: Not applicable
	Diammonium peroxidisulphate	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Oncorhynchus mykiss* - 76.3 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - 120 mg/L Acute Aquatic - Algae -72-hr EC_{10} *Phaedactylum tricornutum* - 320 mg/L Chronic Aquatic - Invertebrate -21-day NOEC *Daphnia magna* 20.8 mg/L **Terrestrial Toxicity** No terrestrial toxicity studies identified. **$PNEC_{water}$** - 0.076 mgL **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Moderate concern (irigating to eyes, skin, and respiratory tract) Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Not applicable	Environmental Fate Properties: Inorganic salt that dissolves to respective cations and anions. PBT Assessment: Does not meet the screening criteria for bioaccumulation. Diammonium peroxidisulphate is not a PBT substance

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
May-21	2-Propenoic acid, polymer with sodium phosphinate (1:1), sodium salt	[redacted]	Tier 1 (Qualitative/PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that 2-propenoic acid, polymer with sodium phosphinate is not a PBT substance. Qualitative Assessment indicated low concern to human health The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is ultimately biodegradable, does not bioaccumulate, and does not meet the PBT criteria for toxicicty. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release.	NA
	Sodium hydroxide	[redacted]	Tier 1 (Qualitative/PBT)	PBT Assessment: The overall conclusion is that sodium hydroxide is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., corrosive). The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA
	Distillates (petroleum), solvent-dewaxed heavy paraffinic	[redacted]	Tier 1 (Qualitative/PBT)	PBT Assessment: The overall conclusion is that ulexite is not a PBT substance. Qualitative assessment indicated low concern to human health. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is inherently biodegradeable, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Therefore, a Tier 2 assessment was not warranted.	NA
	Diammonium peroxidisulphate	[redacted]	Tier 1 (Qualitative Assessment/PBT)	PBT Assessment: The overall conclusion is that diammonium peroxodisulphate is not a PBT substance. Qualitative assessment indicated potential human hazard (e.g., skin, eye, and respiratory irritant). The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is dissociates completely, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Therefore, a Tier 2 assessment was not warranted.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
May-21	Glutaraldehyde	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} Bluegill Sunfish - 13 mg/L -96-hr LC_{50} *Oncorhynchus mykiss* - 10 mg/L Acute Aquatic - Invertebrate -48-hr LC_{50} *Daphnia magna* - 14.87 mg/L -48-hr LC_{50} *Daphnia magna* - 14 mg/L Acute Aquatic - Algae and other aquatic plants -72-hr EC_{50} *Scenedesmus subspicatus* - 0.375 mg/L (biomass), 0.6 (growth rate), 0.025 (NOEC) -72-hr EC_{50} *Scenedesmus subspicatus* - 0.92 mg/L (biomass), 0.61 (growth rate), 0.33 (NOEC) -72-hr EC_{50} *Scenedesmus subspicatus* - 0.61 mg/L (growth rate) Chronic Aquatic - Fish -97-day LOEC *Oncorhynchus mykiss* - 5 mg/L -97-day NOEC *Oncorhynchus mykiss* - 1.6 mg/L Chronic Aquatic - Invertebrate -21-day NOEC *Daphnia magna* - 5 mg/L **Terrestrial Toxicity** Earthworms -14-day LC50 - 500 mg/kg soil dry weight Soil microoganisms -28-day EC50 - 360 mg/kg soil dry weight - > 593 mg/kg soil dry weight -28-day EC10 - 1.5 mg/kg soil dry weight - 11.5 mg/kg soil dry weight Avian -single dose (oral gavage) LC50 Mallard duck - 206 mg/kg -5-day dietary NOEC - Mallard duck - >2500 ppm Terrestrial Plants: -19-day EC_{50} - *Avena sativa* (oats) - >1,000 mg/kg soil dry weight; NOEC - >1000 (emergence rate, dry matter, shoot length) -19-day EC_{50} . *Brassica napus* (rapeseed) - >1,000 mg/kg soil dry weight; NOEC - >1000 (emergence rate), 500 (dry matter), 250 (shoot length) -19-day EC_{50} - *Vicia sativa* (vetch) - >1,000 mg/kg soil dry weight; NOEC - >1000 (emergence rate), 125 (dry matter), 125 (shoot length) **$PNEC_{water}$** - 0.0025 mg/L (Chronic algae) **$PNEC_{soil}$** -0.02 mg/kg soil dry weight (IChronic soil organisms)	Qualitative Assessment: Human Health Hazard - Corrosive; skin/respiratory sensitizer Ecological Hazard - Very toxic to aquatic life with long lasting effects. Low concern to terrestrial organisms. PBT Assessment: Substance exhibits higher toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable. PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: Expected to have a low potential for bioaccumulation PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Sorbitan, mono-9-octadecenoate, (Z)	[redacted]	[redacted]	**Aquatic Toxicity** -96-hr LL_{50} *Salmo gairdneri* - >1,000 [WAF] mg/L -96-hr LL_{50} *Oryzias latipes* - >1,000 [WAF] mg/L -48-hr EL_{50} *Daphnia magna* - >1,000 [WAF] mg/L -72-hr EL_{50} *Pseudokirchneriella subcapitata* - >1,000 [WAF] mg/L **Chronic Aquatic - Invertebrate** -21-day NOELR (no-observed-effect-loading-rate) in a *Daphnia* reproduction test for sorbitan stearate (CAS No. [redacted] is 16 mg/L WAFA (ECHA) [Kl. score = 2]. -72-hr NOELR (no-observed-effect-loading-rate) to *Pseudokirschneriella subcapitata* for sorbitan stearate was 560 mg/L [WAF] (ECHA) [Kl. score = 1]. **Terrestrial Toxicity** -No data available. **$PNEC_{water}$** - 0.32 mg/L WAF **$PNEC_{soil}$** -10 mg/kg soil dry weight	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence	Environmental Fate Properties: modeled BCF values ranged from 36 to 92 L.kg PBT Assessment: Does not meet the screening criteria for bioaccumulation.

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Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
May-21	Glutaraldehyde	[redacted]	Tier 2	NICNAS Assessment (2018) Human Health - potentially harmful to public health in event of transport spill. - potentially harmful to workers health in event of industrial incident Environment -Potentially harmful to the environment in the event of transport spill PBT Assessment: The overall conclusion is that glutaraldehyde is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., skin irritant). The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical and does meet the screening criteria for toxicity. This chemical is readily biodegradable and does not bioaccumulate. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted for aquatic receptors. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted for human receptors. Chemicals with a high ecotoxicity hazard assessment have a potential avian wildlife exposure to chemicals stored in treatment tanks. Therefore a Tier 2 assessment was conducted for avian receptors.	A quantitative risk characterisation was used to assess the risk to avian receptors from potential exposure to gluteraldehyde (Appendix E). There were no unacceptable potential risks to avian receptors as a result of ingestion of waters stored in treatment tanks.
	Sorbitan, mono-9-octadecenoate, (Z)	[redacted]	Tier 1 (Qualitative Assessment/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that sorbitan monooleate polyoxyethylene derivative is not a PBT substance. Qualitative assessment indicated low concern to human health. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Therefore, a Tier 2 assessment was not warranted.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
May-21	Ethoxylated oleic acid	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish 96-hour - LC_{50} *Danio rerio* and *Cyprinus carpio* 1.2 mg/L Acute Aquatic - Invertebrate 48-hour EC_{50} *Daphnia magna* - 0.39 mg/L Acute Aquatic - Algae 72 hour EC_{50} *Desmodesmus subspicatus* - 1.4 mg/L (biomass) and 1.8 mg/L (growth rate) **Terrestrial Toxicity** -OECD 207 NOEL - *Eisenia fetida* - >1,000 mg/kg dw **PNECwater -** 0.039 mg/L **PNECsoil -** 1 mg/kg soil dry weight	Qualitative Assessment: Human Health Hazard - low concern Ecological Hazard - low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable. PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Sodium Chloride	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC50 *Lepomis macrochirus* - 5,840 mg/L Acute Aquatic - Invertebrate -48-hr EC50 *Daphnia magna* - 1,900 mg/L Acute Aquatic - Algae and other aquatic plants -96-hr NOEC *Lemna* - 6,780 mg/L **Chronic Toxicity** Chronic Aquatic - Fish 33-day NOEC - *Pimephales promelas* - 232 mg/L Chronic Aquatic - Invertebrate 21-day NOEC - *Daphnia pulex* - 314 mg/L **Terrestrial Toxicity** -14-day LC50 *E. fetida* - 3296 mg/kg soil dw -10-week NOEC *E. fetida* - 3,507 mg/kg soil -7-day EC50 - red fescue grass - 500.8 mg/kg soil -12-hr LD50 - wild house sparrow - 3,000 - 3,500 mg/kg **$PNEC_{water}$** - not derived **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - low concern Ecological Hazard - low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Not applicable	Environmental Fate Properties: Essential ions to biological systems. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Sodium Tetraborate Decahydrate	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC50 Fathead minnow 79.7 mg B/L Aquatic Invertebrate -96-hr LC50 *Legumia recta* (black sandshell mussel) 147 mg B/L -96-hr LC50 *Hyalella azteca* 64 mg B/L Aquatic Algae -72-hr EC50 *Pseudokirchneriella subcapitata* 52.4 mg B/L Chronic Aquatic - Fish -34-day NOEC *Danio rerio 1.8* mg B/L -32-day NOEC *Pimephales promelas* 11 mg B/L Chronic Aquatic - Invertebrate -14-day NOEC *Daphnia magna* - 2.4 mg B/L Chronic Aquatic - Algae -4-day NOEC *Pseudokirchneriella subcapitata* - 2.8 mg B/L **Terrestrial Toxicity** -Soil inverteretes - NOEC ranging from 5.2 mgB/kg dw to 315 mg B/kg **$PNEC_{water}$** - 0.94 mg/L (ANZECC Water Quality Guideline for 95% species protection for boron in freshwater) **$PNEC_{soil}$** -5.7 mg/kg soil dry weight (derived for boron)	Qualitative Assessment: Human Health Hazard - low concern Ecological Hazard - low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Not applicable	Environmental Fate Properties: Expected to have a low potential for bioaccumulation PBT Assessment: Does not meet the screening criteria for bioaccumulation.

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Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
May-21	Ethoxylated oleic acid	[redacted]	Tier 1 (Qualitative Assessment/PBT)	PBT Assessment: The overall conclusion is that sorbitan monooleate polyoxyethylene derivative is not a PBT substance. Qualitative assessment indicated low concern to human health. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Therefore, a Tier 2 assessment was not warranted.	NA
	Sodium Chloride	[redacted]	Tier 1 (NICNAS/Qualitative Assessment/PBT)	NICNAS: Identified as chemical of low concern for human health in National assessment of chemicals associated with coal seam gas extraction in Australia, Tech Report Number 11 (NICNAS, 2017). In Technical report number 14, releases to surface waters were found to have limited long-term environmetnal effects because sodium chloride is ubiquitous and present in most water, soil, and sediment. Qualitative assessment indicated low concern to human health Management: No additional management required, Tier 1 screening satisfied.	NA
	Sodium Tetraborate Decahydrate	[redacted]	Tier 1 (Qualitative Assessment/PBT)	PBT Assessment: The overall conclusion is that sodium tetraborate decahydrate is not a PBT substance. Qualitative assessment indicated low concern to human health The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: No additional management required, Tier 1 screening satisfied.	NA

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Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
May-21	Ammonium Chloride	[redacted]	[redacted]	**Aquatic Toxicity** Acute toxicity - Fish -Ranbow trout - 42.91 mg/L ammonium chloride, -Mountain whitefish (Prosopium williamsoni): LC50 (96h) 46.27 mg/L for ammonium chloride; Acute toxicity - Invertebrates - *Daphnia magna* 136.6 mg/L - EC_{20} *Daphnia magna* 47 mg/L Acute Acute - Algae -EC_{50} *Chlorella vulgaris* 1300 mg/L Chronic toxicity - Fish -Lepomis macrochirus EC20 = 4.28 mg/L ammonium chloride. **Terrestrial Toxicity** No data available **$PNEC_{water}$** - 0.25 mg/L **$PNEC_{soil}$** -not derived	Qualitative Assessment: Human Health Hazard - low concern Ecological Hazard - low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties - Substance is inorganic, dissociates completely. PBT Assessment: Not applicable	Environmental Fate Properties: Not expected to bioacumulate because inorganic PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Gelatins	[redacted]	[redacted]	No ecotoxicity data available. **$PNEC_{water}$** - not derived **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - low concern Ecological Hazard - low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Inherently biodegradeable PBT Assessment: Does not meet screening criteria for persistance.	Environmental Fate Properties: Naturally occurring in animal products and are not expected to bioaccumulate. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Calcium Chloride	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC50 - *Pimephales promelas* - 4,630 mg/L -96-hr LC50 - *Lepomis macrochirus* (two studies) - 9,500-11,300 mg/L -96-hr LC50 - *Gambusia affinis* - 13,400 mg/L Acute Aquatic - Invertebrate -48-hr EC50 *Daphnia magna* (three studies) - 1,062 mg/L and 2,770 mg/L -48-hr EC50 - *Ceriodaphnia dubia* - 1,830 mg/L Acute Aquatic - Algae -72-hr EC50 *Pseudokirchneriella subapitata* - 2,900 mg/L Chronic Aquatic - Invertebrate -21-day EC50 *Daphnia* - 610 mg/L **Terrestrial Toxicity** No data available **$PNEC_{water}$** - 11 mg/L **$PNEC_{soil}$** - not derived	Qualitative Assesment: Human Health Hazard - low concern (moderate eye irritation) Ecological Hazard - low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Not applicable	Environmental Fate Properties: Essential ions to biological systems. Neither calcium chloride or its dissociated ions are expected to bioaccumulate. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Vinylidene chloride/methylacrylate copolymer	[redacted]	[redacted]	No ecotoxicity data available. **$PNEC_{water}$** - not derived **$PNEC_{soil}$** - not derived	Qualitative Assesment: Human Health Hazard - low concern Ecological Hazard - low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: No data available PBT Assessment: Not applicable	Environmental Fate Properties: Not expected to bioaccumulate due to large molecular weight of substance PBT Assessment: Not applicable

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Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
May-21	Ammonium Chloride	[redacted]	Tier 1 (Qualitative Assessment/PBT)	PBT Assessment: The overall conclusion is that ammonium chloride is not a PBT substance. Qualitative assessment indicated low concern to human health The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is dissociates completely, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Therefore, a Tier 2 assessment was not warranted.	NA
	Gelatins	[redacted]	Tier 1 (NICNAS/Qualitative Assessment/PBT)	NICNAS: Identified as chemical of low concern for human health in an IMAP Tier 1 assessment and considers this chemical of low concern to the environment PBT Assessment: The overall conclusion is that gelatins is not a PBT substance. Qualitative assessment indicated low concern to human health The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: No additional management required, Tier 1 screening satisfied.	NA
	Calcium Chloride	[redacted]	Tier 1 (Qualitative Assessment/PBT)	PBT Assessment: The overall conclusion is that calcium chloride is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (eye irritant). The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure. No additional management required, Tier 1 screening satisfied.	NA
	Vinylidene chloride/methylacrylate copolymer	[redacted]	Tier 1 (NICNAS)	NICNAS: Determined to be low concern polymer under the National Industrial Chemicals Notification and Assessment Scheme (NICNAS) targeted tier I approach. (AICIS, 2021). An IMAP Tier 1 assessment completed by NICNAS considers it a polyme of loc concern for both human health and the environment. Management: No additional management required, Tier 1 screening satisfied.	NA

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Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
May-21	but-2-enedioic acid (Fumaric Acid)	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-h LC_{50} *Danio rerio* - >100 mg/L Acute Aquatic - Invertebrate -48-h EC_{50} *Daphnia magna* - >100 mg/L Acute Aquatic - Algae -72-h EC_{50} *Pseudokirchneriella subcapitata* - >100 mg/L Chronic Aquatic - Fish No data available **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 1 mg/L **$PNEC_{soil}$** - 0.0115 mg/kg	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence	Environmental Fate Properties: Bioaccumulation of but-2-enedoic acid is not expected to occur based on its log K_{ow} value of -4.02. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Dicoco dimethyl quaternary ammonium chloride	[redacted]	[redacted]	**Aquatic Toxicity:** Acute Aquatic - Fish -96 hour LC_{50} - *Salmo gairdneri* 3.2 mg/L Acute Aquatic - Invertebrates 48-hour EC_{50} - *Dapnia magna* - 0.09 mg/L Acute Aquatic - Algae -72 hour EC_{50} *Pseudokirchneriella subcapitata* 0.062 mg/L Chronic Aquatic - Fish 34 day NOEC - *Pimephales promelas* - 0.032 mg/L Chroni Aquatic - Invertebrates 21 day NOEC - *Daphnia magna* - 0.0068 mg/L **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.00062 mg/L **$PNEC_{soil}$** - 25.6 mg/kg	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Moderate concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence	Environmental Fate Properties: log Kow = 3.15 PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Alcohols, C12-14-secondary, ethoxylated	[redacted]	[redacted]	**Aquatic Toxicity** -NOEC = freshwater fish: 2 species - 720 to 1,500 mg/L -NOEC = freshwater crustaceans: 2 species - 590 to 860 mg/L -NOEC - Freshwater rotifers Brachionus calyciflorus - 1,300 mg/L -NOEC - Freshwater algae, diatoms and blue-green algae: 6 species - 200 to 8,700 mg/L **Chronic Aquatic - Invertebrate** -No data available **Terrestrial Toxicity** -No data available. **$PNEC_{water}$** - 0.14 mg/L (ANZECC Water Quality Guideline for alcohol ethoxyates) **$PNEC_{soil}$** -5.6 mg/kg	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: Expected to have a low potential for bioaccumulation and a moderate potential for adsorption to soil and sedminet. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Non-crystalline Silica (impurity)	[redacted]	[redacted]	**Aquatic and Terrestrial Toxicity** -No studies are available. -Expected to be low concern for toxicity to aquatic organisms. **$PNEC_{water}$** - not derived **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Hazard: Inhalation: silicosis and lung cancer in humans. Oral/dermal: low concern. Ecological Hazard: Low concern PBT Assessment: Substance exhibits higher toxicity than that established by regulatory guidance.	Environmental Fate Properties: Not relevant PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: inorganic complex not expected to bioaccumulate PBT Assessment: Does not meet the screening criteria for bioaccumulation.

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Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
May-21	but-2-enedioic acid (Fumaric Acid)	[redacted]	Tier 1 (Qualitative Assessment/PBT)	PBT Assessment: The overall conclusion is that but-2-enedioic acid is not a PBT substance. Qualitative assessment indicated low concern to human health The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: No additional management required, Tier 1 screening satisfied.	NA
	Dicoco dimethyl quaternary ammonium chloride	[redacted]		PBT Assessment: The overall conclusion is that Dicoco dimethyl quaternary ammonium chloride is not a PBT substance. Qualitative assessment indicated low concern to human health. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Therefore, a Tier 2 assessment was not warranted.	
	Alcohols, C12-14-secondary, ethoxylated	[redacted]	Tier 1 (Qualitative Assessment/PBT)	PBT Assessment: The overall conclusion is that Alcohols, C12 to C14 secondary, ethoxylated are not PBT substances. Qualitative assessment indicated low concern to human health The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: No additional management required, Tier 1 screening satisfied.	NA
	Non-crystalline Silica (impurity)	[redacted]	Tier 1 (Qualitative Assessment/ PBT)	PBT Assessment: The overall conclusion is that Crystalline silica, quartz is not a PBT substance. Qualitative Assessment indicated hazardous to human health by the inhalation pathway; not hazardous by the oral/dermal route. Percent volume in mixture is less than 0.1-percent of the mixture. Therefore, according to the GHS criteria the concentration of the substance in the mixture would not meet the criteria of carcinogenicity. Management: Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure. Therefore a Tier 2 Assessment is not warranted.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
May-21	2,2"-oxydiethanol - impurity (Diethylene glycol)	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-h LC_{50} *Pimephales promelas* - 75,200 mg/L -96-h LC_{50} *Oncorhynchus mykiss* - 66,000 Acute Aquatic - Invertebrate -24-h EC_{50} *Daphnia magna* ->10,000 mg/L -48-hr EC_{50} *Daphnia magna* - 65,980 mg/L -48-hr EC_{50} *Daphnia magna* - 62,630 mg/L Chronic Aquatic - Fish -7-day NOEC *Pimephales promelas* - 15,380 mg/L (for ethylene glycol) Chronic Aquatic - Invertebrate -7-day NOEC *Ceriodaphnia dubia* - 8,590 mg/L (for ethylene glycol) -21 day - *Daphnia magna* - > 15,000 mg/L (for triethylene glycol) Chronic Aquatic - Algae -8-day TGK to algae *Scenedesmus quadricauda* 2,700 mg/L **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 27 mg/L **$PNEC_{soil}$** - 0.36 mg/kg dry weight soil	Qualitative Assessment: Human Health Hazard -Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: log Kow = -1.98 (calculated) PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	2-Propenamid (impurity)	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -LC_{50} Rainbow Trout, *Onchorhyncus mykiss* , 180 mg/L Acute Aquatic - Invertebrate -48 hour EC50 - *Daphnia Magna* - 60 mg/L Acute Aquatic - Algae -72 hour EC50 - *Pseudokirchneriella subcapitata* - 33 mg/L Chronic Aquatic - Fish -28 day - NOEC *Cyprinus carpio* - 5 mg/L **Terrestrial Toxicity** No data available **$PNEC_{water}$** - 0.05 mg/L **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: log Kow of -0.67 PBT Assessment: Does not meet the screening criteria for bioaccumulation
	Propan-2-ol	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Pimpephales promelas* - 9,640 mg/L Acute Aquatic - Invertebrate -24-hr EC_{50} *Daphnia magna* >10,000 mg/L **Chronic Aquatic - Invertebrate** -16 day NOEC *Daphnia magna* 141 mg/L -21 day NOEC *Daphnia magna* 30 mg/L -7-day NOEC *Scenedesmus quadricauda* is 1,800 mg/L **Terrestrial Toxicity** -EC_{50} lettuce seed germination test - 2,100 mg/L **$PNEC_{water}$** - 0.3 mg/L **$PNEC_{soil}$** - 0.014 mg/kg	Qualitative Assessment: Human Health Hazard -Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: Bioaccumulation of isopropanol is not expected to occur based on its log K_{ow} value of 0.05. PBT Assessment: Does not meet the screening criteria for bioaccumulation.

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
May-21	2,2"-oxydiethanol - impurity (Diethylene glycol)	[redacted]	Tier 1 (Qualitative Assessment/PBT)	PBT Assessment: The overall conclusion is that Diethylene glycol is not a PBT substance. Qualitative assessment indicated low concern to human health The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: No additional management required, Tier 1 screening satisfied.	NA
	2-Propenamid (impurity)	[redacted]	Tier 1 (Qualitative/PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that 2-propenamid (impurity) is not a PBT substance. Qualitative Assessment indicated low concern to human health The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release.	NA
	Propan-2-ol	[redacted]	Tier 1 (Qualitative Assessment/PBT)	PBT Assessment: The overall conclusion is that Propan-2-ol is not a PBT substance. Qualitative assessment indicated low concern to human health The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: No additional management required, Tier 1 screening satisfied.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
May-21	Potassium chloride	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Pimpephelas promelas* - 880 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* 660 mg/L -48-hr EC_{50} *Ceriodaphnia dubia* - 630 mg/L Acute Aquatic - Algae and other plants -72-hr EC_{50} *Scenedesmus subspicatus* - >100 mg/L **Chronic Aquatic - Invertebrate** -7-day NOEC in a fathead minnow is 500 mg/L **Terrestrial Toxicity** -No data available. **$PNEC_{water}$** - 1 mg/L (algae) **$PNEC_{soil}$** -not derived	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Does not meet the screening criteria for persistence	Environmental Fate Properties: Will dissociate to potassium and chloride ions which are not expected to bioaccumulate. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Diutan Gum	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic-Fish -96-h LC_{50} *Oncorhynchus mykiss* - 100 mg/L Acute Aquatic- Invertebrate -48-h EC_{50} Daphnid species - 100 mg/L Acute Aquatic - Algae -72 h EC50 Freshwater algae - >100 mg/L Chronic Aquatic - Fish No data available **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 1 mg/L **$PNEC_{soil}$** - 0.01 mg/kg	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: Bioaccumulation of duitan gum is not expected to occur based on its log K_{ow} value of 3.56. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Magnesium Silicate Hydrate (talc)	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic -96-h LC_{50} Unnamed fish species - 89,581 mg/L (QSAR) -48-h LC_{50} Daphnid species - 36,812 mg/L (QSAR) -96 h LC50 Freshwater algae - 7,203 mg/L Chronic Aquatic - Fish No data available **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 72 mg/L **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Biodegradability is not relevant because inorganic substance. PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: Bioaccumulation not expected to occur based on its log K_{ow} value of -9.4. PBT Assessment: Does not meet the screening criteria for bioaccumulation.

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
May-21	Potassium chloride	[redacted]	Tier 1 (Qualitative Assessment/PBT)	PBT Assessment: The overall conclusion is that Potassium chloride is not a PBT substance. Qualitative assessment indicated low concern to human health. The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: No additional management required, Tier 1 screening satisfied.	NA
	Diutan Gum	[redacted]	Tier 1 (Qualitative Assessment/PBT)	PBT Assessment: The overall conclusion is that duitan gum is not a PBT substance. Qualitative assessment indicated low concern to human health The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: No additional management required, Tier 1 screening satisfied.	NA
	Magnesium Silicate Hydrate (talc)	[redacted]	Tier 1 (Qualitative Assessment/PBT)	PBT Assessment: The overall conclusion is that magnesium silicate is not a PBT substance. Qualitative assessment indicated low concern to human health The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: No additional management required, Tier 1 screening satisfied.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Feb-22	Crystalline silica, quartz	[redacted]	[redacted]	**Aquatic and Terrestrial Toxicity** -No studies are available. -Expected to be low concern for toxicity to aquatic organisms. **$PNEC_{water}$** - not derived **$PNEC_{soil}$ -** not derived	Qualitative Assessment: Human Hazard: Inhalation: silicosis and lung cancer in humans. Oral/dermal: low concern. Ecological Hazard: Low concern PBT Assessment: Substance exhibits higher toxicity than that established by regulatory guidance.	Environmental Fate Properties: Not relevant PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: inorganic complex not expected to bioaccumulate PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Choline Chloride (2-hydroxy-N,N,N-trimethylethanaminium chloride)	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Oryzias latipes* - >100 mg/L (nominal and measured) -96-hr LC_{50} *Leuciscus idus* - >10,000 mg/L (78% solution of choline chloride) Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - 349 mg/L (nominal and measured) -48-hr EC_{50} *Daphnia magna* - >500 mg/L (78% solution of choline chloride) Acute Aquatic - Algae and other aquatic plants -72-hr EC_{50} *Pseudokirchneriella subcapitata* - >1,000 (nominal and measured) Chronic Aquatic - Invertebrate -21-day *Daphnia magna* reproduction test NOEC 30.2 mg/L (nominal and measured) Chronic Aquatic - Algae and other aquatic plants -72-hr *Pseudokirchneriella subcapitata* study NOEC 30.2 mg/L **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.3 mg/L **$PNEC_{soil}$** - 0.007 mg/kg soil dry weight (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard -Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: Experimental log Kow is -3.77 PBT Assessment: Does not meet the criteria for bioaccumulation.
	Guar gum	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Oncorhynchus mykiss* - 218 mg/L Acute Aquatic - Invertebrate -48-hr LC_{50} *Daphnia magna* - 42 mg/L -96-hr LC_{50} *Daphnia magna* - <6.2 mg/L Chronic Aquatic -No chronic studies available **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.006 mg/L (Acute *Daphnia*) **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern to fish, moderate acute toxicity to invertebrates PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable. PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: Expected to not bioaccumulate. PBT Assessment: Does not meet the screening criteria for bioaccumulation.

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Feb-22	Crystalline silica, quartz	[redacted]	Tier 1 (Qualitative Assessment/ PBT)	PBT Assessment: The overall conclusion is that Crystalline silica, quartz is not a PBT substance. Qualitative Assessment indicated hazardous to human health by the inhalation pathway; not hazardous by the oral/dermal route. Management: Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure. Therefore a Tier 2 Assessment is not warranted.	NA
	Choline Chloride (2-hydroxy-N,N,N-trimethylethanaminium chloride)	[redacted]	Tier 1 (NICNAS/ PBT/ Exposure Assessment)	NICNAS: Identified as chemical of low concern for human health in National assessment of chemicals associated with coal seam gas extraction in Australia, Tech Report Number 11 (NICNAS, 2017) PBT Assessment: The overall conclusion is that choline chloride is not a PBT substance. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. This chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: No additional management required, Tier 1 screening satisfied.	NA
	Guar gum	[redacted]	Tier 1 (NICNAS/ PBT/ Exposure Assessment)	NICNAS Assessment (2018) Human Health - unlikely to cause harm to public - unlikely to cause harm to workers Environment -Potentially harmful to the environment in the event of transport spill NICNAS: Identified as chemical of low concern for human health in National assessment of chemicals associated with coal seam gas extraction in Australia, Tech Report Number 11 (NICNAS, 2017) Qualitative assessment indicated low concern to human health. PBT Assessment - The overall conclusion is that guar gum is not a PBT substance. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT criteria for toxicicty. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Therefore, a Tier 2 assessment was not warranted.	NA

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Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Feb-22	Ulexite	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC50 Fathead minnow 79.7 mg B/L Aquatic Invertebrate -48-hr Freshwater invertebrates 64 - > 544 mg B/L Aquatic Algae -72-hr EC50 *Pseudokirchneriella subcapitata* 52.4 mg B/L Chronic Aquatic - Fish -4-day EC10 *Microp salmoides 36.8* mg B/L -long term NOEC-LOEC *Pimephales promelas* 21.3 mg B/L -long term NOEC-LOEC Brachydanio rerio - 36 mg/L Chronic Aquatic - Invertebrate -NOEC *Daphnia magna* - 13.9 mg B/L -NOEC Hyalella azteca - 6.3 mg B/L Chronic Aquatic - Algae and aquatic plants -NOEC *Brachionus calyciflorus* 24.6 mg B/L -NOEC *Lampsilis siliquoidea* - 30 mg B/L **Terrestrial Toxicity** -NOEC ranging from 7.2 mgB/kg dw to 86.7 mg B/kg **$PNEC_{water}$** - not derived **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Envrionmental Fate Property: Naturally occuring mineral; not expected to bioaccumulate PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Ethylene glycol	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Pimephales promelas* - >72,860 mg/L -96-hr LC_{50} *Oncorhynchus mykiss* - 22,810 mg/L and 24,591 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - >100 mg/L, 46,300 mg/L (20°C), 51,000 mg/L (24°C) -48-hr EC50 *Ceriodaphnia dubia-affinis* - 25,800 mg/L (20°C), 10,000 mg/L (24°C) Acute Aquatic - Algae and other aquatic plants -96-hr IC_{50} *Selenastrum capricornutum* - 10,940 mg/L -96-hr NOEC *Selenastrum capricornutum* - 10,000 mg/L Chronic Aquatic - Fish -7-day NOEC *Pimephales promelas* - 15,380 mg/L Chronic Aquatic - Invertebrate -7-day NOEC *Ceriodaphnia dubia* - 8,590 mg/L Chronic Aquatic - Algae -72-hr NOEC *Pseudokirchneriella subcapitata* - >100 mg/L **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 10 mg/L **$PNEC_{soil}$** - 0.13 mg/kg soil dry weight (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - Repeated exposures may cause kidney toxicity Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Readily biodegradable. PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: -Calculated log Kow is -1.36 -BCF in golden ide (*Leuciscus idus melanotus*) after 3 days exposure was 10 PBT Assessment: Does not meet the criteria for bioaccumulation.
	Diammonium peroxidisulphate	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Oncorhynchus mykiss* - 76.3 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - 120 mg/L Acute Aquatic - Algae -72-hr EC_{10} *Phaedactylum tricornutum* - 320 mg/L Chronic Aquatic - Invertebrate -21-day NOEC *Daphnia magna* 20.8 mg/L **Terrestrial Toxicity** No terrestrial toxicity studies identified. **$PNEC_{water}$** - 0.076 mgL **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Moderate concern (irigating to eyes, skin, and respiratory tract.) Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Not applicable	Environmental Fate Properties: Inorganic salt that dissolves to respective cations and anions. PBT Assessment: Does not meet the screening criteria for bioaccumulation. Diammonium peroxidisulphate is not a PBT substance

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Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Feb-22	Ulexite	[redacted]	Tier 1 (Qualitative/PBT)	PBT Assessment: The overall conclusion is that ulexite is not a PBT substance. Qualitative assessment indicated low concern to human health. Management: No additional management required, Tier 1 screening satisfied.	NA
	Ethylene glycol	[redacted]	Tier 1 (Qualitative Assessment/ PBT)	PBT Assessment: The overall conclusion is that ethylene glycol is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., kidney toxicity). Management: Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA
	Diammonium peroxidisulphate	[redacted]	Tier 1 (Qualitative Assessment/PBT)	PBT Assessment: The overall conclusion is that sodium diammonium peroxodisulphate is not a PBT substance. Qualitative assessment indicated potential human hazard (e.g., skin, eye, and respiratory irritant). The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is dissociates completely, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Therefore, a Tier 2 assessment was not warranted.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Feb-22	Sodium hydroxide	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -24-hr LC50 *Carassius auratus* - 160 mg/L -48-hr LC50 *Leuciscus idus melanotus* - 189 mg/L -96-hr LC50 *Gambusia affinis* - 125 mg/L Acute Aquatic - Invertebrate -48-hr EC50 *Ceriodaphnia cf. dubia* - 40 mg/L -toxicity threshold of sodium hydroxide for Daphnia magna - 40 mg/L ot 240 mg/L **Terrestrial Toxicity** No terrestrial toxicity studies identified. **$PNEC_{water}$** - not derived **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Corrosive Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Not applicable	Environmental Fate Property: Sodium hydroxide is not expected to bioaccumulate in the environment. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Acrylamide, sodium acrylate copolymer	[redacted]	[redacted]	**Aquatic and Terrestrial Toxicity** -No studies are available. -Expected to be low concern for toxicity to aquatic organisms. Due to poor solubility and high molecular weight not expected to be bioavailable. Does not contain any reactive functional groups. **PNECwater -** not derived **PNECsoil -** not derived	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance due to its very high molecular weight and poor water solubility.	Environmental Fate Property: Not readily biodegradable PBT Assessment: Does meet the screening criteria for persistence.	Environmental Fate Property: Very high molecular weight and poor water solubility PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Poly(oxy-1,2-ethanediyl), alphahexyl-omega-hydroxy	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Oncorhynchus mykiss* - 1,464 mg/L -96-hr LC_{50} *Pimephales promelas* - range from 1,580 mg/L - 2,137 mg/L -96 hr LC_{50} - *Lepomis machrochirus* - 1,490 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - range from - 881 mg/L - 2,650 mg/L Acute Aquatic - Algae and other aquatic plants -72-hr EC_{50} *Pseudokirchneriella subcapitata* - 911 mg/L (biomass); 88 mg/L -72-hr EC_{50} *Selenastrum capricornutum* - 720 mg/L (biomass); 280 mg/L **Chronic Toxicity** Chronic Aquatic - Fish -21-day NOEC *Brachydanio rerio* - > 100 mg/L Chronic Aquatic - Invertebrate - 21-day NOEC *Daphnia magna* - 100 mg/L **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 8.8 mg/L **$PNEC_{soil}$** - 0.9 mg/kg soil dry weight	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Harmful to aquatic life PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: Log Kow is 0.81 No bioconcentration studies PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	2-Propenoic acid, polymer with sodium phosphinate (1:1), sodium salt	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} Rianbow Trout - >1,000 mg/L -96-hr LC_{50} Zebra Fish - >1,000 mg/L Acute Aquatic - Invertebrate -24-hr EC_{50} *Daphnia* - 320 mg/L Acute Aquatic - Algae -72-hr EC_{50} - 130 mg/L **Terrestrial Toxicity** No terrestrial toxicity studies identified. **$PNEC_{water}$** - 0.13 mg/L **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - low concern Ecological Hazard - Low toxicity concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Meets 150 day critierion for ultimate biodegradability. PBT Assessment: Meets the screening criteria for persistence	Environmental Fate Property: Not expected to bioaccumulate in the environment. PBT Assessment: Does not meet the screening criteria for bioaccumulation.

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Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Feb-22	Sodium hydroxide	[redacted]	Tier 1 (Qualitative/PBT)	PBT Assessment: The overall conclusion is that sodium hydroxide is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., corrosive). The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA
	Acrylamide, sodium acrylate copolymer	[redacted]	Tier 1 (NICNAS/PBT/Exposure Assessment)	NICNAS: Identified as chemical of low concern for human health in an IMAP Tier 1 assessment and considers these polymers of low concern to human health PBT Assessment: The overall conclusion is that acrylamide/sodium acrylate copolymer is not a PBT substance. Management: No additional management required, Tier 1 screening satisfied.	NA
	Poly(oxy-1,2-ethanediyl), alphahexyl-omega-hydroxy	[redacted]	Tier 1 (Qualitative/PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that poly(oxy-1,2-ethanediyl), alphahexyl-omega-hydroxy is not a PBT substance. Qualitative assessment indicated low concern to human health. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT criteria for toxicicty. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: No additional management required, Tier 1 screening satisfied.	NA
	2-Propenoic acid, polymer with sodium phosphinate (1:1), sodium salt	[redacted]	Tier 1 (Qualitative/PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that 2-propenoic acid, polymer with sodium phosphinate is not a PBT substance. Qualitative Assessment indicated low concern to human health The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is ultimately biodegradable, does not bioaccumulate, and does not meet the PBT criteria for toxicicty. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Feb-22	Glutaraldehyde	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} Bluegill Sunfish - 13 mg/L -96-hr LC_{50} *Oncorhynchus mykiss* - 10 mg/L Acute Aquatic - Invertebrate -48-hr LC_{50} *Daphnia magna* - 14.87 mg/L and 14 mg/L Acute Aquatic - Algae and other aquatic plants -72-hr EC_{50} *Scenedesmus subspicatus* - 0.375 mg/L (biomass), 0.6 (growth rate), 0.025 (NOEC) -72-hr EC_{50} *Scenedesmus subspicatus* - 0.92 mg/L (biomass), 0.61 (growth rate), 0.33 (NOEC) -72-hr EC_{50} *Scenedesmus subspicatus* - 0.61 mg/L (growth rate) Chronic Aquatic - Fish -97-day LOEC *Oncorhynchus mykiss* - 5 mg/L -97-day NOEC *Oncorhynchus mykiss* - 1.6 mg/L Chronic Aquatic - Invertebrate -21-day NOEC *Daphnia magna* - 5 mg/L **Terrestrial Toxicity** Earthworms -14-day LC50 - 500 mg/kg soil dry weight Soil microoganisms -28-day EC50 - 360 mg/kg soil dry weight - > 593 mg/kg soil dry weight -28-day EC10 - 1.5 mg/kg soil dry weight - 11.5 mg/kg soil dry weight Avian -single dose (oral gavage) LC50 Mallard duck - 206 mg/kg -5-day dietary NOEC - Mallard duck - >2,500 ppm Terrestrial Plants: -19-day EC_{50} - *Avena sativa* (oats) - >1,000 mg/kg soil dry weight; NOEC - >1000 (emergence rate, dry matter, shoot length) -19-day EC_{50} . *Brassica napus* (rapeseed) - >1,000 mg/kg soil dry weight; NOEC - >1000 (emergence rate), 500 (dry matter), 250 (shoot length) -19-day EC_{50} - *Vicia sativa* (vetch) - >1,000 mg/kg soil dry weight; NOEC - >1000 (emergence rate), 125 (dry matter), 125 (shoot length) **$PNEC_{water}$** - 0.0025 mg/L (Chronic algae) **$PNEC_{soil}$** -0.02 mg/kg soil dry weight (lChronic soil organisms)	Qualitative Assessment: Human Health Hazard - Corrosive; skin/respiratory sensitizer Ecological Hazard - Very toxic to aquatic life with long lasting effects. Moderatly toxic to birds on acute basis. PBT Assessment: Substance exhibits higher toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable. PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: Expected to have a low potential for bioaccumulation PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Hydrochloric acid	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Lepomis macrochirus* - pH 3.25-3.5 (20 mg/L) Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - pH 4.92 (0.45 mg/L) Acute Aquatic - Algae and other aquatic plants -72-hr EC_{50} *Chlorella vulgaris* - pH 4.7 (growth rate) (0.73 m/L), pH 4.7 (0.364 mg/L) Chronic Aquatic -No chronic studies available **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - not derived **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Corrosive; respiratory irritant Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely PBT Assessment: Not applicable.	Environmental Fate Property: Expected to not bioaccumulate. PBT Assessment: Does not meet the screening criteria for bioaccumulation.

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Feb-22	Glutaraldehyde	[redacted]	Tier 2	NICNAS Assessment (2018) Human Health - potentially harmful to public health in event of transport spill. - potentially harmful to workers health in event of industrial incident Environment -Potentially harmful to the environment in the event of transport spill PBT Assessment: The overall conclusion is that glutaraldehyde is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., skin irritant). The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical and does meet the screening criteria for toxicity. This chemical is readily biodegradable and does not bioaccumulate. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted for aquatic receptors. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted for human receptors. Chemicals with a high ecotoxicity hazard assessment have a potential avian wildlife exposure to chemicals stored in treatment tanks. Therefore a Tier 2 assessment was conducted for avian receptors.	A quantitative risk characterisation was used to assess the risk to avian receptors from potential exposure to gluteraldehyde (Appendix E). There were no unacceptable potential risks to avian receptors as a result of ingestion of waters stored in treatment tanks.
	Hydrochloric acid	[redacted]	Tier 1 (NICNAS/ Qualitative Assessment/ PBT)	NICNAS Assessment (2018) Human Health - unlikely to cause harm to public - potentially harmful to workers health in event of industrial incident Environment -Potentially harmful to the environment in the event of transport spill PBT Assessment - The overall conclusion is that hydrochloric acid is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., corrosive). Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Feb-22	Sodium Tetraborate Decahydrate	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC50 Fathead minnow 79.7 mg B/L Aquatic Invertebrate -96-hr LC50 *Legumia recta* (black sandshell mussel) 147 mg B/L -96-hr LC50 *Hyalella azteca* 64 mg B/L Aquatic Algae -72-hr EC50 *Pseudokirchneriella subcapitata* 52.4 mg B/L Chronic Aquatic - Fish -34-day NOEC *Danio rerio 1.8* mg B/L -32-day NOEC *Pimephales promelas* 11 mg B/L Chronic Aquatic - Invertebrate -14-day NOEC *Daphnia magna* - 2.4 mg B/L Chronic Aquatic - Algae -4-day NOEC *Pseudokirchneriella subcapitata* - 2.8 mg B/L **Terrestrial Toxicity** -Soil inverteretes - NOEC ranging from 5.2 mgB/kg dw to 315 mg B/kg **$PNEC_{water}$** - 0.94 mg/L (ANZECC Water Quality Guideline for 95% species protection for boron in freshwater) **$PNEC_{soil}$** -5.7 mg/kg soil dry weight (derived for boron)	Qualitative Assessment: Human Health Hazard - low concern Ecological Hazard - low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Not applicable	Environmental Fate Properties: Expected to have a low potential for bioaccumulation PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Sodium Chloride	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC50 *Lepomis macrochirus* - 5,840 mg/L Acute Aquatic - Invertebrate -48-hr EC50 *Daphnia magna* - 1,900 mg/L Acute Aquatic - Algae and other aquatic plants -96-hr NOEC *Lemna* - 6,780 mg/L **Chronic Toxicity** Chronic Aquatic - Fish 33-day NOEC - *Pimephales promelas* - 232 mg/L Chronic Aquatic - Invertebrate 21-day NOEC - *Daphnia pulex* - 314 mg/L **Terrestrial Toxicity** -14-day LC50 *E. fetida* - 3296 mg/kg soil dw -10-week NOEC *E. fetida* - 3,507 mg/kg soil -7-day EC50 - red fescue grass - 500.8 mg/kg soil -12-hr LD50 - wild house sparrow - 3,000 - 3,500 mg/kg **$PNEC_{water}$** - not derived **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - low concern Ecological Hazard - low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Not applicable	Environmental Fate Properties: Essential ions to biological systems. PBT Assessment: Does not meet the screening criteria for bioaccumulation.

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Feb-22	Sodium Tetraborate Decahydrate	[redacted]	Tier 1 (Qualitative Assessment/PBT Exposure Assessment)	PBT Assessment: The overall conclusion is that sodium tetraborate decahydrate is not a PBT substance. Qualitative assessment indicated low concern to human health The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical dissociates completely in aqueous media and persistence criteria is not applicable, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: No additional management required, Tier 1 screening satisfied.	NA
	Sodium Chloride	[redacted]	Tier 1 (NICNAS/Qualitative Assessment/PBT)	NICNAS: Identified as chemical of low concern for human health in National assessment of chemicals associated with coal seam gas extraction in Australia, Tech Report Number 11 (NICNAS, 2017). In Technical report number 14, releases to surface waters were found to have limited long-term environmetnal effects because sodium chloride is ubiquitous and present in most water, soil, and sediment. Qualitative assessment indicated low concern to human health Management: No additional management required, Tier 1 screening satisfied.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Feb-22	Ammonium sulfate	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hour *Onchorhyncus mykiss, Salmo gairdneri* - LC50 - 53 mg/L -96-hour *Prosopium williamsoni* - LC50 - 57.2 mg/L Acute Aquatic - Invertebrate -48-hr EC50 *Daphnia magna* - 169 mg/L -48-hr EC50 *Ceriodaphnia acanthina* - 121.7 mg/L Chronic Aquatic - Fish -30-day *Lepomis macrochirus* - EC10 5.29 mg/L Chronic Aquatic - Invertebrate -10-week EC10 *Hyallella azteca* - 3.12 mg/L Chronic Aquatic - Algae -18-day EC50 - *Chlorella vulgaris* - 2,700 mg/L -5-day EC50 - *Chlorella vulgaris* - 1,605 mg/L **Terrestrial Toxicity** No data were available **$PNEC_{water}$** - 0.312 mg/L **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - low concern Ecological Hazard - low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: Log Kow is -5.1 PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Acrylamide, 2-acrylamido-2-methylpropanesulfonic acid, sodium salt polymer	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC50 *Lepomis macrochirus* - 1,000 mg/L Acute Aquatic - Invertebrate -48-hr EC50 *Daphnia magna* - 1,000 mg/L Acute Aquatic - Algae and other aquatic plants -96-hr NOEC *Pseudokirchneriella subcapitata* - 2,000 mg/L Chronic Aquatic No data available. **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 10 mg/L **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: Log Kow is -4.34 No bioconcentration studies PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Vinylidene chloride/methylacrylate copolymer	[redacted]	[redacted]	No ecotoxicity data available. **$PNEC_{water}$** - not derived **$PNEC_{soil}$** - not derived	Qualitative Assesment: Human Health Hazard - low concern Ecological Hazard - low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: No data available PBT Assessment: Not applicable	Environmental Fate Properties: Not expected to bioaccumulate due to large molecular weight of substance PBT Assessment: Not applicable
	Calcium Chloride	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC50 - *Pimephales promelas* - 4,630 mg/L -96-hr LC50 - *Lepomis macrochirus* (two studies) - 9,500-11,300 mg/L -96-hr LC50 - *Gambusia affinis* - 13,400 mg/L Acute Aquatic - Invertebrate -48-hr EC50 *Daphnia magna* (three studies) - 1,062 mg/L and 2,770 mg/L -48-hr EC50 - *Ceriodaphnia dubia* - 1,830 mg/L Acute Aquatic - Algae -72-hr EC50 *Pseudokirchneriella subapitata* - 2,900 mg/L Chronic Aquatic - Invertebrate -21-day EC50 *Daphnia* - 610 mg/L **Terrestrial Toxicity** No data available **$PNEC_{water}$** - 11 mg/L **$PNEC_{soil}$** - not derived	Qualitative Assesment: Human Health Hazard - low concern (moderate eye irritation) Ecological Hazard - low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Not applicable	Environmental Fate Properties: Essential ions to biological systems. Neither calcium chloride or its dissociated ions are expected to bioaccumulate. PBT Assessment: Does not meet the screening criteria for bioaccumulation.

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Feb-22	Ammonium sulfate	[redacted]	Tier 1 (Qualitative Assessment/PBT)	PBT Assessment: The overall conclusion is that ammonium sulfate is not a PBT substance. Qualitative assessment indicated low concern to human health. The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: No additional management required, Tier 1 screening satisfied.	NA
	Acrylamide, 2-acrylamido-2-methylpropanesulfonic acid, sodium salt polymer	[redacted]	Tier 1 (NICNAS/Qualitative/ PBT)	NICNAS: Determined to be low concern polymer under the National Industrial Chemicals Notification and Assessment Scheme (NICNAS) targeted tier I approach. (AICIS, 2021). An IMAP Tier 1 assessment completed by NICNAS considers it a polymer of low concern for both human health and the environment. PBT Assessment: The overall conclusion is that Acrylamide, 2-acrylamido-2-methylpropanesulfonic acid, sodium salt polymer is not a PBT substance. Qualitative assessment indicated low concern to human health and ecological receptors. The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: No additional management required, Tier 1 screening satisfied.	NA
	Vinylidene chloride/methylacrylate copolymer	[redacted]	Tier 1 (NICNAS)	NICNAS: Determined to be low concern polymer under the National Industrial Chemicals Notification and Assessment Scheme (NICNAS) targeted tier I approach. (AICIS, 2021). An IMAP Tier 1 assessment completed by NICNAS considers it a polymer of low concern for both human health and the environment. Management: No additional management required, Tier 1 screening satisfied.	NA
	Calcium Chloride	[redacted]	Tier 1 (Qualitative Assessment/PBT)	PBT Assessment: The overall conclusion is that calcium chloride is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (eye irritant). The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure. No additional management required, Tier 1 screening satisfied.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Feb-22	but-2-enedioic acid (Fumaric Acid)	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-h LC_{50} *Danio rerio* - >100 mg/L Acute Aquatic - Invertebrate -48-h EC_{50} *Daphnia magna* - >100 mg/L Acute Aquatic - Algae -72-h EC_{50} *Pseudokirchneriella subcapitata* - >100 mg/L Chronic Aquatic - Fish No data available **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 1 mg/L **$PNEC_{soil}$** - 0.0115 mg/kg	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence	Environmental Fate Properties: Bioaccumulation of but-2-enedoic acid is not expected to occur based on its log K_{ow} value of -4.02. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Dicoco dimethyl quaternary ammonium chloride	[redacted]	[redacted]	**Aquatic Toxicity:** Acute Aquatic - Fish -96 hour LC_{50} - *Salmo gairdneri* 3.2 mg/L Acute Aquatic - Invertebrates 48-hour EC_{50} - *Dapnia magna* - 0.09 mg/L Acute Aquatic - Algae -72 hour EC_{50} *Pseudokirchneriella subcapitata* 0.062 mg/L Chronic Aquatic - Fish 34 day NOEC - *Pimephales promelas* - 0.032 mg/L Chronic Aquatic - Invertebrates 21 day NOEC - *Daphnia magna* - 0.0068 mg/L **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.00068 mg/L **$PNEC_{soil}$** - 28.1 mg/kg	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Moderate concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence	Environmental Fate Properties: log Kow = 3.15 PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Gelatins	[redacted]	[redacted]	No ecotoxicity data available. **$PNEC_{water}$** - not derived **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - low concern Ecological Hazard - low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Inherently biodegradeable PBT Assessment: Does not meet screening criteria for persistance.	Environmental Fate Properties: Naturally occurring in animal products and are not expected to bioaccumulate. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Non-crystalline Silica (impurity)	[redacted]	[redacted]	**Aquatic and Terrestrial Toxicity** -No studies are available. -Expected to be low concern for toxicity to aquatic organisms. **$PNEC_{water}$** - not derived **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Hazard: Inhalation: silicosis and lung cancer in humans. Oral/dermal: low concern. Ecological Hazard: Low concern PBT Assessment: Substance exhibits higher toxicity than that established by regulatory guidance.	Environmental Fate Properties: Not relevant PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: inorganic complex not expected to bioaccumulate PBT Assessment: Does not meet the screening criteria for bioaccumulation.

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Feb-22	but-2-enedioic acid (Fumaric Acid)	[redacted]	Tier 1 (Qualitative Assessment/PBT)	PBT Assessment: The overall conclusion is that but-2-enedioic acid is not a PBT substance. Qualitative assessment indicated low concern to human health The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: No additional management required, Tier 1 screening satisfied.	NA
	Dicoco dimethyl quaternary ammonium chloride	[redacted]	Tier 2	PBT Assessment: The overall conclusion is that Dicoco dimethyl quaternary ammonium chloride is not a PBT substance. Qualitative assessment indicated low concern to human health. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Therefore, a Tier 2 assessment was not warranted.	
	Gelatins	[redacted]	Tier 1 (NICNAS/Qualitative Assessment/PBT)	NICNAS: Identified as chemical of low concern for human health in an IMAP Tier 1 assessment and considers this chemical of low concern to the environment PBT Assessment: The overall conclusion is that gelatins is not a PBT substance. Qualitative assessment indicated low concern to human health The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: No additional management required, Tier 1 screening satisfied.	NA
	Non-crystalline Silica (impurity)	[redacted]	Tier 1 (Qualitative Assessment/ PBT)	PBT Assessment: The overall conclusion is that Crystalline silica, quartz is not a PBT substance. Qualitative Assessment indicated hazardous to human health by the inhalation pathway; not hazardous by the oral/dermal route. Percent volume in mixture is less than 0.1-percent of the mixture. Therefore, according to the GHS criteria the concentration of the substance in the mixture would not meet the criteria of carcinogenicity. Management: Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure. Therefore a Tier 2 Assessment is not warranted.	NA

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Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Feb-22	Polymer of 2-acrylamido-2-methylpropanesulfonic acid sodium salt and methyl acrylate	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC50 *Lepomis macrochirus* - 1,000 mg/L Acute Aquatic - Invertebrate -48-hr EC50 *Daphnia magna* - 1,000 mg/L Acute Aquatic - Algae and other aquatic plants -96-hr NOEC *Pseudokirchneriella subcapitata* - 2,000 mg/L Chronic Aquatic No data available. **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 10 mg/L **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: Log Kow is -4.34 No bioconcentration studies PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	2,2"-oxydiethanol - impurity (Diethylene glycol)	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-h LC_{50} *Pimephales promelas* - 75,200 mg/L -96-h LC_{50} *Oncorhynchus mykiss* - 66,000 Acute Aquatic - Invertebrate -24-h EC_{50} *Daphnia magna* ->10,000 mg/L -48-hr EC_{50} *Daphnia magna* - 65,980 mg/L -48-hr EC_{50} *Daphnia magna* - 62,630 mg/L Chronic Aquatic - Fish -7-day NOEC *Pimephales promelas* - 15,380 mg/L (for ethylene glycol) Chronic Aquatic - Invertebrate -7-day NOEC *Ceriodaphnia dubia* - 8,590 mg/L (for ethylene glycol) -21 day - *Daphnia magna* - > 15,000 mg/L (for triethylene glycol) Chronic Aquatic - Algae -8-day TGK to algae *Scenedesmus quadricauda* 2,700 mg/L **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 27 mg/L **$PNEC_{soil}$** - 0.36 mg/kg dry weight soil	Qualitative Assessment: Human Health Hazard -Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: log Kow = -1.98 (calculated) PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Urea	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -48-h LC_{50} *Golden orfe fish* - 10,000 mg/L -96-h EC_{50} *Tilapia mossambica* - > 20,000 mg/L -96-hr EC_{50} *Barilius barna* - >9,100 mg/L Acute Aquatic - Invertebrate -24-hr EC_{50} *Daphnia magna* - >10,000 mg/L -24-hr EC_{50} *Helisoma trivolvis* - 14,241 mg/L -24-hr EC50 *Biomphalaria havanensis* - 13,532 mg/L Chronic Aquatic - Fish -No data are available. Chronic Aquatic - Algae -192 hr - *Scenedesmus quadricauda* - 10,000 mg/L - 7-day - *Scenedesmus quadricauda* - 10,000 mg/L - 192 hr - *Microcystis aeruginosa* - 47 mg/L **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.94 mg/L **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard -Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: Bioaccumulation is not expected to occur based on its log K_{ow} value of -1.73. PBT Assessment: Does not meet the screening criteria for bioaccumulation.

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Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Feb-22	Polymer of 2-acrylamido-2-methylpropanesulfonic acid sodium salt and methyl acrylate	[redacted]	Tier 1 (Qualitative/PBT)	PBT Assessment: The overall conclusion is that Acrylamide, 2-acrylamido-2-methylpropanesulfonic acid, sodium salt polymer is not a PBT substance. Qualitative assessment indicated low concern to human health and ecological receptors. The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: No additional management required, Tier 1 screening satisfied.	NA
	2,2"-oxydiethanol - impurity (Diethylene glycol)	[redacted]	Tier 1 (Qualitative Assessment/PBT)	PBT Assessment: The overall conclusion is that Diethylene glycol is not a PBT substance. Qualitative assessment indicated low concern to human health The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: No additional management required, Tier 1 screening satisfied.	NA
	Urea	[redacted]	Tier 1 (Qualitative Assessment/PBT)	PBT Assessment: The overall conclusion is that urea is not a PBT substance. Qualitative assessment indicated low concern to human health The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: No additional management required, Tier 1 screening satisfied.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Feb-22	Propan-2-ol	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Pimpephales promelas* - 9,640 mg/L Acute Aquatic - Invertebrate -24-hr EC_{50} *Daphnia magna* >10,000 mg/L Chronic Aquatic - Invertebrate -16 day NOEC *Daphnia magna* 141 mg/L -21 day NOEC *Daphnia magna* 30 mg/L -7-day NOEC *Scenedesmus quadricauda* is 1,800 mg/L **Terrestrial Toxicity** -EC_{50} lettuce seed germination test - 2,100 mg/L **$PNEC_{water}$** - 0.3 mg/L **$PNEC_{soil}$** - 0.014 mg/kg	Qualitative Assessment: Human Health Hazard -Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: Bioaccumulation of isopropanol is not expected to occur based on its log K_{ow} value of 0.05. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Magnesium Silicate Hydrate (talc)	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic -96-h LC_{50} Unnamed fish species - 89,581 mg/L (QSAR) -48-h LC_{50} Daphnid species - 36,812 mg/L (QSAR) -96 h LC50 Freshwater algae - 7,203 mg/L Chronic Aquatic - Fish No data available **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 72 mg/L **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Biodegradability is not relevant because inorganic substance. PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: Bioaccumulation not expected to occur based on its log K_{ow} value of -9.4. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Diutan	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic-Fish -96-h LC_{50} *Oncorhynchus mykiss* - 100 mg/L Acute Aquatic- Invertebrate -48-h EC_{50} Daphnid species - 100 mg/L Acute Aquatic - Algae -72 h EC50 Freshwater algae - >100 mg/L Chronic Aquatic - Fish No data available **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 1 mg/L **$PNEC_{soil}$** - 0.01 mg/kg	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: Bioaccumulation of duitan gum is not expected to occur based on its log K_{ow} value of 3.56. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Potassium chloride	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Pimpephelas promelas* - 880 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* 660 mg/L -48-hr EC_{50} *Ceriodaphnia dubia* - 630 mg/L Acute Aquatic - Algae and other plants -72-hr EC_{50} *Scenedesmus subspicatus* - >100 mg/L **Chronic Aquatic - Invertebrate** -7-day NOEC in a fathead minnow is 500 mg/L **Terrestrial Toxicity** -No data available. **$PNEC_{water}$** - 1 mg/L (algae) **$PNEC_{soil}$** -not derived	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Does not meet the screening criteria for persistence	Environmental Fate Properties: Will dissociate to potassium and chloride ions which are not expected to bioaccumulate. PBT Assessment: Does not meet the screening criteria for bioaccumulation.

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Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Feb-22	Propan-2-ol	[redacted]	Tier 1 (Qualitative Assessment/PBT)	PBT Assessment: The overall conclusion is that isopropanol is not a PBT substance. Qualitative assessment indicated low concern to human health The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: No additional management required, Tier 1 screening satisfied.	NA
	Magnesium Silicate Hydrate (talc)	[redacted]	Tier 1 (Qualitative Assessment/PBT)	PBT Assessment: The overall conclusion is that magnesium silicate is not a PBT substance. Qualitative assessment indicated low concern to human health The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: No additional management required, Tier 1 screening satisfied.	NA
	Diutan	[redacted]	Tier 1 (Qualitative Assessment/PBT)	PBT Assessment: The overall conclusion is that duitan gum is not a PBT substance. Qualitative assessment indicated low concern to human health The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: No additional management required, Tier 1 screening satisfied.	NA
	Potassium chloride	[redacted]	Tier 1 (Qualitative Assessment/PBT)	PBT Assessment: The overall conclusion is that Potassium chloride is not a PBT substance. Qualitative assessment indicated low concern to human health. The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: No additional management required, Tier 1 screening satisfied.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Feb-22	Sodium sulfate	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} Pimephales promelas 7,960 mg/L Acute Aquatic - Invertebrate -48-hr EC50 - *Daphnia magna* - 4,736 mg/L Chronic Aquatic - Invertebrate -7-day - $LOEC_{50}$ - *Ceriodapnia dubia* 1,329 mg/l **Terrestrial Toxicity** No data available **$PNEC_{water}$** - 11 mg/L **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Does not meet the screening criteria for persistence	Environmental Fate Properties: Will dissociate to sodium and sulfate ions which are not expected to bioaccumulate. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	2-Propenamid (impurity)	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -LC_{50} Rainbow Trout, *Onchorhyncus mykiss* , 180 mg/L Acute Aquatic - Invertebrate -48 hour EC50 - *Daphnia Magna* - 60 mg/L Acute Aquatic - Algae -72 hour EC50 - *Pseudokirchneriella subcapitata* - 33 mg/L Chronic Aquatic - Fish -28 day - NOEC *Cyprinus carpio* - 5 mg/L **Terrestrial Toxicity** No data available **$PNEC_{water}$** - 0.05 mg/L **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: log Kow of -0.67 PBT Assessment: Does not meet the screening criteria for bioaccumulation
	Tetrasodium ethylenediaminetetraacetate	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -LC_{50} > 100 mg/L for Na_4EDTA and sodium salts Acute Aquatic - Invertebrate -24-hr EC50 - *Daphnia magna* - 480 to 790 mg/L Chronic Aquatic - fish -NOEC - zebra fish - >26.8 mg/L H_4EDTA Chronic Aquatic - Invertebrate -21-day NOEC - *Daphnia Magna* - 22 mg/L Aquatic - Algae -Ecb50, ECr50 - *Pseudokirchneriella subcapitata* - >100 mg/L -NOEC - *Pseudokirchneriella subcapitata* - 48.4 mg/L **Terrestrial Toxicity** No data available **$PNEC_{water}$** - 22 mg/L **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Not expected to biodegrade PBT Assessment: Meets the screening criteria for persistence.	Environmental Fate Properties: BCF of 1.1 - 1.8 in fish. PBT Assessment: Does not meet the screening criteria for bioaccumulation.

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Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Feb-22	Sodium sulfate	[redacted]	Tier 1 (Qualitative Assessment/PBT)	PBT Assessment: The overall conclusion is that sodium sulfate is not a PBT substance. Qualitative assessment indicated low concern to human health. The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: No additional management required, Tier 1 screening satisfied.	NA
	2-Propenamid (impurity)	[redacted]	Tier 1 (Qualitative Assessment/PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that 2-propenamid (impurity) is not a PBT substance. Qualitative Assessment indicated low human health concern and carcinogenicity to animals. Percent volume in mixture is less than 0.1-percent of the mixture. Therefore, according to the GHS criteria the concentration of the substance in the mixture would not meet the criteria of carcinogenicity. The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted for human receptors.	NA
	Tetrasodium ethylenediaminetetraacetate	[redacted]	Tier 1 (Qualitative Assessment/PBT)	PBT Assessment: While the OECD tests for tetrasodium ethylenediaminetetraacetate indicate that the criteria for persistance is satisified, it is believed to be ultimately biodegradable under environmental conditions. The overall conclusion is that tetrasodium ethylenediaminetetraacetate is not a PBT substance. Qualitative assessment indicated low concern to human health. The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: No additional management required, Tier 1 screening satisfied.	NA

Table 1
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Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Feb-22	Dimethyl siloxanes and silicones	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96 hr - LC_{50} - 1.17 mg/L -96 hr - LC50 - 0.963-2.5203 mg/L Chronic Aquatic- Fish -7 day LC50 *Ictalurus punctatus* - 3.16 mg/L **Terrestrial Toxicity** Chronic terrestrial -14-day NOEC Earthworms - 124 mg/kg bw/day -28-day - NOEC - *Folsomia candida* - 230 mg/kg bw/day -28- day NOEC soil microflora - > 1,000 mg/kg bw /day **$PNEC_{water}$** - 0.0632 mg/L **$PNEC_{soil}$** - 23 mg/kg bw/day	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Not readily biodegradable PBT Assessment: Meets the screening criteria for persistence.	Environmental Fate Properties: No evidence of bioaccumulation. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Siloxanes and silicones, dimethyl, reaction products with silica	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96 hr - LC_{50} - 1.17 mg/L -96 hr - LC50 - 0.963-2.5203 mg/L Chronic Aquatic- Fish -7 day LC50 *Ictalurus punctatus* - 3.16 mg/L **Terrestrial Toxicity** Chronic terrestrial -14-day NOEC Earthworms - 124 mg/kg bw/day -28-day - NOEC - *Folsomia candida* - 230 mg/kg bw/day -28- day NOEC soil microflora - > 1,000 mg/kg bw /day **$PNEC_{water}$** - 0.0632 mg/L **$PNEC_{soil}$** - 23 mg/kg bw/day	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Not readily biodegradable PBT Assessment: Meets the screening criteria for persistence.	Environmental Fate Properties: No evidence of bioaccumulation. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Octamethylcyclotetrasiloxane	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96 hr LC_{50} *Oncorhynchus mykiss* > 0.022 mg/L Acute Aquatic - Invertebrate -48-hr NOEC/EC50 - *Daphnia magna* - >0.015 mg/L Acute Aquatic - Algae -96 hr LC50 - *Pseudokirchneriella subcapitata* - > 0.022 mg/L Chronic Aquatic - fish -93-day NOAEC - *Oncorhynchus mykiss* - ≥0.004 mg/L Chronic Aquatic - Invertebrate -21-day NOEC - *Daphnia Magna* - 0.0079 mg/L **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.0004 mg/L **$PNEC_{soil}$** - 10 mg/kg/dw	Qualitative Assessment: Human Health Hazard - low concern Ecological Hazard - very toxic to aquatic life with long lasting effects. PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance. However, classification is uncertain, refer to dossier.	Environmental Fate Properties: Not readibly biodegrade PBT Assessment: Meets the screening criteria for persistence.	Environmental Fate Properties: measured BCF greater than 2000 L/kg PBT Assessment: Does meet the screening criteria for bioaccumulation.
	Decamethyl cyclopentasiloxane	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96 hr LC_{50} *Oncorhynchus mykiss* > 0.016 mg/L Acute Aquatic - Invertebrate -48-hr EC50 - *Daphnia magna* - >0.0029 mg/L Acute Aquatic - Algae -96 hr NOEC- *Pseudokirchneriella subcapitata* - > 0.016 mg/L Chronic Aquatic - fish -90-day NOAEC - *Oncorhynchus mykiss* - ≥ 0.014 mg/L Chronic Aquatic - Invertebrate -21-day NOEC - *Daphnia Magna* - 0.015 mg/L **Terrestrial Toxicity** -28 day and 56-day - NOEC *Eisenia andrei* (earthworms) - > 4,074 mg/kg/bw **$PNEC_{water}$** - 0.0004 mg/L **$PNEC_{soil}$** - 10 mg/kg/dw	Qualitative Assessment: Human Health Hazard - low concern Ecological Hazard - very toxic to aquatic life with long lasting effects. PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance. However, classification is uncertain, refer to dossier.	Environmental Fate Properties: Not readibly biodegrade PBT Assessment: Meets the screening criteria for persistence.	Environmental Fate Properties: measured BCF greater than 2000 L/kg PBT Assessment: Does meet the screening criteria for bioaccumulation.

Table 1
Evaluation of Compiled List of Chemicals
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Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Feb-22	Dimethyl siloxanes and silicones	[redacted]	Tier 1 (NICNAS/Qualitative Assessment/PBT)	NICNAS: Determined to be low concern polymer under the National Industrial Chemicals Notification and Assessment Scheme (NICNAS) targeted tier I approach and concluded that it poses no unreasonable risk to human health and the environment. (AICIS, 2021). PBT Assessment: The overall conclusion is that dimethyl siloxanes and silicones is not a PBT substance. Qualitative assessment indicated low concern to human health Management: No additional management required, Tier 1 screening satisfied.	NA
	Siloxanes and silicones, dimethyl, reaction products with silica	[redacted]	Tier 1 (NICNAS/Qualitative Assessment/PBT)	NICNAS: Determined to be low concern polymer under the National Industrial Chemicals Notification and Assessment Scheme (NICNAS) targeted tier I approach. (AICIS, 2021). PBT Assessment: The overall conclusion is that siloxanes and silicones, dimethyl, reaction products with silica is not a PBT substance. Qualitative assessment indicated low concern to human health Management: No additional management required, Tier 1 screening satisfied.	NA
	Octamethylcyclotetrasiloxane	[redacted]	Tier 2	PBT Assessment: The overall conclusion is that octamethylcyclotetrasiloxane is a PBT substance (with uncertainty). Qualitative Assessment indicated low concern to human health The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical and does meet the screening criteria for toxicity. This chemical is not readily biodegradable and it does have potential to bioaccumulate. The potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted for aquatic receptors. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. There is low concern to human health; therefore, a Tier 2 assessment was not warranted for human receptors. Chemicals with a high ecotoxicity hazard assessment have a potential avian wildlife exposure to chemicals stored in treatment tanks. Therefore a Tier 2 assessment was conducted for avian receptors.	A quantitative risk characterisation was used to assess the risk to avian receptors from potential exposure to octamethylcyclotetrasiloxane (Appendix E). There were no unacceptable potential risks to avian receptors as a result of ingestion of waters stored in treatment tanks.
	Decamethyl cyclopentasiloxane	[redacted]	Tier 2	PBT Assessment: The overall conclusion is that Decamethyl cyclopentasiloxane is not a PBT substance. Qualitative Assessment indicated low concern to human health The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical and does meet the screening criteria for toxicity. This chemical is not readily biodegradable and it does not bioaccumulate. The potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted for aquatic receptors. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. There is low concern to human health; therefore, a Tier 2 assessment was not warranted for human receptors. Chemicals with a high ecotoxicity hazard assessment have a potential avian wildlife exposure to chemicals stored in treatment tanks. Therefore a Tier 2 assessment was conducted for avian receptors.	A quantitative risk characterisation was used to assess the risk to avian receptors from potential exposure to decamethyl cyclopentasiloxane (Appendix E). There were no unacceptable potential risks to avian receptors as a result of ingestion of waters stored in treatment tanks.

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Feb-22	Copper(II) sulfate	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic -toxicity data for Australian species range from 0.040 to 21 mg/L (for copper) Chronic Aquatic - fish -7-day LC50 - ranged from 0.0026 mg/L (*Ptylocheilus oregonenis*) to 0.131 mg/L (*Pimephales promelas*) (for copper) Chronic Aquatic - Invertebrate -NOEC - *D. pulex and G. pulex* - 0.0017 mg/L (for copper) -10 to 14-day NOEC - *Hyalella azteca* - 0.00121 mg/L (for copper) -14 day LC50 - *Flumicola virens* 0.00164 mg/L (for copper) Chronic Aquatic -Insects -10-day LC50 - *Tanytarsus dissimilis* - 0.0022 mg/L (for copper) -10 to 20-day LC50 *Chironomus tentans* - 0.011 mg/L (for copper) **Terrestrial Toxicity** -NOECs/EC10s vary between 8.4 mg/kg (*Eisenia andrei*) and 2,402 mg/kg (maize respiration) (for copper) **$PNEC_{water}$** - 0.0014 mg/L (ANZG water quality guideline for for copper at 95% species protection) **$PNEC_{soil}$** - 0.0001 mg/kg/dw	Qualitative Assessment: Human Health Hazard - Moderate concern (i.e., eye irritant) Ecological Hazard - Very toxic to aquatic life with long lasting effects. PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Inorganic substance; biodegradation not applicable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: Copper is an essential nutrient, therefore bioaccumulation is not relevant. Does not biomagnifiy in aquatic or terrestrial ecosystems. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Dodecamethylcyclohexasiloxane	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96 hr LC_{50} *Oncorhynchus mykiss* > 0.016 mg/L (for Decamethylcyclopentasiloxane) Acute Aquatic - Invertebrate -48-hr NOEC/EC50 - *Daphnia magna* - >0.0029 mg/L (for Decamethylcyclopentasiloxane) Acute Aquatic - Algae -96 hr - *Pseudokirchneriella subcapitata* - > 0.016 mg/L Chronic Aquatic - fish -90-day NOAEC - *Oncorhynchus mykiss* - ≥ 0.014 mg/L Chronic Aquatic - Invertebrate -21-day NOEC - *Daphnia Magna* - 0.015 mg/L **Terrestrial Toxicity** -28 day and 56-day - NOEC *Eisenia andrei* (earthworms) - > 4,074 mg/kg/bw **$PNEC_{water}$** - 0.0004 mg/L **$PNEC_{soil}$** - 10 mg/kg/dw	Qualitative Assessment: Human Health Hazard - low concern Ecological Hazard - very toxic to aquatic life with long lasting effects. PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance. However, classification is uncertain, refer to dossier.	Environmental Fate Properties: Not readibly biodegrade PBT Assessment: Meets the screening criteria for persistence.	Environmental Fate Properties: log Kow of 6.98 PBT Assessment: Does not meet the screening criteria for bioaccumulation.

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Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Feb-22	Copper(II) sulfate	[redacted]	Tier 2	PBT Assessment: The overall conclusion is that copper (II) sulfate is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (eye irritant). The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical and does meet the screening criteria for toxicity. This chemical is an inorganic substance and does not bioaccumulate. The potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted for aquatic receptors. Management: Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure. No additional management required, Tier 1 screening satisfied. Chemicals with a high ecotoxicity hazard assessment have a potential avian wildlife exposure to chemicals stored in treatment tanks. Therefore a Tier 2 assessment was conducted for avian receptors.	A quantitative risk characterisation was used to assess the risk to avian receptors from potential exposure to copper (II)sulfate (Appendix E). There were no unacceptable potential risks to avian receptors as a result of ingestion of waters stored in treatment tanks.
	Dodecamethylcyclohexasiloxane	[redacted]	Tier 2	PBT Assessment: The overall conclusion is that Dodecamethylcyclohexasiloxane is not a PBT substance. Qualitative Assessment indicated low concern to human health The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical and does meet the screening criteria for toxicity. This chemical is not readily biodegradable and it does not bioaccumulate. The potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted for aquatic receptors. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. There is low concern to human health; therefore, a Tier 2 assessment was not warranted for human receptors. Chemicals with a high ecotoxicity hazard assessment have a potential avian wildlife exposure to chemicals stored in treatment tanks. Therefore a Tier 2 assessment was conducted for avian receptors.	A quantitative risk characterisation was used to assess the risk to avian receptors from potential exposure to dodecamethylcyclohexasiloxane (Appendix E). There were no unacceptable potential risks to avian receptors as a result of ingestion of waters stored in treatment tanks.

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Evaluation of Compiled List of Chemicals
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Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Oct-24	2-Propenoic acid, [redacted]		[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} - *Oncorhynchus mykiss* 27 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} - *Daphnia magna* 47 mg/L Acute Aquatic - Algae and other aquatic organisms -72-hr EC_{50}- *Pseudokirchneriella subcapitata* 18 mg/L **Chronic toxicity** -72-hr NOEC 35 mg/L **Terrestrial Toxicity** No data available. **PNECwater** - 0.0035 mg/L **PNECsoil** - 0.0021 mg/kg soil dry weight (equilibrium partioning method)	Qualitative Assessment: Human Health Hazard - potentially corrosive to the eyes. Ecological Hazard - low concern PBT Assessment: Surrogate substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: There are no BCF data for 2-propenoic acid, homopolymer. The measure BCF for acrylic acid was determined to be 3.16. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Methyloxirane polymer with oxirane, ether with 1,2-propanediol (2:1)	[redacted]	[redacted]	**Aquatic Toxicity** No studies are available. Copolymer is practically acutely non-toxic to aquatic organisms. Chronic Aquatic No chronic studies available **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.1 mg/L (E(L)C50 value for the most sensitive species from acute toxicity testing) **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - practically acutely non-toxic to aquatic organisms PBT Assessment: There are no chronic aquatic toxicity studies. However, the acute E(L)C50 for copolymers is >1 mg/L and they have a high molecular weight. Thus, they do not meet the screening criteria for toxicity.	Environmental Fate Properties: Known or expected to be either readily biodegradable or inherently biodegradable. PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: Expected to have high molecular weights and are not expected to be bioavailable. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Poly(oxy-1,2-ethanediyl), a-hydro-w-hydroxy-, mono-C10-14-alkyl ethers, phosphates	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic -Fish: 3 species, 96-hr LC_{50} - 1200 to 2000 µg/L. -Invertebrate: 1 species, 48-hr EC_{50} 140 to 2840 µg/L. -Algae, 2 species, 410 to 1300 µg/L. Chronic Aquatic Freshwater fish: 2 species, 720 to 1,500 µg/L. Freshwater crustaceans: 2 species, 590 to 860 µg/L. Freshwater rotifers: 1 species, Brachionus calyciflorus, 1,300 µg/L. Freshwater algae, diatoms and blue-green algae: 6 species, 200 to 8,700 µg/L. Freshwater mesocosms: 4 NOEC data for multiple species tests were 80, 80, 320 and 330 µg/L, although replication was insufficient to meet OECD (1992) requirements. Normalised data were 380, 380, 320 and 1,520 µg/L. **Terrestrial Toxicity** -No studies are available **$PNEC_{water}$** - 0.14 mg/L (ANZECC Water Quality Guideline for alcohol ethoxyates) **$PNEC_{soil}$** - 2.2 mg/kg dry weight (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - irritating to eyes Ecological Hazard - moderate chronic toxicity to aquatic life PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: Log K_{ow} range from <5 to 387.5 PBT Assessment: Does not meet the screening criteria for bioaccumulation.

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Oct-24	2-Propenoic acid, [redacted]		Tier 1 (Qualitative/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that 2-Propenoic acid, homopolymer is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., corrosive to eyes). While the estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. This chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	
	Methyloxirane polymer with oxirane, ether with 1,2-propanediol (2:1)	[redacted]	Tier 1 (NICNAS/PBT/Exposure Assessment)	NICNAS: Assessed poloxalene in an IMAP Tier 1 assessment and considers it a polymer of low concern. AICIS: Assessed oxirane, methyl-, polymer with oxirane, mono(2-ethylhexyl) ether and also considers it a polymer of low concern. PBT Assessment: The overall conclusion is that EO/PO copolymers are not PBT substances Qualitative assessment indicated low concern to human health. While the estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. This chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Therefore, a Tier 2 assessment was not warranted.	NA
	Poly(oxy-1,2-ethanediyl), a-hydro-w-hydroxy-, mono-C10-14-alkyl ethers, phosphates	[redacted]	Tier 1 (Qualitative/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that Alcohols, C12-16, ethoxylated is not a PBT substance. Qualitative Assessment indicated low concern to human health (e.g., eye irritant).. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable and does not bioaccumulate. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Oct-24	2-Propenoic acid, telomer with mercaptoacetic acid	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} - *Oncorhynchus mykiss* 27 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} - *Daphnia magna* 47 mg/L Acute Aquatic - Algae and other aquatic organisms -72-hr EC_{50}- *Pseudokirchneriella subcapitata* 18 mg/L **Chronic toxicity** -72-hr NOEC 35 mg/L **Terrestrial Toxicity** No data available. **PNECwater** - 0.0035 mg/L **PNECsoil** - 0.0021 mg/kg soil dry weight (equilibrium partioning method)	Qualitative Assessment: Human Health Hazard - potentially corrosive to the eyes. Ecological Hazard - low concern PBT Assessment: Surrogate substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: There are no BCF data for 2-propenoic acid, homopolymer. The measure BCF for acrylic acid was determined to be 3.16. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Acetic acid, 2-mercapto-, sodium salt (1:1)	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC50 - *Oncorhynchus mykiss* >100 mg/L Acute Aquatic - Invertebrate -48-hr EC50 - *Daphnia magna* 42.36 mg/L Acute Aquatic - Algae and other aquatic organisms -72-hr EC50- *Pseudokirchneriella subcapitata* 5.07 mg/L Chronic Aquatic - Invertebrate -21-day NOEC - *Daphnia magna* 3.9 mg/L Chronic Aquatic - Algae -72 hr NOEC - *Pseudokirchneriella subcapitata* 0.54 mg/L **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.011 mg/L **PNECsoil** - 0.00021 mg/kg (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - mild skin irritant and slight eye irritant Ecological Hazard - moderate aquatic toxicity PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: Log Kow -2.99 at 20°C PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Alcohols, C6-12, ethoxylated propoxylated	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic -Fish: 3 species, 96-hr LC_{50} - 1200 to 2000 µg/L. -Invertebrate: 1 species, 48-hr EC_{50} 140 to 2840 µg/L. -Algae, 2 species, 410 to 1300 µg/L. Chronic Aquatic Freshwater fish: 2 species, 720 to 1,500 µg/L. Freshwater crustaceans: 2 species, 590 to 860 µg/L. Freshwater rotifers: 1 species, Brachionus calyciflorus, 1,300 µg/L. Freshwater algae, diatoms and blue-green algae: 6 species, 200 to 8,700 µg/L. Freshwater mesocosms: 4 NOEC data for multiple species tests were 80, 80, 320 and 330 µg/L, although replication was insufficient to meet OECD (1992) requirements. Normalised data were 380, 380, 320 and 1,520 µg/L. **Terrestrial Toxicity** -No studies are available **$PNEC_{water}$** - 0.14 mg/L (ANZECC Water Quality Guideline for alcohol ethoxyates) **$PNEC_{soil}$** - 2.2 mg/kg dry weight (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - irritating to eyes Ecological Hazard - moderate chronic toxicity to aquatic life PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: Log K_{ow} range from <5 to 387.5 PBT Assessment: Does not meet the screening criteria for bioaccumulation.

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Oct-24	2-Propenoic acid, telomer with mercaptoacetic acid	[redacted]	Tier 1 (Qualitative/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that 2-Propenoic acid, homopolymer is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., corrosive to eyes). While the estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. This chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	
	Acetic acid, 2-mercapto-, sodium salt (1:1)	[redacted]	Tier 1 (Qualitative/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that acetic acid, 2-mercapto-sodium salt (1:1) is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., eye irritant). While the estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. This chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA
	Alcohols, C6-12, ethoxylated propoxylated	[redacted]	Tier 1 (Qualitative/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that Alcohols, C6-12, ethoxylated propoxylated is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., eye irritant). While the estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. This chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Oct-24	Alcohols, C10-16, ethoxylated propoxylated	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic -Fish: 3 species, 96-hr LC_{50} - 1200 to 2000 µg/L. -Invertebrate: 1 species, 48-hr EC_{50} 140 to 2840 µg/L. -Algae, 2 species, 410 to 1300 µg/L. Chronic Aquatic Freshwater fish: 2 species, 720 to 1,500 µg/L. Freshwater crustaceans: 2 species, 590 to 860 µg/L. Freshwater rotifers: 1 species, Brachionus calyciflorus, 1,300 µg/L. Freshwater algae, diatoms and blue-green algae: 6 species, 200 to 8,700 µg/L. Freshwater mesocosms: 4 NOEC data for multiple species tests were 80, 80, 320 and 330 µg/L, although replication was insufficient to meet OECD (1992) requirements. Normalised data were 380, 380, 320 and 1,520 µg/L. **Terrestrial Toxicity** -No studies are available **$PNEC_{water}$** - 0.14 mg/L (ANZECC Water Quality Guideline for alcohol ethoxyates) **$PNEC_{soil}$** - 2.2 mg/kg dry weight (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - irritating to eyes Ecological Hazard - moderate chronic toxicity to aquatic life PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: Log K_{ow} range from <5 to 387.5 PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Sodium perborate tetrahydrate	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Brachydanio rerio* - 5.5 mg Boron/L Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - 2.1 mg Boron/L Acute Aquatic - Alga -72-hr EC_{50} *Pseudokirchneriella subcapitata* - 0.36 mg Boron/L Chronic Aquatic - Fish -32-day NOEC - *Danio rerio* 1.8 mg Boron/L -32-day NOEC - *Pimpephales promelas* 11 mg Boron/L Chronic Aquatic - Invertebrate -14-day NOEC - *Daphnia magna* 2.4 mg Boron/L Chronic Aquatic - Algae and other aquatic plants -4-day NOEC- *Pseudokirchneriella subcapitata* 2.8 mg Boron/L **PNECwater** - 0.94 mg/L (ANZECC water quality guideline for boron) **PNECsoil** - 5.7 mg/kg soil (derived using boron species sensitivity distribution method and assessment factor of 2)	Qualitative Assessment: Human Health Hazard - Slight to moderate toxicity by inhalation route; severe eye irritant; known or presumed human reproductive toxicant. Ecological Hazard - low chronic aquatic toxicity concern. PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Persistence criteria are not applicable.	Environmental Fate Properties: unlikely to bioaccumulate to any signifcant degree; BCF for boron < 0.1 PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Tributyl tetradecyl phosphonium chloride	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} Bluegill sunfish - 58.6 mg/L -96-hr LC_{50} Common carp - 87 mg/L -96-hr LC_{50} Rainbow trout - 490 mg/L -96-hr LC_{50} Rainbow trout - 200 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - 25.2 mg/L Acute Aquatic - Algae and other aquatic plants -72-hr EC_{50} *Selenastrum capricornutum* - 19 mg/L **Terrestrial Toxicity** -8-d dietary LC_{50} Bobwhite Quail 4,215 ppm -8-d dietary NOEC Bobwhite Quail 1,980 ppm -8-d dietary LC50 Mallard Duck 3,663 ppm -8-d dietary NOEL Mallard Duck 1,780 ppm -14-d oral gavage LD50 Mallard Duck 232 mg/kg -14-d oral gavage NOEL Mallard Duck <178 mg/kg **$PNEC_{water}$** -0.000019 mg/L (Acute algae) **$PNEC_{soil}$** - 6.49 mg/kg soil dry weight (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - Corrosive; acute toxicity by oral route, very high acute inhalation toxicity Ecological Hazard - Very toxic to aquatic life. PBT Assessment: Substance exhibits higher toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: No bioaccumulation studies are available on TTPC. Log Kow = 2.45 PBT Assessment: Does not meet the screening criteria for bioaccumulation.

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Evaluation of Compiled List of Chemicals
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Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Oct-24	Alcohols, C10-16, ethoxylated propoxylated	[redacted]	Tier 1 (Qualitative/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that Alcohols, C10-16, ethoxylated propoxylated is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., eye irritant). While the estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA
	Sodium perborate tetrahydrate	[redacted]	Tier 1 (Qualitative/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that Sodium perborate tetrahydrate is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., severe eye irritant, moderate toxicity via inhalation route). The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical dissociates completely in aqueous media, does not bioaccumulate, and does not meet the PBT toxicity criteria. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA
	Tributyl tetradecyl phosphonium chloride	[redacted]	Tier 2	NICNAS Assessment (2018) Human Health - potentially harmful to public health in event of transport spill. - potentially harmful to workers health in event of industrial incident Environment -Limited assessment - detailed information unavailable therefore, chemical assessed at earliest most conservative level of testing, which overestimates risk. Therefore, classified as potentially harmful at this level, but further information and testing would be required to determine actual level of risk PBT Assessment: The overall conclusion is that TTPC is not a PBT substance. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is inherently biodegradable and does not bioaccumulate. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Chemicals with a high ecotoxicity hazard assessment have a potential avian wildlife exposure to chemicals stored in treatment tanks. Therefore a Tier 2 assessment was conducted for avian receptors.	A quantitative risk characterisation was used to assess the risk to avian receptors from potential exposure to Tributyl tetradecyl phosphonium chloride (Appendix E). There were no unacceptable potential risks to avian receptors as a result of ingestion of waters stored in treatment tanks.

Table 1
Evaluation of Compiled List of Chemicals
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Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Oct-24	Polyethylene glycol	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Poecilia reticulata* - >100 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - > 100 mg/L Acute Aquatic - Algae and other aquatic plants -96-hr EC_{50} *Selenastrum subspicatus* - >100 mg/L Chronic Aquatic -28 d modelled NOEC fish - 13,671.586 mg/L -7-d LC_{50} *Poeciliia reticulata* (guppy fish) - 1150 mg/L -21-d modelled NOEC invertebrate - 17475.27 mg/L -8-d EC_{50} *Scenedesmus quadricauda* (algae) - diethylene glycol mono-butyl ehter (CAS No. [redacted] 1000 mg/L **Terrestrial Toxicity** No terrestrial toxicity studies. Not needed because little to no adsorption is expcted in soil compartment. **$PNEC_{water}$** - 100 mg/L (chronic algae) **$PNEC_{soil}$** - 13 mg/kg soil dw (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable. PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: -Estimated BCF is 3.162 PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Sorbitan, mono-9-octadecenoate, (Z)	[redacted]	[redacted]	**Aquatic Toxicity** -96-hr LL_{50} *Salmo gairdneri* - >1,000 [WAF] mg/L -96-hr LL_{50} *Oryzias latipes* - >1,000 [WAF] mg/L -48-hr EL_{50} *Daphnia magna* - >1,000 [WAF] mg/L -72-hr EL_{50} *Pseudokirchneriella subcapitata* - >1,000 [WAF] mg/L **Chronic Aquatic - Invertebrate** -21-day NOELR (no-observed-effect-loading-rate) in a *Daphnia* reproduction test for sorbitan stearate (CAS No. [redacted] is 16 mg/L WAFA (ECHA) [Kl. score = 2]. -72-hr NOELR (no-observed-effect-loading-rate) to *Pseudokirschneriella subcapitata* for sorbitan stearate was 560 mg/L [WAF] (ECHA) [Kl. score = 1]. **Terrestrial Toxicity** -No data available. **$PNEC_{water}$** - 0.32 mg/L WAF **$PNEC_{soil}$** -10.3 mg/kg soil dry weight	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence	Environmental Fate Properties: modeled BCF values ranged from 36 to 92 L.kg PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Sorbitan monooleate polyoxyethylene derivative	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic -72-hr EL_{50} *Pseudokirchneriella subcapitata* - 58.84 [WAF] mg/L -96-hr LL_{50} Brachydanio rerio - >100 [WAF] mg/L **Chronic Toxicity -** -21-day NOELR (No-Observed-Effect-Loading-Rate) for sorbitan monolaurate, ethoxylated (1-6.5 moles ethoxylated) [CAS No. [redacted] in a Daphnia reproduction test was 10 mg/L WAF (ECHA) [Kl. score = 2]. -72-hr EL10 for sorbitan monolaurate, ethoxylated (1-6.5 moles ethoxylated) [CAS No. [redacted] to Pseudokirchneriella subcapitata is 19.05 mg/L WAF (ECHA) [Kl. score = 2]. **Terrestrial Toxicity** No studies are available **$PNEC_{water}$** - 0.2 mg/L **$PNEC_{soil}$** - 3.4 mg/kg soil dry weight.	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: BCF in fish ranges from 12.6 to 14.6 L/kg PBT Assessment: Does not meet the screening criteria for bioaccumulation.

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Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Oct-24	Polyethylene glycol	[redacted]	Tier 1 (Qualitative Assessment/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that polyethylene glycol is not a PBT substance. Qualitative assessment indicated low concern to human health. The estimated injected concentration does not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: No additional management required, Tier 1 screening satisfied.	NA
	Sorbitan, mono-9-octadecenoate, (Z)	[redacted]	Tier 1 (Qualitative Assessment/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that Sorbitan monooleate polyoxyethylene derivative is not a PBT substance. Qualitative assessment indicated low concern to human health. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Therefore, a Tier 2 assessment was not warranted.	NA
	Sorbitan monooleate polyoxyethylene derivative	[redacted]	Tier 1 (Qualitative/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that sorbitan monooleate polyoxyethylene derivative is not a PBT substance. Qualitative assessment indicated low concern to human health. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted for aquatic receptors. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Therefore, a Tier 2 assessment was not warranted.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Oct-24	Sodium diacetate	[redacted]	[redacted]	**Aquatic Toxicity** - on Sodium Acetate and Potassium Acetate -96-hr LC_{50} *Brachydanio rerio* - >100 mg/L -48-hr EC_{50} *Daphnia magna* - Sodium acetate - >1,000 and 1,730* mg/L. *Values converted to sodium diacetate using the molecular weights of sodium acetate (82.03 g/mol), potassium acetate (98.15 g/mol), and sodium diacetate (142.09g/mol). -48-hr EC50 Daphnia magna - Potassium acetate - >459.5 and 665* mg/L. *Values converted to sodium diacetate using the molecular weights of sodium acetate (82.03 g/mol), potassium acetate (98.15 g/mol), and sodium diacetate (142.09 g/mol). -72-hr EC_{50} *Skeletonema costatum* - >500 and 724* mg/L *Values converted to sodium diacetate using the molecular weights of sodium acetate (82.03 g/mol), potassium acetate (98.15 g/mol), and sodium diacetate (142.09 g/mol). **Chronic Aquatic - Algae and other aquatic plants** No studies are available. **Terrestrial Toxicity** No studies are available. **$PNEC_{water}$** - 1.7 mg/L **$PNEC_{soil}$** - 0.02 mg/kg soil dry weight	Qualitative Assessment: Human Health Hazard - Severe eye irritant Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradeable PBT Assessment: Not applicable	Environmental Fate Properties: log Kow = -3.72 PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Disodium octaborate tetrahydrate	[redacted]	[redacted]	**Aquatic Toxicity:** Following utilised by ANZECC to develop water quality guideline for boron Chronic Aquatic - Fish 32-day LOEC *O mykiss* - 0.04 mg/L 32-day LOEC *O mykiss* - 27.6 mg/L Chronic Aquatic - Invertebrates - 21-day LC_{50} *Daphnia magna* 4.665 mg/L - 21-day LC_{50} *Daphnia magna* 54.2 mg/L - NOEC 6.0 mg/L (reproduction) Chronic Aquatic - Algae and other aquatic plants -14-day NOEC *Chlorella pyrenoidosa* 0.4 mg/L -NOEC *Chlorella vulgaris* 5.2 mg/L. **$PNEC_{water}$** - 0.37 mg/L (ANZECC water quality guideline for boron) **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard -Known or presumed human reproductive toxicant. Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Not applicable.	Environmental Fate Property: Water soluble and not expected to bioaccumulate PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Amine oxides, cocoalkyldimethyl	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic -96-hr LC_{50} - *Salmo gairdneri* - 13 mg/L -96-hr LC_{50} - *Brachydanio rerio* - 1.0 mg/L -96-hr LC50 - *Leuciscus idus melanotus* - 4.3 mg/L -48-hr EC_{50} *Daphnia magna* - 2.9 mg/L -72-hr EC_{50} *Selenastrum capricornutum* - 0.29 mg/L **Chronic Aquatic** -302-d NOEC - *Pimephales promelas* 0.31 mg/L -21-d NOEC - *Daphnia* - 0.28 mg/L -72 hr EC_{20} - 0.11 mg/L mean for algal group **Terrestrial Toxicity** -No experimental studies are available. **$PNEC_{water}$** -0.009 mg/L (Acute *Algae*) **$PNEC_{soil}$ -** 0.18 mg/kg dry weight soil (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard -Skin irritant/Severe eye irritant Ecological Hazard - Moderately toxic to aquatic organisms PBT Assessment: Substance exhibits higher toxicity than that established by regulatory guidance.	Environmental Fate Property: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: log K_{ow} <2.7 PBT Assessment: Does not meet the criteria for bioaccumulation

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Oct-24	Sodium diacetate	[redacted]	Tier 1 (Qualitative/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that sodium bicarbonate is not a PBT substance. Qualitative assessment indicated health hazard of eye irritant.. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical dissociates completely in aqueous media, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA
	Disodium octaborate tetrahydrate	[redacted]	Tier 1 (Qualitative/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that Disodium octaborate tetrahydrate is not a PBT substance. Qualitative assessment indicated known or presumed human reproductive toxicant. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical dissociates completely in aqueous media, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA
	Amine oxides, cocoalkyldimethyl	[redacted]	Tier 1 (Qualitative Assessment/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that Amine oxides, cocoalkyldimethyl is not a PBT substance. Qualitative Assessment indicated human health hazard of skin/eye irritant. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT criteria for toxicity to aquatic organisms. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release.Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Oct-24	Benzaldehyde	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic -96-hr LC_{50} -Fathead minnow - 12.4 mg/L -96-hr LC_{50} -Rainbow trout- 11.2 mg/L -96-hr LC_{50} - Goldfish - 13.8 mg/L -96-hr LC_{50} - Channel catfish- 5.39 mg/L -96-hr LC_{50} - Bluegill - 1.07 mg/L -48-hr EC_{50} Daphnia magna - 19.7 mg/L -72-hr EC_{50} Pseudokirchneriella subcapitata - 33.1 (growth) 8.05 (yeild) **Chronic Aquatic** -7-day NOEC to 1- day Pimephales promelas larvae was 0.12 mg/L (measured) based on growth rate and mortality (ECHA) [Kl. score = 2]. -8-day NOEC to Scenedesmus quadricauda is 34 mg/L (ECHA) [Kl. score = 4]. -72-hr EC_{10} for Raphidocelis subcapitata was reported as 0.039 mg/L (ECHA) [Kl.score=1]. **Terrestrial Toxicity** -No experimental studies are available. **$PNEC_{water}$** -0.0008 mg/L (Acute *Algae*) **$PNEC_{soil}$ -** 0.0003 mg/kg dry weight soil (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - Hazardous and considered harmful if swallowed. Low acute dermal toxicity and moderate acute inhalation toxicity potential. Ecological Hazard - Benzaldehyde has moderate toxicity to aquatic organisms PBT Assessment: Substance exhibits higher toxicity than that established by regulatory guidance.	Environmental Fate Property: Readily biodegradable. It has low potential to adsorb to soil or sediment. PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: Not Expected to bioaccumulate based on a log K_{ow} of 1.4 PBT Assessment: Does not meet the criteria for bioaccumulation
	Sodium iodide	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic -48-hr EC_{50} *Daphnia magna* - 0.17 mg/L -96-hr LC_{50} *Danio rerio* - >100 mg/L -96-hr LC_{50} *Oncorhynchus mykiss* 3780 mg/L -72-hr EC_{50} *Pseudokirchneriella subcapitata* >37.26 mg/L (growth) **Chronic Toxicity -** -35-day NOEC *Danio rerio* >10 mg/L -21-day NOEC Dapnia 0.153 mg/L (reproduction test) -72 hr NOEC to green algae *Pseudokirchneriella subcapitata* was >37.26 mg/L **Terrestrial Toxicity** No studies are available **$PNEC_{water}$** - 0.0153 mg/L **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Repeated exposures may cause thyroid gland toxicity. Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Not applicable	Environmental Fate Properties: the low log K_{ow} (-1.301) suggetss sodium iodide will not bioaccumulate PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Polypropylene glycol	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Danio rerio* - >100 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - 105.8 mg/L Acute Aquatic - Algae and other aquatic plants -72-hr EC_{50} *Desmodesmus subspicatus* ->100 mg/L Chronic Aquatic -No chronic studies available **Terrestrial Toxicity** No terrestrial toxicity studies **$PNEC_{water}$** - 0.1 mg/L (NOEC for Dapnia) **$PNEC_{soil}$** - 0.0067 mg/kg soil dry weight (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - Low to moderately toxic, depending on molecular weight Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence	Environmental Fate Properties: log Kow <= 3 PBT Assessment: Does not meet the screening criteria for bioaccumulation.

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Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Oct-24	Benzaldehyde	[redacted]	Tier 1 (Qualitative Assessment/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that benzaldehyde is not a PBT substance. Qualitative assessment indicates that this chemical is of low to moderate concern to human health. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT criteria for toxicity to aquatic organisms. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA
	Sodium iodide	[redacted]	Tier 1 (PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that sodium iodide is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., corrosive). The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical dissociates completely in aqueous media and does not bioaccumulate. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA
	Polypropylene glycol	[redacted]	Tier 1 (Qualitative Assessment/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that Polypropylene glycol is not a PBT substance. Qualitative assessment indicated low to moderate toxicity to human health. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is inherently biodegradable, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Oct-24	Hydrochloric acid	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Lepomis macrochirus* - pH 3.25-3.5 (20 mg/L) Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - pH 4.92 (0.45 mg/L) Acute Aquatic - Algae and other aquatic plants -72-hr EC_{50} *Chlorella vulgaris* - pH 4.7 (growth rate) (0.73 m/L), pH 4.7 (0.364 mg/L) Chronic Aquatic -No chronic studies available **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - not derived **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Corrosive; respiratory irritant Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely PBT Assessment: Not applicable.	Environmental Fate Property: Expected to not bioaccumulate. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Acrylamide, sodium acrylate polymer	[redacted]	[redacted]	**Aquatic and Terrestrial Toxicity** -No studies are available. -Expected to be low concern for toxicity to aquatic organisms. Due to poor solubility and high molecular weight not expected to be bioavailable. Does not contain any reactive functional groups. **PNECs** - not calculated	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low Concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Not readily biodegradable PBT Assessment: Does meet the criteria for persistence.	Environmental Fate Property: Not expected to bioaccumulate because of poor water solubility and high molecular weight PBT Assessment: Does not meet criteria for bioaccumulation
	Citric acid	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -48-hr LC_{50} *Leuciscus idus melanotus* (golden orfe) - 440 mg/L and 760 mg/L -96-hr LC_{50} *Lepomis macrochirus* (fathead minnow)- >100 mg/L Acute Aquatic - Invertebrate -24-hr EC_{50} *Daphnia magna* - 85 mg/L (un-neutralised test solution) 1,535 mg/L in neutralised solution Acute Aquatic - Algae and other aquatic plants -8-day EC_0 *Scenedesmus quadricauda* - 640 mg/L Chronic Aquatic -No chronic studies available **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.44 mg/L (Acute Daphnia) **$PNEC_{soil}$** - 0.002 mg/kg soil dry weight (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard -Eye irritant Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: log Kow is -1.5 to -1.80 PBT Assessment: Does not meet the screening criteria for bioaccumulation.

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Oct-24	Hydrochloric acid	[redacted]	Tier 1 (NICNAS/ Qualitative Assessment/ PBT)	NICNAS Assessment (2018) Human Health - unlikely to cause harm to public - potentially harmful to workers health in event of industrial incident Environment -Potentially harmful to the environment in the event of transport spill PBT Assessment - The overall conclusion is that hydrochloric acid is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., corrosive). Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA
	Acrylamide, sodium acrylate polymer	[redacted]	Tier 1 (NICNAS/ PBT)	NICNAS Assessment (2018) NICNAS assessed in an IMAP Tier 1 assessment and considers it a "polymer identified as low concern to human health by application of expert validated rules". PBT Assessment: The overall conclusion is that acrylamide/sodium acrylate copolymer is not a PBT substance. Management: No additional management required, Tier 1 screening satisfied.	NA
	Citric acid	[redacted]	Tier 1 (NICNAS/ PBT/ Exposure Assessment)	NICNAS: Identified as chemical of low concern for human health and the environment in National assessment of chemicals associated with coal seam gas extraction in Australia, Tech Report Number 11 (NICNAS, 2017) Qualitative Assessment indicated potential hazard to human health (e.g., eye irritant). PBT Assessment: The overall conclusion is that citric acid is not a PBT substance. The estimated injected concentration did exceed the PNECs for this chemical. This chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA

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Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Oct-24	2,2"-oxydiethanol - impurity (Diethylene glycol)	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-h LC_{50} *Pimephales promelas* - 75,200 mg/L -96-h LC_{50} *Oncorhynchus mykiss* - 66,000 Acute Aquatic - Invertebrate -24-h EC_{50} *Daphnia magna* ->10,000 mg/L -48-hr EC_{50} *Daphnia magna* - 65,980 mg/L -48-hr EC_{50} *Daphnia magna* - 62,630 mg/L Chronic Aquatic - Fish -7-day NOEC *Pimephales promelas* - 15,380 mg/L (for ethylene glycol) Chronic Aquatic - Invertebrate -7-day NOEC *Ceriodaphnia dubia* - 8,590 mg/L (for ethylene glycol) -21 day - *Daphnia magna* - > 15,000 mg/L (for triethylene glycol) Chronic Aquatic - Algae -8-day TGK to algae *Scenedesmus quadricauda* 2,700 mg/L **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 27 mg/L **$PNEC_{soil}$** - 0.36 mg/kg dry weight soil	Qualitative Assessment: Human Health Hazard -Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: log Kow = -1.98 (calculated) and BCF is 100 PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Alcohols, C12-16, ethoxylated	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic -Fish: 3 species, 96-hr LC_{50} - 1200 to 2000 µg/L. -Invertebrate: 1 species, 48-hr EC_{50} 140 to 2840 µg/L. -Algae, 2 species, 410 to 1300 µg/L. Chronic Aquatic Freshwater fish: 2 species, 720 to 1,500 µg/L. Freshwater crustaceans: 2 species, 590 to 860 µg/L. Freshwater rotifers: 1 species, Brachionus calyciflorus, 1,300 µg/L. Freshwater algae, diatoms and blue-green algae: 6 species, 200 to 8,700 µg/L. Freshwater mesocosms: 4 NOEC data for multiple species tests were 80, 80, 320 and 330 µg/L, although replication was insufficient to meet OECD (1992) requirements. Normalised data were 380, 380, 320 and 1,520 µg/L. **Terrestrial Toxicity** -No studies are available **$PNEC_{water}$** - 0.14 mg/L (ANZECC Water Quality Guideline for alcohol ethoxyates) **$PNEC_{soil}$** - 2.2 mg/kg dry weight (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - irritating to eyes Ecological Hazard - moderate chronic toxicity to aquatic life PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: Log K_{ow} range from <5 to 387.5 PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Methyloxirane polymer with oxirane, ether with 1,2,3-propanetriol (3:1)	[redacted]	[redacted]	**Aquatic Toxicity** No studies are available. Copolymer is practically acutely non-toxic to aquatic organisms. Chronic Aquatic No chronic studies available **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.1 mg/L (E(L)C50 value for the most sensitive species from acute toxicity testing) **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - practically acutely non-toxic to aquatic organisms PBT Assessment: There are no chronic aquatic toxicity studies. However, the acute E(L)C50 for copolymers is >1 mg/L and they have a high molecular weight. Thus, they do not meet the screening criteria for toxicity.	Environmental Fate Properties: Known or expected to be either readily biodegradable or inherently biodegradable. PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: Expected to have high molecular weights and are not expected to be bioavailable. PBT Assessment: Does not meet the screening criteria for bioaccumulation.

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Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Oct-24	2,2"-oxydiethanol - impurity (Diethylene glycol)	[redacted]	Tier 1 (Qualitative Assessment/PBT)	PBT Assessment: The overall conclusion is that Diethylene glycol is not a PBT substance. Qualitative assessment indicated low concern to human health The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: No additional management required, Tier 1 screening satisfied.	NA
	Alcohols, C12-16, ethoxylated	[redacted]	Tier 1 (Qualitative/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that Alcohols, C12-16, ethoxylated is not a PBT substance. Qualitative Assessment indicated low concern to human health (e.g., eye irritant).. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable and does not bioaccumulate. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA
	Methyloxirane polymer with oxirane, ether with 1,2,3-propanetriol (3:1)	[redacted]	Tier 1 (NICNAS/PBT)	NICNAS: Assessed poloxalene in an IMAP Tier 1 assessment and considers it a polymer of low concern. AICIS: Assessed oxirane, methyl-, polymer with oxirane, mono(2-ethylhexyl) ether and also considers it a polymer of low concern. PBT Assessment: The overall conclusion is that EO/PO copolymers are not PBT substances Qualitative assessment indicated low concern to human health. Management: No additional management required, Tier 1 screening satisfied.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Oct-24	Sodium bicarbonate	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Oncorhynchus mykiss* - 7,700 mg/L -96-hr LC_{50} *Lepomis macrochirus* - 7,100 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - 4,100 mg/L -48-hr EC_{50} *Daphnia magna* - 1,640 mg/L -48-hr EC_{50} *Daphnia magna* - 1,020 mg/L Chronic Aquatic - Invertebrate -21-day NOEC Dapnia (reproduction) - >576 mg/L **Terrestrial Toxicity** -48-hr LC50 - acute honeybee test >24 µg/bee -48 hr NOEC - acute honeybee test 24µg/bee **$PNEC_{water}$** - not derived **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Not applicable	Environmental Fate Properties: Na+ and HCO3- ions will not adsorb on particulate matter or surfaces and will not accumulate in living tissues. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Hydrotreated light petroleum distillate	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Oncorhynchus mykiss* - 2-5 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - 1.4 mg/L Acute Aquatic - Algae and other aquatic plants -72-hr EC_{50} *Raphidocelis subcapitata* - <1-3 mg/L -72-hr EC50 *Selenastrum capricornutum* - 3.7 mg/L Chronic Aquatic -No chronic studies available for fish -21-d EL_{50} - *Daphnia magna* 0.89 mg/L **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.005 mg/L **$PNEC_{soil}$** - 0.32 mg/kg dry weight	Qualitative Assessment: Human Health Hazard - skin sensitizer Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence	Environmental Fate Properties: BCF = 3.162 L/kg PBT Assessment: Does not meet the screening criteria for bioaccumulation.

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Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Oct-24	Sodium bicarbonate	[redacted]	Tier 1 (NICNAS/PBT)	NICNAS: Identified as chemical of low concern for human health in National assessment of chemicals associated with coal seam gas extraction in Australia, Tech Report Number 11 (NICNAS, 2017) PBT Assessment: The overall conclusion is that sodium bicarbonate is not a PBT substance. Qualitative assessment indicated low concern to human health. Management: No additional management required, Tier 1 screening satisfied.	NA
	Hydrotreated light petroleum distillate	[redacted]	Tier 1 (Qualitative/PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that hydrotreated light petroleum distillate is not a PBT substance. Qualitative assessment indicated low concern for human and ecological hazards. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. This chemical is inherently biodegradable and does not meet the PBT assessment criteria for toxicity or bioaccumulation. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Australia SafeWork Place and Condor Occupational Safety Guidance will be used to minimise human health exposure. Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Therefore, a Tier 2 assessment was not warranted.	NA

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Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Oct-24	Sodium polyacrylate	[redacted]	[redacted]	**Aquatic Toxicity** toxicity studies for MW 4,500 shown because these MW polymers are most commonly used for detergents. For additional toxicity studies, refer to the dossier. Acute Aquatic - Fish -96-hr LC_{50} - *Lepomis macrochirus* >1,000 mg/L -96-hr LC_{50} - *Lepomis macrochirus* >1,000 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} - *Daphnia magna* >200 mg/L -48-hr EC_{50} - *Daphnia magna* >1,000 mg/L Chronic Aquatic - Fish -32-d NOEC - *Pimephales promelas* 56 mg/L -28-d NOEC - *Brachydanio rerio* >450 mg/L Chronic Aquatic - Invertebrate -21-d NOEC - *Daphnia magna* >450 mg/L -21-d NOEC - *Daphnia magna* 58 mg/L -21-d NOEC - *Daphnia magna* 12 mg/L Chronic Aquatic - Algae and other aquatic plants -96-hr NOEC *Scenedesmus. subspicatus* - 480 mg/L **Terrestrial Toxicity** -14-d EC0 - (4,500 Mean MW sodium polyacrylate) Eisenia foetida foetida 1,000 mg/L -28-d EC10 - (4,500 Mean MW sodium polyacrylate) Nitrogen transformation (soil microorganisms) >2,500 mg/L -28-d EC10 - (4,500 Mean MW sodium polyacrylate) Carbon transformation (soil microorganisms) >2,500 mg/L **$PNEC_{water}$** - 1.2 mg/L (lChronic Daphnia) **$PNEC_{soil}$** - 25 mg/kg soil dry weight (lChronic soil microogranisms)	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Not biodegradable. PBT Assessment: Does meet the screening criteria for persistence.	Environmental Fate Properties: Due to their high molecular weights, sodium polyacrylates are not expected to bioaccumulate. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Acetic acid	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Oncorhynchus mykiss* - (test substance potassium acetate) >300.82 mg/L (as acetate ion) -96-hr LC_{50} *Danio rerio* - (test substance potassium acetate) >300.82 mg/L (as acetate ion) -96-hr LC_{50} *Oncorhynchus mykiss* - (test substance acetic acid) 64.8 mg/L (measured) -96-hr LC_{50} *Oncorhynchus mykiss* - (test substance acetic acid) 31.3 mg/L - 67.6 mg/L Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - (test substance potassium acetate) >300.82 mg/L (as acetate ion) -48-hr EC_{50} *Daphnia magna* - (test substance acetic acid) 79.5 mg/L (measured) -48-hr EC_{50} *Daphnia magna* - (test substance acetic acid) 18.9 mg/L (measured) Acute Aquatic - Algae and other aquatic plants -72-hr EC_{50} *Desmodesmus subspicatus* - 486.5 mg/L Chronic Aquatic - Fish -21-day *Oncorhynchus mykiss* study - measured NOEC 57.2 mg/L (60% acetic acid) and 34.3 mg/L (100% acetic acid) Chronic Aquatic - Invertebrate -21-day *Daphnia magna* reproduction study measured NOEC 80 mg/L (60% acetic acid) and 31.4 mg/L (100% acetic acid) -21-day *Daphnia magna* reproduction study measured NOEC 22.7 mg/L (100% acetic acid) **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 3.0 mg/L (E(L)C50 test fish or *Dapnhia magna*) **$PNEC_{soil}$** - 0.04 mg/kg soil dry weight (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - Corrosive, respiratory irritant Ecological Hazard - Low Concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Hazard Assessment: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: Low Kow is -0.17 PBT Assessment: Does not meet the screening criteria for bioaccumulation.

Table 1
Evaluation of Compiled List of Chemicals
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Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Oct-24	Sodium polyacrylate	[redacted]	Tier 1 (NICNAS/PBT)	NICNAS: Identified as chemical of low concern for human health in National assessment of chemicals associated with coal seam gas extraction in Australia, Tech Report Number 11 (NICNAS, 2017) PBT Assessment: The overall conclusion is that sodium polyacrylates are not PBT substances. Qualitative assessment indicated low concern to human health. Management: No additional management required, Tier 1 screening satisfied.	NA
	Acetic acid	[redacted]	Tier 1 (NICNAS/ PBT/ Exposure Assessment)	NICNAS Assessment (2018) Human Health - potentially harmful to public health in event of transport spill. - potentially harmful to workers health in event of industrial incident Environment -unlikely to cause harm to environment PBT Assessment: The overall conclusion is that acetic acid is not a PBT substance. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT criteria for toxicity to aquatic organisms. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Oct-24	Guar gum	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Oncorhynchus mykiss* - 218 mg/L Acute Aquatic - Invertebrate -48-hr LC_{50} *Daphnia magna* - 42 mg/L -96-hr LC_{50} *Daphnia magna* - <6.2 mg/L Chronic Aquatic -No chronic studies available **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.006 mg/L (Acute *Daphnia*) **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Low concern Ecological Hazard - Low concern to fish, moderate acute toxicity to invertebrates PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable. PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: Expected to not bioaccumulate. PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Ethoxylated branched C13 alcohol	[redacted]	[redacted]	**Aquatic Toxicity** Freshwater fish: 2 species, 720 to 1,500 µg/L. Freshwater crustaceans: 2 species, 590 to 860 µg/L. Freshwater rotifers: 1 species, Brachionus calyciflorus, 1,300 µg/L Freshwater algae, diatoms and blue-green algae: 6 species, 200 to 8,700 µg/L. Freshwater mesocosms: 4 NOEC data for multiple species tests were 80, 80, 320, and 330 µg/L, although replication was insufficient to meet OECD (1992) requirements. Normalised data were 380, 380, 320, and 1,520 µg/L. **Chronic Toxicity** -No studies available **Terrestrial Toxicity** -No studies are available **$PNEC_{water}$** - 0.14 mg/L **$PNEC_{soil}$** - 0.56 mg/kg soil dry weight	Qualitative Assessment: Human Health Hazard -Low concern Ecological Hazard - Harmful to aquatic life with long lasting effects PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Property: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: 4.9 PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Sodium hydroxide	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -24-hr LC50 *Carassius auratus* - 160 mg/L -48-hr LC50 *Leuciscus idus melanotus* - 189 mg/L -96-hr LC50 *Gambusia affinis* - 125 mg/L Acute Aquatic - Invertebrate -48-hr EC50 *Ceriodaphnia cf. dubia* - 40 mg/L -toxicity threshold of sodium hydroxide for Daphnia magna - 40 mg/L ot 240 mg/L **Terrestrial Toxicity** No terrestrial toxicity studies identified. **$PNEC_{water}$** - not derived **$PNEC_{soil}$** - not derived	Qualitative Assessment: Human Health Hazard - Corrosive Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Dissociates completely in aqueous media PBT Assessment: Not applicable	Environmental Fate Property: Sodium hydroxide is not expected to bioaccumulate in the environment. PBT Assessment: Does not meet the screening criteria for bioaccumulation.

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Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Oct-24	Guar gum	[redacted]	Tier 1 (NICNAS/ PBT/ Exposure Assessment)	NICNAS Assessment (2018) Human Health - unlikely to cause harm to public - unlikely to cause harm to workers Environment -Potentially harmful to the environment in the event of transport spill NICNAS: Identified as chemical of low concern for human health in National assessment of chemicals associated with coal seam gas extraction in Australia, Tech Report Number 11 (NICNAS, 2017) Qualitative assessment indicated low concern to human health. PBT Assessment - The overall conclusion is that guar gum is not a PBT substance. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT criteria for toxicicty. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Therefore, a Tier 2 assessment was not warranted.	NA
	Ethoxylated branched C13 alcohol	[redacted]	Tier 1 (PBT/Exposure Assessment)	PBT Assessment: The overall conclusion is that Ethoxylated branched C13 alcohol is not a PBT substance. Qualitative Assessment indicated low concern to human health. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. However, this chemical is readily biodegradable and does not bioaccumulate. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Therefore, a Tier 2 assessment was not warranted.	NA
	Sodium hydroxide	[redacted]	Tier 1 (Qualitative/PBT)	PBT Assessment: The overall conclusion is that sodium hydroxide is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., corrosive). The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical. Therefore, a Tier 2 assessment was not warranted. Management: Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA

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Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Oct-24	Cinnamaldehyde	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} *Brachydanio rerio* - 4.15 mg/L -96-hr LC_{50} *Poecilia reticulata* - >3.5 Acute Aquatic - Invertebrate -48-hr EC_{50} *Daphnia magna* - 3.21 mg/L Acute Aquatic - Algae and other aquatic plants -72-hr EC_{50} *Desmodesmus subspicatus* - 31.6 mg/L -72-hr EC_{50} *Chlorella vulgaris* - 16.09 mg/L Chronic Aquatic - Fish -28-day LOEC *Oryzias latipes* 66.08 mg/L **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.04 mg/L (Acute Fish) **$PNEC_{soil}$** - 0.02 mg/kg dry weight soil (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard -Skin/eye irritant; skin sensitizer Ecological Hazard - Toxic to aquatic life PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable. PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Property: log Kow is 2.107 PBT Assessment: Does not meet the screening criteria for bioaccumulation.
	Methanol	[redacted]	[redacted]	**Aquatic Toxicity** Acute Aquatic - Fish -96-hr LC_{50} Bluegill - 15,400 mg/L -96-hr LC_{50} *Salmo gairdneri* - 20,100 mg/L -96-hr LC_{50} *Pimphales promelas* - 28,100 mg/L Acute Aquatic - Invertebrate -96-hr EC_{50} *Daphnia magna* - 18,620 mg/L -48-hr EC_{50} *Daphnia magna* - >10,620 mg/L Acute Aquatic - Algae and other aquatic plants -96-hr EC_{50} *Selenastrum capricornutum* -~22,000 mg/L -10-14 d EC_{50} *Chlorella pyrenoidosa* - 28,400 mg/L Chronic Aquatic -No chronic studies available **Terrestrial Toxicity** 35-d EC_{50} Earthworm *Eisenia fetida* - 17,199 mg/kg soil dw 63-d EC_{50} Earthworm *Eisenia fetida* - 26,646 mg/kg soil dw 28-d EC_{25} *Folsomia candida* - 2,842 mg/kg soil dw (test results) 28-d NOEC (reproduction) *Folsomia candida* - 1,000 mg/kg soil dw (derived graphically) 14-d EC_{50} *Hordeum vulgare* - 15,492 mg/kg soil dw 14-d NOEC (seedline emergence) *Hordeum vulgare* - 12,000 mg/kg soil dw (derived graphically) 14-d EC_{25} *Hordeum vulgare* - 2,538 mg/kg soil dw (test results) 14-d NOEC (shoot dry mass) *Hordeum vulgare* - 1,555 mg/kg soil dw (derived graphically) 14-d EC_{25} *Hordeum vulgare* - 2,823 mg/kg soil dw (test results) 14-d NOEC (root dry mass) *Hordeum vulgare* - 2,592 mg/kg soil dw (derived graphically) 14-d EC_{25} *Hordeum vulgare* - 4,885 mg/kg soil dw (test results) 14-d NOEC (shoot length) *Hordeum vulgare* - 2,592 mg/kg soil dw (derived graphically) 14-d EC_{25} *Hordeum vulgare* - 5,752 mg/kg soil dw (test results) 14-d NOEC (rott length length) *Hordeum vulgare* - 4,320 mg/kg soil dw (derived graphically) **$PNEC_{water}$** - 10 mg/L (Acute *Daphnia)* **$PNEC_{soil}$** - 6.3 mg/kg soil dry weight (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - Low concern if used at <3% Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: -Calculated log Kow -1.36 -BCF in *Cyprinus carpio* 1.0, BCF *Leuciscus idus* <10 PBT Assessment: Does not meet the criteria for bioaccumulation.

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Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Oct-24	Cinnamaldehyde	[redacted]	Tier 1 (Qualitative Assessment/ PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that cinnamaldehyde is not a PBT substance. Qualitative Assessment indicated potential hazard to human health (e.g., skin irritant). The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical. This chemical is readily biodegradable, does not bioaccumulate, and does not meet the PBT assessment criteria for toxicity. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Therefore, a Tier 2 assessment was not warranted. Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. Australia WorkSafe and inGauge Occupational Health & Safety procedures will be used to minimise human health exposure.	NA
	Methanol	[redacted]	Tier 1 (NICNAS/ Qualitative Assessment/ PBT)	NICNAS Assessment (2018) Human Health - potentially harmful to public in event of transport spill or pond leak - potentially harmful to workers when mixing and/or cleaning or in event of industrial accident Environment -unlikely to cause harm to environment PBT Assessment: The overall conclusion is that methanol is not a PBT substance. Qualitative assessment indicated low concern to human health Management: Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA

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Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Oct-24	Diethylenetriaminepentakis (methylene phophonic acid), sodium salt	[redacted]	[redacted]	**Aquatic Toxicity** **Acute Aquatic - Fish** -96-hr LC_{50} *Gambusia affinis* (mosquito fish) - 180-252 (mean:216) mg active/L **Acute Aquatic - Invertebrate** -48-hr EC_{50} *Chironomus tentans* - 7,589 mg active/L **Chronic Toxicity** -60-day NOEC *Oncorhynchus mykiss* - 25.6 mg active acid/L **Terrestrial Toxicity** -14-day LC_{50} Mallard duck (*Anas platyrhynchos*)- >454 mg/kg -14-day LC_{50} Bobwhite quail (*Colunus virginianus*)- >454 mg/kg **$PNEC_{water}$** - 0.31 mg DTPMP sodium salt/L **$PNEC_{soil}$** - 40 mg DTPMP sodium salt/kg soil dry	Qualitative Assessment: Human Health Hazard - Low toxicity Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Not readily biodegradable PBT Assessment: Does meet the screening criteria for persistence.	Environmental Fate Properties: BCF values in fish studies are <10 and <94 for concentrations 18.8 and 2.03 mg/L respectively PBT Assessment: Does not meet the criteria for bioaccumulation.
	Benzoic acid, 3-fluoro-, sodium salt (1:1)	[redacted]	[redacted]	**Aquatic Toxicity** **Acute Aquatic - Fish** -96-hr LC_{50} *Lepomis macrochirus* - 44.6 mg/L -96-hr LC_{50} *Salmo gairdneri* - 47.3 mg/L -96-hr LC_{50} *Oncorhynchus mykiss* - 47.3 mg/L **Acute Aquatic - Invertebrate** -48-hr EC_{50} *Daphnia magna* - ≥ 100 mg/L **Acute Aquatic - Algae and other aquatic plants** - 72-hr EC_{50} *Raphidocelis subcapitata* - 33 mg/L **Chronic Toxicity** -28-day EC_{50} *Oncorhynchus mykiss* - >120 mg/L -21-day EC_{50} *Daphnia magna* - > 25 mg/L -14-day EC_{50} *Anabaena inaequalis* - >10 mg/L -72-hr NOEC *Raphidocelis subcapitata* - 7.5 mg/L **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.75 mg/L **$PNEC_{soil}$** - 0.45 mg/kg (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - considered iritating to skin and severley irritating/corrosive to the eye Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Chemical is expected to be readily biodegradable both aerobically and anaerobically. PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: No experimental data are available. This chemical has a low potential for bioaccumulation based on the BCF value of 4.79 L/kg and log K_{ow} value of 0.138. PBT Assessment: Does not meet the criteria for bioaccumulation.
	Benzoic acid, 4-fluoro-, sodium salt (1:1)	[redacted]	[redacted]	**Aquatic Toxicity** **Acute Aquatic - Fish** -96-hr LC_{50} *Lepomis macrochirus* - 44.6 mg/L -96-hr LC_{50} *Salmo gairdneri* - 47.3 mg/L -96-hr LC_{50} *Oncorhynchus mykiss* - 47.3 mg/L **Acute Aquatic - Invertebrate** -48-hr EC_{50} *Daphnia magna* - ≥ 100 mg/L **Acute Aquatic - Algae and other aquatic plants** - 72-hr EC_{50} *Raphidocelis subcapitata* - 33 mg/L **Chronic Toxicity** -28-day EC_{50} *Oncorhynchus mykiss* - >120 mg/L -21-day EC_{50} *Daphnia magna* - > 25 mg/L -14-day EC_{50} *Anabaena inaequalis* - >10 mg/L -72-hr NOEC *Raphidocelis subcapitata* - 7.5 mg/L **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.75 mg/L **$PNEC_{soil}$** - 0.45 mg/kg (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - considered iritating to skin and severley irritating/corrosive to the eye Ecological Hazard - Low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Chemical is expected to be readily biodegradable both aerobically and anaerobically. PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: No experimental data are available. This chemical has a low potential for bioaccumulation based on the BCF value of 4.79 L/kg and log K_{ow} value of 0.138. PBT Assessment: Does not meet the criteria for bioaccumulation.

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Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Oct-24	Diethylenetriaminepentakis (methylene phophonic acid), sodium salt	[redacted]	Tier 1 (Qualitative/PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that hepta sodium phosphonate is not a PBT substance. Qualitative Assessment indicated low concern to human health. The estimated injected concentration did exceed the ecotoxicity values or PNECs for this chemical and is not readily biodegradable. However, this chemical is of low ecological concern and does not bioaccumulate. Additionally, the potential exposure to aquatic receptors is considered incomplete (refer to text). Management: Implementation of Constraints Protocol in EMP will be required to prevent accidental discharge/release. No additional management required, Tier 1 screening satisfied.	NA
	Benzoic acid, 3-fluoro-, sodium salt (1:1)	[redacted]	Tier 1 (Qualitative/PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that benzoic acid, 3-fluoro-, sodium salt (1:1) is not a PBT substance. Qualitative assessment indicates that this chemical may pose a hazard to human health (e.g., eye/skin irritant). The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical and is readily biodegradable. Management: Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA
	Benzoic acid, 4-fluoro-, sodium salt (1:1)	[redacted]	Tier 1 (Qualitative/PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that benzoic acid, 3-fluoro-, sodium salt (1:1) is not a PBT substance. Qualitative assessment indicates that this chemical may pose a hazard to human health (e.g., eye/skin irritant). The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical and is readily biodegradable. Management: Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA

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Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Oct-24	Benzoic acid, 2-chloro-4-fluoro-, sodium salt (1:1)	[redacted]	[redacted]	**Aquatic Toxicity** **Acute Aquatic - Fish** -96-hr LC_{50} *Lepomis macrochirus* - 44.6 mg/L -96-hr LC_{50} *Oncorhynchus mykiss* - 47.3 mg/L **Acute Aquatic - Invertebrate** -48-hr EC_{50} *Daphnia magna* - ≥ 100 mg/L **Acute Aquatic - Algae and other aquatic plants** - 72-hr EC_{50} *Raphidocelis subcapitata* - 33 mg/L **Chronic Toxicity** -28-day EC_{50} *Oncorhynchus mykiss* - >120 mg/L -21-day EC_{50} *Daphnia magna* - > 25 mg/L -14-day EC_{50} *Anabaena inaequalis* - >10 mg/L -72-hr NOEC *Raphidocelis subcapitata* - 7.5 mg/L **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.75 mg/L **$PNEC_{soil}$** - 0.42 mg/kg (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - Skin irritant/Severe eye irritant Ecological Hazard - Expected to be low concern. PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Exepected to be readily biodegradable both aerobically and anaerobically. Some phototransformation of benzoic acid may also be possible in water. PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: No experimental data are available. This chemical has a low potential for bioaccumulation based on the BCF value of 3.98 L/kg and log K_{ow} value of -1.36. PBT Assessment: Does not meet the criteria for bioaccumulation.
	Sodium-2-Chloro-5-fluorobenzoate	[redacted]	[redacted]	**Aquatic Toxicity** **Acute Aquatic - Fish** -96-hr LC_{50} *Lepomis macrochirus* - 44.6 mg/L -96-hr LC_{50} *Oncorhynchus mykiss* - 47.3 mg/L **Acute Aquatic - Invertebrate** -48-hr EC_{50} *Daphnia magna* - ≥ 100 mg/L **Acute Aquatic - Algae and other aquatic plants** - 72-hr EC_{50} *Raphidocelis subcapitata* - 33 mg/L **Chronic Toxicity** -28-day EC_{50} *Oncorhynchus mykiss* - >120 mg/L -21-day EC_{50} *Daphnia magna* - > 25 mg/L -14-day EC_{50} *Anabaena inaequalis* - >10 mg/L -72-hr NOEC *Raphidocelis subcapitata* - 7.5 mg/L **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.75 mg/L **$PNEC_{soil}$** - 0.42 mg/kg (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - Skin irritant/Severe eye irritant Ecological Hazard - Expected to be low concern. PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Exepected to be readily biodegradable both aerobically and anaerobically. Some phototransformation of benzoic acid may also be possible in water. PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: No experimental data are available. This chemical has a low potential for bioaccumulation based on the BCF value of 3.98 L/kg and log K_{ow} value of -1.36. PBT Assessment: Does not meet the criteria for bioaccumulation.

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Oct-24	Benzoic acid, 2-chloro-4-fluoro-, sodium salt (1:1)	[redacted]	Tier 1 (Qualitative/PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that benzoic acid, 2-chloro-4-fluoro-, sodium salt (1:1) is not a PBT substance. Qualitative assessment indicates that this chemical may pose a hazard to human health (e.g., eye/skin irritant). The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical and is readily biodegradable. Management: Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA
	Sodium-2-Chloro-5-fluorobenzoate	[redacted]	Tier 1 (Qualitative/PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that benzoic acid, 2-chloro-4-fluoro-, sodium salt (1:1) is not a PBT substance. Qualitative assessment indicates that this chemical may pose a hazard to human health (e.g., eye/skin irritant). The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical and is readily biodegradable. Management: Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA

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Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Oct-24	Sodium 4-chloro-3-methylbenzoate	[redacted]	[redacted]	**Aquatic Toxicity** **Acute Aquatic - Fish** -96-hr LC_{50} *Lepomis macrochirus* - 44.6 mg/L -96-hr LC_{50} *Oncorhynchus mykiss* - 47.3 mg/L **Acute Aquatic - Invertebrate** -48-hr EC_{50} *Daphnia magna* - ≥ 100 mg/L **Acute Aquatic - Algae and other aquatic plants** - 72-hr EC_{50} *Raphidocelis subcapitata* - 33 mg/L **Chronic Toxicity** -28-day EC_{50} *Oncorhynchus mykiss* - >120 mg/L -21-day EC_{50} *Daphnia magna* - > 25 mg/L -14-day EC_{50} *Anabaena inaequalis* - >10 mg/L -72-hr NOEC *Raphidocelis subcapitata* - 7.5 mg/L **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.75 mg/L **$PNEC_{soil}$** - 0.29 mg/kg (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - Skin irritant/Severe eye irritant Ecological Hazard - Expected to be low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Expected to be readily biodegradable both aerobically and anaerobically. Some phototransformation of benzoic acid may also be possible in water. PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: No experimental data are available. Based on estimated BCF of 4.79 L/kg and log K_{ow} of 0.138, this chemical expected to have a low potential for bioaccumulation. PBT Assessment: Does not meet the criteria for bioaccumulation.
	Benzoic acid, 2-chloro-3-methyl-, sodium salt (1:1)	[redacted]	[redacted]	**Aquatic Toxicity** **Acute Aquatic - Fish** -96-hr LC_{50} *Lepomis macrochirus* - 44.6 mg/L -96-hr LC_{50} *Oncorhynchus mykiss* - 47.3 mg/L **Acute Aquatic - Invertebrate** -48-hr EC_{50} *Daphnia magna* - ≥ 100 mg/L **Acute Aquatic - Algae and other aquatic plants** - 72-hr EC_{50} *Raphidocelis subcapitata* - 33 mg/L **Chronic Toxicity** -28-day EC_{50} *Oncorhynchus mykiss* - >120 mg/L -21-day EC_{50} *Daphnia magna* - > 25 mg/L -14-day EC_{50} *Anabaena inaequalis* - >10 mg/L -72-hr NOEC *Raphidocelis subcapitata* - 7.5 mg/L **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.75 mg/L **$PNEC_{soil}$** - 0.29 mg/kg (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - Skin irritant/Severe eye irritant Ecological Hazard - Expected to be low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Expected to be readily biodegradable both aerobically and anaerobically. Some phototransformation of benzoic acid may also be possible in water. PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: No experimental data are available. Based on estimated BCF of 4.79 L/kg and log K_{ow} of 0.138, this chemical expected to have a low potential for bioaccumulation. PBT Assessment: Does not meet the criteria for bioaccumulation.

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Oct-24	Sodium 4-chloro-3-methylbenzoate	[redacted]	Tier 1 (Qualitative/PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that 4-chloro-3-methyl, sodium salt (1:1) is not a PBT substance. Qualitative assessment indicates that this chemical may pose a hazard to human health (e.g., eye/skin irritant). The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical and is readily biodegradable. Management: Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA
	Benzoic acid, 2-chloro-3-methyl-, sodium salt (1:1)	[redacted]	Tier 1 (Qualitative/PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that Benzoic acid, 2-chloro-3-methyl-, sodium salt (1:1) is not a PBT substance. Qualitative assessment indicates that this chemical may pose a hazard to human health (e.g., eye/skin irritant). The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical and is readily biodegradable. Management: Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Concentration in Injected Fluid (mg/L)	Ecotoxicity	Toxicity	Biodegradation	Bioaccummulative
Oct-24	Benzoic acid, 3-chloro-2-methyl-, sodium salt (1:1)	[redacted]	[redacted]	**Aquatic Toxicity** **Acute Aquatic - Fish** -96-hr LC_{50} *Lepomis macrochirus* - 44.6 mg/L -96-hr LC_{50} *Oncorhynchus mykiss* - 47.3 mg/L **Acute Aquatic - Invertebrate** -48-hr EC_{50} *Daphnia magna* - ≥ 100 mg/L **Acute Aquatic - Algae and other aquatic plants** - 72-hr EC_{50} *Raphidocelis subcapitata* - 33 mg/L **Chronic Toxicity** -28-day EC_{50} *Oncorhynchus mykiss* - >120 mg/L -21-day EC_{50} *Daphnia magna* - > 25 mg/L -14-day EC_{50} *Anabaena inaequalis* - >10 mg/L -72-hr NOEC *Raphidocelis subcapitata* - 7.5 mg/L **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.75 mg/L **$PNEC_{soil}$** - 0.29 mg/kg (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - Skin irritant/Severe eye irritant Ecological Hazard - Expected to be low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Expected to be readily biodegradable both aerobically and anaerobically. Some phototransformation of benzoic acid may also be possible in water. PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: No experimental data are available. Based on estimated BCF of 4.79 L/kg and log K_{ow} of 0.138, this chemical expected to have a low potential for bioaccumulation. PBT Assessment: Does not meet the criteria for bioaccumulation.
	Benzoic acid, 3-fluoro-2-methyl-, sodium salt (1:1)	[redacted]	[redacted]	**Aquatic Toxicity** **Acute Aquatic - Fish** -96-hr LC_{50} *Lepomis macrochirus* - 44.6 mg/L -96-hr LC_{50} *Oncorhynchus mykiss* - 47.3 mg/L **Acute Aquatic - Invertebrate** -48-hr EC_{50} *Daphnia magna* - ≥ 100 mg/L **Acute Aquatic - Algae and other aquatic plants** - 72-hr EC_{50} *Raphidocelis subcapitata* - 33 mg/L **Chronic Toxicity** -28-day EC_{50} *Oncorhynchus mykiss* - >120 mg/L -21-day EC_{50} *Daphnia magna* - > 25 mg/L -14-day EC_{50} *Anabaena inaequalis* - >10 mg/L -72-hr NOEC *Raphidocelis subcapitata* - 7.5 mg/L **Terrestrial Toxicity** No data available. **$PNEC_{water}$** - 0.75 mg/L **$PNEC_{soil}$** - 0.49 mgkg (equilibrium partitioning method)	Qualitative Assessment: Human Health Hazard - Skin irritant/Severe eye irritant Ecological Hazard - Expected to be low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Expected to be readily biodegradable both aerobically and anaerobically. Some phototransformation of benzoic acid may also be possible in water. PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: No experimental data are available. Based on estimated BCF of 4.73 L/kg and log K_{ow} of 0.193, this chemical expected to have a low potential for bioaccumulation. PBT Assessment: Does not meet the criteria for bioaccumulation.
	Soybean oil	[redacted]	[redacted]	**Aquatic toxicity** -No studies are available. -Expected to be of low concern based on studies conducted on the surrogate copound glycerol trioleate (CAS number [redacted] **Terrestrial Toxicity** No data available. **PNECs** - not derived	Qualitative Assessment: Human Health Hazard - low concern Ecological Hazard - low concern PBT Assessment: Substance exhibits lower toxicity than that established by regulatory guidance.	Environmental Fate Properties: Expected to be readily biodegradable PBT Assessment: Does not meet the screening criteria for persistence.	Environmental Fate Properties: No experimental data are available. Based on estimated BCF of 255 L/kg, this chemical expected to have a low potential for bioaccumulation. PBT Assessment: Does not meet the criteria for bioaccumulation.

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Stimulation Formulation Evaluation	Chemical Name	CAS Number	Screening	Discussion	Outcome of Tier 2 Assessment
Oct-24	Benzoic acid, 3-chloro-2-methyl-, sodium salt (1:1)	[redacted]	Tier 1 (Qualitative/PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that benzoic acid, 3-chloro-2-methyl-, sodium salt (1:1) is not a PBT substance. Qualitative assessment indicates that this chemical may pose a hazard to human health (e.g., eye/skin irritant). The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical and is readily biodegradable. Management: Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	NA
	Benzoic acid, 3-fluoro-2-methyl-, sodium salt (1:1)	[redacted]	Tier 1 (Qualitative/PBT/ Exposure Assessment)	PBT Assessment: The overall conclusion is that Benzoic acid, 3-fluoro-2-methyl-, sodium salt (1:1) is not a PBT substance. Qualitative assessment indicates that this chemical may pose a hazard to human health (e.g., eye/skin irritant). The estimated injected concentration did not exceed the ecotoxicity values or PNECs for this chemical and is readily biodegradable. Management: Australia SafeWork Place and inGauge Occupational Safety Guidance will be used to minimise human health exposure. Therefore, a Tier 2 assessment was not warranted.	
	Soybean oil	[redacted]	Tier 1 (PBT/Qualitative/PBT Assessment)	PBT Assessment: The overall conclusion is that sodium polyacrylates are not PBT substances. Qualitative assessment indicated low concern to human health. Management: No additional management required, Tier 1 screening satisfied.	NA

Table 1
Evaluation of Compiled List of Chemicals
Imperial Oil Gas and Imperial Oil and Gas A Northern Territory Tenement- Chemical Risk Assessment

Table Notes:
°C = degrees Celsius
µg/L = microgram per litre
ANZECC = Australian and New Zealand Environment Conservation Council
Ca:Mg = calcium:magnesium
CaCO3 = calcium carbonate
CAS = Chemical Abstract Service
CFT = Chemical Fracture Tracer
dw = dry weight
EC_0 = The concentration of a substance that is estimated to be lethal to 0% of the test organisms
EC_{50} = effects concentration of half the maximal response
ECHA = European Chemicals Agency
EG = ethylene glycol
EMP = Environmental Management Plan
GFT = Gas Fracture Tracer
HCO3- = bicarbonate
IMAP = Inventory Multi-tiered Assessment and Prioritisation
kg/L = kilogram per litre
Kow = n-octanol-water partition coefficient
L = litre
LC_{50} = lethal concentration of 50 percent of population
LOEC = lowest observed effects concentration
mg/kg = milligram per kilogram
mg/L = milligrams per litre
Na+ = Sodium ion
NA = not applicable
NICNAS = National Industrial Chemicals Notification and Assessment Scheme
NOEC = no observed effect concentration
NOELR = no observed effect loading rate
PBT = persistence, bioaccumulative, toxic
PEG - polyethylene glycol
PNEC = predicted no effect concentration
TGK = toxicity threshold (growth inhibition)
WAF = Water Accommodated Fraction Analysis
Additional NICNAS che
Silica dioxide
Sodium Chloride
Tributyl tetradecyl phosphonium chloride
UVCB = unknown or variable composition, complex reaction products or biological materials

Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (ANZECC & ARMCANZ). (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Canberra, ACT: Author.

NICNAS 2017, Chemicals of low concern for human health based on an initial assessment of hazards, Project report prepared by the National Industrial Chemicals Notification and Assessment Scheme (NICNAS) as part of the National Assessment of Chemicals Associated with Coal Seam Gas Extraction in Australia, Commonwealth of Australia, Canberra.

NICNAS 2018, Human health Tier II assessment, Project report prepared by the National Industrial Chemicals Notification and Assessment Scheme (NICNAS) as part of the National Assessment of Chemicals Associated with Coal Seam Gas Extraction in Australia, Commonwealth of Australia, Canberra.

Organisation for Economic Co-operation and Development (OECD). (1992). Test No. 301: Ready Biodegradability. (Biodégradabilité Facile.) Paris: OECD Publishing.

Soucek, D.J. (2007). Comparison of hardness and chloride regulated acute effects of sodium sulfate on two freshwater crustaceans. Environ. Toxicol. Chem. 26: 773-779.

Australian Industrial Chemicals Introduction Scheme. 2021. Chemical Information Database. Available online at: https://www.industrialchemicals.gov.au/chemical-information/search-assessments

Appendix A Compiled List of Chemicals

Appendix A.1 Compiled List of March 2020 Chemicals

APPENDIX A

CHEMICAL SUMMARY LIST		
Chemical Name	**CAS Number**	**Max Concentration (mg/L)**
Choline Chloride	[redacted]	[redacted]
Guar gum	[redacted]	[redacted]
Hydrochloric acid	[redacted]	[redacted]
Alcohols, C6-12, ethoxylated propoxylated	[redacted]	[redacted]
Ethylene glycol	[redacted]	[redacted]
Ulexite	[redacted]	[redacted]
Triethanol amine	[redacted]	[redacted]
Sodium Chloride	[redacted]	[redacted]
Sodium polyacrylate	[redacted]	[redacted]
Sodium hydroxide	[redacted]	[redacted]
Alcohols, C10-16, ethoxylated propoxylated	[redacted]	[redacted]
Acetic acid	[redacted]	[redacted]
Diethanolamine	[redacted]	[redacted]
Tributyl tetradecyl phosphonium chloride	[redacted]	[redacted]
Acrylamide acrylate copolymer	[redacted]	[redacted]
Sodium bisulfite	[redacted]	[redacted]
Chlorous acid, sodium salt	[redacted]	[redacted]
Disodium octaborate tetrahydrate	[redacted]	[redacted]
Cinnamaldehyde	[redacted]	[redacted]
Polyethylene glycol	[redacted]	[redacted]
Diethylene glycol	[redacted]	[redacted]
Crystalline silica, quartz	[redacted]	[redacted]
Methanol	[redacted]	[redacted]
Sodium persulfate	[redacted]	[redacted]
Amine oxides, cocoalkyldimethyl	[redacted]	[redacted]
Citric acid	[redacted]	[redacted]
Benzaldehyde	[redacted]	[redacted]
Ethanol	[redacted]	[redacted]
Hydrotreated light petroleum distillate	[redacted]	[redacted]
Fatty acids, tall-oil, ethoxylated	[redacted]	[redacted]
Amides, tall-oil fatty, N,N- bis(hydroxyethyl)	[redacted]	[redacted]
Butyl alcohol	[redacted]	[redacted]
Alcohols, C12-15, ethoxylated	[redacted]	[redacted]
Alcohols, C12-16, ethoxylated	[redacted]	[redacted]

Sodium iodide	[redacted]	[redacted]
Acrylonitrile	[redacted]	[redacted]
Sodium Sulfate	[redacted]	[redacted]
Glutaraldehyde	[redacted]	[redacted]
Acrylamide, sodium acrylate polymer	[redacted]	[redacted]
Ethoxylated branched C13 alcohol	[redacted]	[redacted]
Sobitan, mono-9-octadecenoate, (Z)	[redacted]	[redacted]
Sodium diacetate	[redacted]	[redacted]
Sorbitan monooleate polyoxyethylene derivative	[redacted]	[redacted]
Potassium chloride	[redacted]	[redacted]
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	[redacted]	[redacted]
Cocobetaine	[redacted]	[redacted]
Sodium perborate tetrahydrate	[redacted]	[redacted]
Sodium thiosulfate	[redacted]	[redacted]
Amides, tall-oil fatty, N,N-bis(hydroxyethyl)	[redacted]	[redacted]
Hydroxylpropyl guar	[redacted]	[redacted]
Glycerine	[redacted]	[redacted]
Polypropylene glycol	[redacted]	[redacted]
Sodium Sulfite	[redacted]	[redacted]
Silica dioxide	[redacted]	[redacted]
Sodium carbonate	[redacted]	[redacted]
Fatty acids, C8-C16, ethylhexyl ester	[redacted]	[redacted]
Sodium bicarbonate	[redacted]	[redacted]
Iron gluconate	[redacted]	[redacted]
Aldol	[redacted]	[redacted]
Propylene glycol n-propyl ether	[redacted]	[redacted]
Bismuth Oxide	[redacted]	[redacted]
Crontonaldehyde	[redacted]	[redacted]
2-Ethyl hexanol	[redacted]	[redacted]
Acetaldehyde	[redacted]	[redacted]

Appendix A.2 Compiled List of May 2021 Chemicals

Schlumberger

Client:	Imperial Energy
Well:	Unknown
Basin/Field:	
State:	
County/Parish:	
Case:	
Disclosure Type:	Pre-Job
Well Completed:	
Date Prepared:	3/10/2021
Report ID:	RPT-1265

Fluid Name & Volume		Additive	Additive Description	Concentration	Volume
WF100:YF120FlexD:HVFR	1,109,400 gal	B499	Natural Corrosion Inhibitor B499	[redacted]	[redacted]
		F112	Surfactant	[redacted]	[redacted]
		H015	Acid	[redacted]	[redacted]
		J218	Breaker J218	[redacted]	[redacted]
		J475	Breaker J475	[redacted]	[redacted]
		J580	Gel J580	[redacted]	[redacted]
		J604 †	Crosslinker J604	[redacted]	[redacted]
		J693	HV Friction Reducer J693	[redacted]	[redacted]
		L065	Scale Inhibitor	[redacted]	[redacted]
		L071	Clay Control Agent	[redacted]	[redacted]
		M300	Myacide GA 25	[redacted]	[redacted]
		S100	100 Mesh Sand	varied concentrations	[redacted]
		S521-4070-NRT	CARBOPROP® NRT S521-4070-NRT	varied concentrations	[redacted]
		S521-4070	Propping Agent	varied concentrations	[redacted]
		U028	Activator	[redacted]	[redacted]

† 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)*	[redacted]			
[redacted]	Ceramic materials and wares, chemicals				
[redacted]	Quartz, Crystalline silica				
[redacted]	Guar gum				
[redacted]	2-hydroxy-N,N,N-trimethylethanaminium chloride				
[redacted]	Acrylamide/ammonium acrylate copolymer				
[redacted]	Ethylene Glycol				
[redacted]	Hydrochloric acid				
[redacted]	Distillates, petroleum, hydrotreated light				
[redacted]	Ulexite				
[redacted]	Poly(oxy-1,2-ethanediyl), alphahexyl-omega-hydroxy-				
[redacted]	2-Propenoic acid, polymer with sodium phosphinate				
[redacted]	Sodium hydroxide (impurity)				
[redacted]	Distillates (petroleum), solvent-dewaxed heavy paraffinic				
[redacted]	Diammonium peroxidisulphate				
[redacted]	Glutaraldehyde				
[redacted]	Sorbitan, mono-(9Z)-9-octadecenoate				
[redacted]	Ethoxylated oleic acid				
[redacted]	Sodium chloride				
[redacted]	Sodium Tetraborate Decahydrate				
[redacted]	Ammonium chloride				
[redacted]	Gelatins				
[redacted]	Calcium Chloride				
[redacted]	Vinylidene chloride/methylacrylate copolymer				
[redacted]	but-2-enedioic acid				
[redacted]	Dicoco dimethyl quaternary ammonium chloride				
[redacted]	Alcohols, C12-14-secondary, ethoxylated				
[redacted]	Non-crystalline silica (impurity)				
[redacted]	2,2"-oxydiethanol (impurity)				
[redacted]	2-Propenamid (impurity)				
[redacted]	Propan-2-ol				
[redacted]	Potassium chloride (impurity)				
[redacted]	Diutan gum				
[redacted]	Magnesium silicate hydrate (talc)				
[redacted]	poly(tetrafluoroethylene)				

** 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.*

Appendix A.3 Compiled List of January 2022 Chemicals

Schlumberger

Client:	Imperial Energy
Well:	Carpentaria-2H
Basin/Field:	
State:	
County/Parish:	
Case:	
Disclosure Type:	Pre-Job
Well Completed:	
Date Prepared:	11/15/2021
Report ID:	RPT-1407

Fluid Description(s)	
YF125FlexD:SW: HVFR 4,268,500 gal	Contains: Water, Natural Corrosion Inhibitor B499, Surfactant , Acid, Breaker J218, Breaker J475, Gel J580, Crosslinker J604, Friction Reducer, 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)*				
[redacted]	Quartz, Crystalline silica				
[redacted]	2-hydroxy-N,N,N-trimethylethanaminium chloride				
[redacted]	Guar gum				
[redacted]	Ulexite				
[redacted]	Ethylene Glycol				
[redacted]	Diammonium peroxidisulphate				
[redacted]	Sodium hydroxide (impurity)				
[redacted]	Acrylamide sodium acrylate copolymer				
[redacted]	Poly(oxy-1,2-ethanediyl), alphahexyl-omega-hydroxy-				
[redacted]	2-Propenoic acid, polymer with sodium phosphinate				
[redacted]	Glutaraldehyde				
[redacted]	Hydrochloric acid				
[redacted]	Sodium Tetraborate Decahydrate				
[redacted]	Sodium chloride				
[redacted]	Ammonium sulfate				
[redacted]	Acrylamide, 2-acrylamido-2-methylpropanesulfonic acid, sodium salt polymer				
[redacted]	Vinylidene chloride/methylacrylate copolymer				
[redacted]	Calcium Chloride				
[redacted]	but-2-enedioic acid				
[redacted]	Dicoco dimethyl quaternary ammonium chloride				
[redacted]	Gelatins				
[redacted]	Non-crystalline silica (impurity)				
[redacted]	Polymer of 2-acrylamido-2-methylpropanesulfonic acid sodium salt and methyl acrylate				
[redacted]	2,2''-oxydiethanol (impurity)				
[redacted]	Urea				
[redacted]	Propan-2-ol				
[redacted]	Magnesium silicate hydrate (talc)				
[redacted]	Diutan				
[redacted]	Potassium chloride (impurity)				
[redacted]	Sodium sulfate				
[redacted]	poly(tetrafluoroethylene)				
[redacted]	2-Propenamid (impurity)				
[redacted]	Tetrasodium ethylenediaminetetraacetate				
[redacted]	Dimethyl siloxanes and silicones				
[redacted]	Siloxanes and silicones, dimethyl, reaction products with silica				
[redacted]	Octamethylcyclotetrasiloxane				
[redacted]	Decamethyl cyclopentasiloxane				
[redacted]	Copper(II) sulfate				
[redacted]	Dodecamethylcyclohexasiloxane				

** 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.*

Appendix A.4 Compiled List of October 2024 Chemicals

HALLIBURTON CONFIDENTIAL INFORMATION - ONLY TO BE USED FOR REGULATOR NOTIFICATION (QLD FORMAT)

Comments:
Empire C5H Fluid: DFS-BGL & HVFR PreJob

Total injected fluid volume (kiloliters):	[redacted]

Comprising of: (Kilograms, liters or kiloliters)		
Base Fluid type (e.g. water)	**Liters**	**% of total volume**
Makeup Water	[redacted]	[redacted]

Proppant type (e.g sand)	**Proppant Size**	**Kilograms**	**Liters**	**% of total volume**
Sand	100 Mesh	[redacted]	[redacted]	[redacted]
Sand	40/70			

Any wet chemical constitutes:		**Liters**	**% of total volume**
Water in Products	[redacted]	[redacted]	
Hydrochloric acid			
Acrylamide, sodium acrylate polymer			
Alcohols, C6-12, ethoxylated propoxylated			
Hydrotreated light petroleum distillate			
Alcohols, C10-16, ethoxylated propoxylated			
Sodium perborate tetrahydrate			
Sodium polyacrylate			
Acetic acid			
Guar gum			
Tributyl tetradecyl phosphonium chloride			
Diethylenetriaminepentakis (methylene phophonic acid), sodium salt			
Polyethylene glycol			
Ethoxylated branched C13 alcohol			
Sobitan, mono-9-octadecenoate, (Z)			
Sodium diacetate			
Sorbitan monooleate polyoxyethylene derivative			
Citric acid			
Cinnamaldehyde			
Soybean oil			
Diethylene glycol			
Sodium hydroxide			
Methanol			
Amine oxides, cocoalkyldimethyl			
Disodium octaborate tetrahydrate			
2-Propenoic acid, homopolymer			
Benzaldehyde			
Polypropylene glycol			
Alcohols, C12-16, ethoxylated			
Methyloxirane polymer with oxirane, ether with 1,2,3-propanetriol (3:1)			
Methyloxirane polymer with oxirane, ether with 1,2-propanediol (2:1)			
Poly(oxy-1,2-ethanediyl), a-hydro-w-hydroxy-, mono-C10-14-alkyl ethers, [redacted]			
2-Propenoic acid, telomer with mercaptoacetic acid			
Acetic acid, 2-mercapto-, sodium salt (1:1)			
Sodium iodide			
Sodium bicarbonate			

Appendix B Potential Risk to Groundwater from Hypothetical Water Releases

Potential Risk to Groundwater from Hypothetical Water Releases

Imperial Oil & Gas and Imperial Oil & Gas A Exploration Permits (167, 168, 169, 184, 187, 198 & 305)

Prepared for:

INGAUGE
Well Engineering & Project Management
Reliable I Experienced I Engaged

Prepared by:

EHS Support

December 2021

Document Control

PROJECT DETAILS

Project No.:	04921.0000
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REVISION HISTORY

Date	Revision #	Status / Summary of Key Changes
21/12/2021	A	Draft for client review
14/04/2023	0	Issued as final. Added revision history and corrected revision numbers.
01/11/2023	1	VLEACH modelling completed for chloride in lieu of sodium.

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Acronyms

atm-m^3/mol	atmospheric pressure and cubic metres per mole
BMR	Bureau of Mineral Resources
CEC	cation exchange capacity
CLA	Cambrian Limestone Aquifer
EC	electrical conductivity
EP	Exploration Permit
mbgl	metres below ground level
MITC	methylisothiocyanate
NMBCT	Northern McArthur Basin Central Trough
SWL	standing water level

Units of Measure

Area	
ha	hectare
m^2	square metres
Density	
kg/m^3	kilograms per cubic metre
Electrical Conductance	
µS/cm	micro Siemen per centimetre
mV	millivolt
Length	
µm	micrometres
cm	centimetres
km	kilometres
m	metres
Mass	
µg	micrograms
kg	kilograms
mg	milligrams
t	metric tonnes
Concentration by Mass	
µg/kg	microgram per kilogram
mg/kg	milligram per kilogram
Pressure	
kPa	kilopascals
Pa	Pascals
Temperature	
°C	degrees Celsius
°F	degrees Fahrenheit
K	kelvin
Velocity	
m/d	metres per day
m/s	metres per second
L/s	Litres per second
Volume	
µL	microlitres
cm^3	cubic centimetre
GL	gigalitre
L	litres
m^3	cubic metre
mL	millilitres
ML	megalitre
Concentration by Volume	
µg/L	microgram per litre
mg/L	milligram per litre
ppmv	parts per million by volume
ppbv	parts per billion by volume

1 Introduction

This report provides an assessment of the potential for impacts on groundwater associated with shale gas activities of Imperial Oil & Gas and Imperial Oil & Gas A in the Northern Territory (NT). For the purpose of this assessment the primary mode of potential impact was identified as an accidental release to the land surface and the resulting radial land flow and sub-surface infiltration. The technical assessment and modelling are provided in the following sections.

1.1 Objective

The objective of this assessment is to define the potential extent of the area impacted by a release or "spill" of fluids and the likelihood of migration to groundwater. Specifically, the following questions were addressed:

1. Using three spill scenarios (1,000 L, 100,000 L and 1 ML), determine the maximum pooled area in which a spill would inundate.
2. Over the size of the pooled area, determine infiltration rates to gain an understanding of vertical groundwater movement and associated travel time.
3. Evaluate the potential impacts on groundwater if the spilt fluid contained drilling muds (where muds are blended with soils).

1.2 Scope of Work

To meet the objectives described above, the following work tasks were undertaken:

1. Establish applicable soil/aquifer characteristics within the areas of interest based on a literature review, available stratigraphic information from the Petroleum Onshore Information Northern Territory (POINT) web-based data catalogue and other literature (as appropriate).
2. Assess the water pooling area on a flat surface using the formulae proposed by Grimaz et al. (2007).
3. Assess the infiltration capacity of surface soils and ponding time using the analytical Green-Ampt infiltration equation (Green and Ampt, 1911).
4. Assess the infiltration velocity and depth once surface soils become saturated using Darcy's Law (Darcy, 1856).
5. Evaluate the potential impacts on groundwater (using VLEACH) if the spilt fluid contained drilling muds (where muds are blended with soils).

1.3 Area of Interest

This assessment of the potential for impacts on groundwater associated with shale gas activities in the Northern Territory is applicable to Exploration Permits (EP) 167, 168, 169, 184, 187, 198 and 305 only. The EP's are shown on **Figure 1-1**, along with the major Basins and Sub-basins.

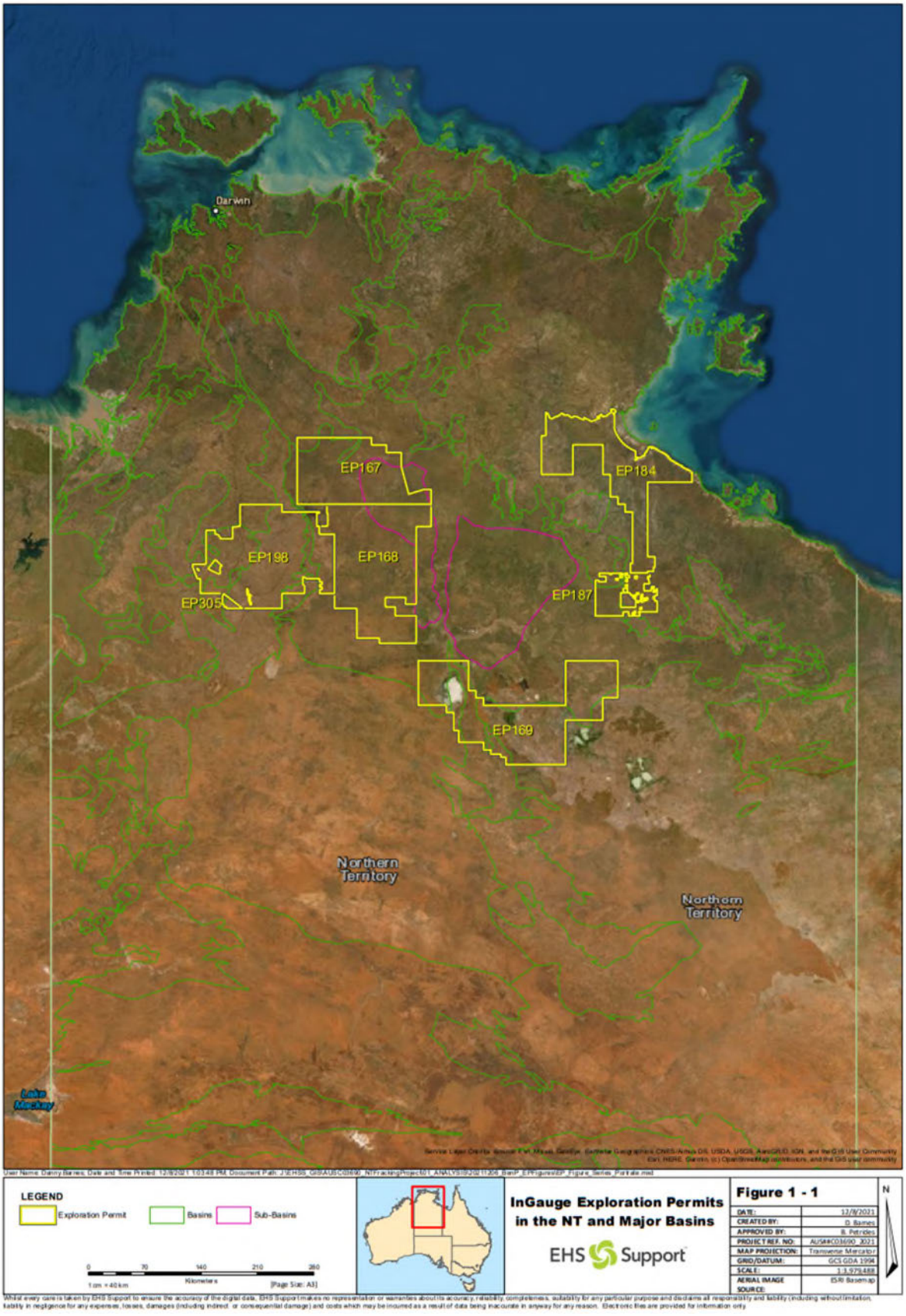


Figure 1-1 Imperial Oil & Gas and Imperial Oil & Gas A Exploration Permits in the Northern Territory and Major Basins and Sub-basins

2 Overview of Hydrogeology/Geology

Imperial Oil & Gas and Imperial Oil & Gas A plan to progressively explore its NT tenements, following the drilling and present appraisal of Carpentaria-1 and Carpentaria-2 in EP187. Carpentaria-2 encountered thick liquid rich gas shales across the four stacked Velkerri Formation pay zones with strong gas shows across the target formations and live gas bleeding from core samples. Well log interpretation indicated a strong correlation in thickness and rock characteristics of the four stacked shale targets to the Carpentaria-1 location.

Imperial Oil & Gas and Imperial Oil & Gas A are presently planning for exploration drilling on EP167 and EP168, as future stages. This assessment addresses all of their NT tenements (see **Table 2-1** and **Figure 1-1**), but given the immediate focus, the most detail is provided for EP167, EP168, EP184 and EP187. As additional tenements are planned for exploration, where relevant, this assessment will be updated with more detailed and site-specific information, if required.

2.1 Basins and Sub-basins

Table 2-1 presents Imperial Oil & Gas and Imperial Oil & Gas A tenements and the associated geological basins (sub basins where relevant). **Table 2-2** provides a summary of the basins and the inter-relationships. These tenements are split into two main areas:

- Eastern: EP184 and EP187, which are predominantly located in the McArthur Basin, but also within the Carpentaria and Georgia Basins; and
- Western: EP167-169, EP198 and EP305, which are spread over a number of basins including the Birrindudu, Carpentaria, Daly, Georgina, Victoria and Wiso Basins.

Figure 2-1 presents the Eastern tenements and relevant basins while **Figure 2-2** presents the Western tenements and relevant basins.

Table 2-1 Basins and Sub-basins Relevant to the Areas of Interest

Exploration Permit	Owner	Basin(s)	Sub-basin
Eastern			
EP184	Imperial Oil & Gas Pty Ltd	McArthur	-
EP187	Imperial Oil & Gas Pty Ltd	Carpentaria, Georgina, McArthur	-
Western			
EP167	Imperial Oil & Gas A Pty Ltd	Carpentaria and Daly	Beetaloo
EP168	Imperial Oil & Gas A Pty Ltd	Carpentaria	Beetaloo
EP169	Imperial Oil & Gas A Pty Ltd	Carpentaria, Georgina, Wiso	-
EP198	Imperial Oil & Gas A Pty Ltd	Birrindudu, Carpentaria, Victoria, Wiso	-
EP305	Imperial Oil & Gas A Pty Ltd	Victoria	-

Table 2-2 Basin Summary and Relationships

Basin	Age (Ma)	Thickness (km)	Lithology	Relationship
Carpentaria	–5 - 205	5	Sedimentary: sandstone, mudstone, limestone	Unconformably overlies the sedimentary rocks of Palaeoproterozoic Murphy Inlier, Paleo-Mesoproterozoic McArthur and South Nicholson basins, Neoproterozoic to Palaeozoic Georgina Basin and Palaeozoic Daly Basin.
Wiso	360 – 540	<0.3 to 3	Sedimentary: dolostone, limestone, shale, sandstone, siltstone.	Faulted against Palaeo-Neoproterozoic metamorphic rocks of the Aileron Province to the south. Unconformably overlies Palaeoproterozoic rocks of the Tanami Region to the west, Tennant Region to the east, and the Palaeo-Mesoproterozoic Birrindudu Basin to the northwest. Cretaceous rocks of the Carpentaria Basin cover its northern margin.
Georgina	355 -850	3.7	Sedimentary: dolostone, limestone, shale, sandstone, siltstone.	Unconformably overlies Palaeoproterozoic Murphy, Warramunga and Davenport provinces, Palaeo-Mesoproterozoic McArthur and South Nicholson basins and Lawn Hill Platform, and in fault contact with Palaeo-Neoproterozoic Aileron Province. Interpreted to be contiguous with Neoproterozoic to Palaeozoic Wiso and Daly basins that developed as distinct depocentres isolated by basement highs formed from the Cambrian Kalkarindji Province. Unconformably overlain by Mesozoic Carpentaria and Eromanga basins.
Daly	4–0 - 520	1	Sedimentary: limestone, dolostone, sandstone, siltstone, conglomerate	Unconformably overlies the Palaeoproterozoic Pine Creek Orogen and Palaeo-Mesoproterozoic Birrindudu Basin to the north and east and Neoproterozoic Victoria Basin to the west. Overlain by Mesozoic Carpentaria Basin on its southern margin
Victoria	7–0 - 850	0.950	Sedimentary: dolostone, sandstone, limestone, shale.	Unconformably overlies Palaeoproterozoic Pine Creek Orogen and Palaeo-Mesoproterozoic Birrindudu Basin. Unconformably overlain by Neoproterozoic Wolfe Basin, Neoproterozoic to Palaeozoic Wiso Basin, Palaeozoic Daly Basin and Cambrian Kalkarindji Province.
Beetaloo Sub-basin	1320- 1650	10	Sedimentary and minor volcanic: dolostone, sandstone, shale, felsic and mafic volcanic rocks.	The Beetaloo Sub-basin is a structural component of the Proterozoic greater McArthur Basin. It consists of two discrete subsurface volumes of sedimentary rock, typically bounded by faults, containing the thickest preserved formations that host significant hydrocarbon resources. Significant thicknesses of Mesoproterozoic sediment accumulated in the Beetaloo Sub-basin relative to adjacent areas (Munson, 2016). The sub-basin lies entirely under the cover of younger basin sediments of the Neoproterozoic Centralian A Superbasin, the Paleozoic Centralian B Superbasin (including the Georgina, Wiso and Daly basins) and the Mesozoic Carpentaria Basin.
McArthur	14–0 - 1800	12	Sedimentary and minor volcanic: dolostone, sandstone, shale, felsic and mafic volcanic rocks.	Unconformably overlies Palaeoproterozoic Pine Creek Orogen, Murphy Province and Arnhem Province to the northwest, southeast and northeast respectively. Unconformably overlain by the Palaeozoic Arafura, Georgina and Mesozoic Carpentaria basins. Interpreted to be contiguous under cover with the Palaeo-Mesoproterozoic Birrindudu Basin and Tomkinson Province.
Birrindudu	15–0 - 1780	10	Sedimentary: sublithic arenite, quartz arenite, siltstone, shale, conglomerate, stromatolitic chert, limestone, glauconitic sandstone.	Unconformably overlies Palaeoproterozoic Pine Creek Orogen to the north. Unconformably overlain by Palaeozoic Wiso and Daly basins to the east; by Cambrian Ord Basin to southwest; by Neoproterozoic Wolfe Creek Basin to west and Neoproterozoic Victoria Basin to the north; and in places, by Cambrian Kalkarindji Province and patchy sedimentary rocks of basin-margin Mesozoic sandstone. Towards the south is underlain by Palaeoproterozoic metasediments and granites of Tanami Region. In northwest, in faulted contact with Palaeozoic–Mesozoic Bonaparte Basin and Palaeoproterozoic rocks of Halls Creek Orogen.

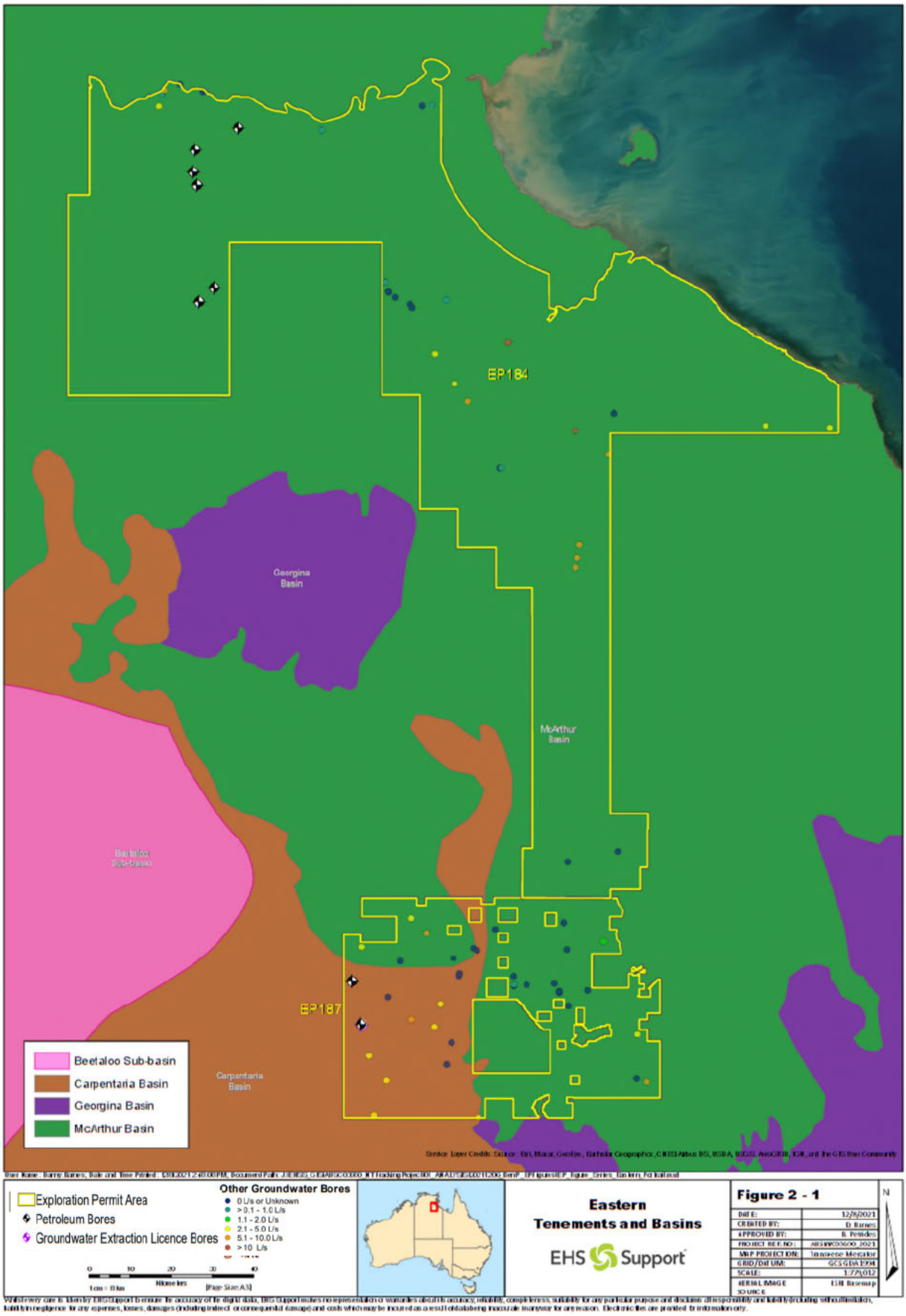


Figure 2-1 Eastern Tenements and Basins (EP184 and EP 187)

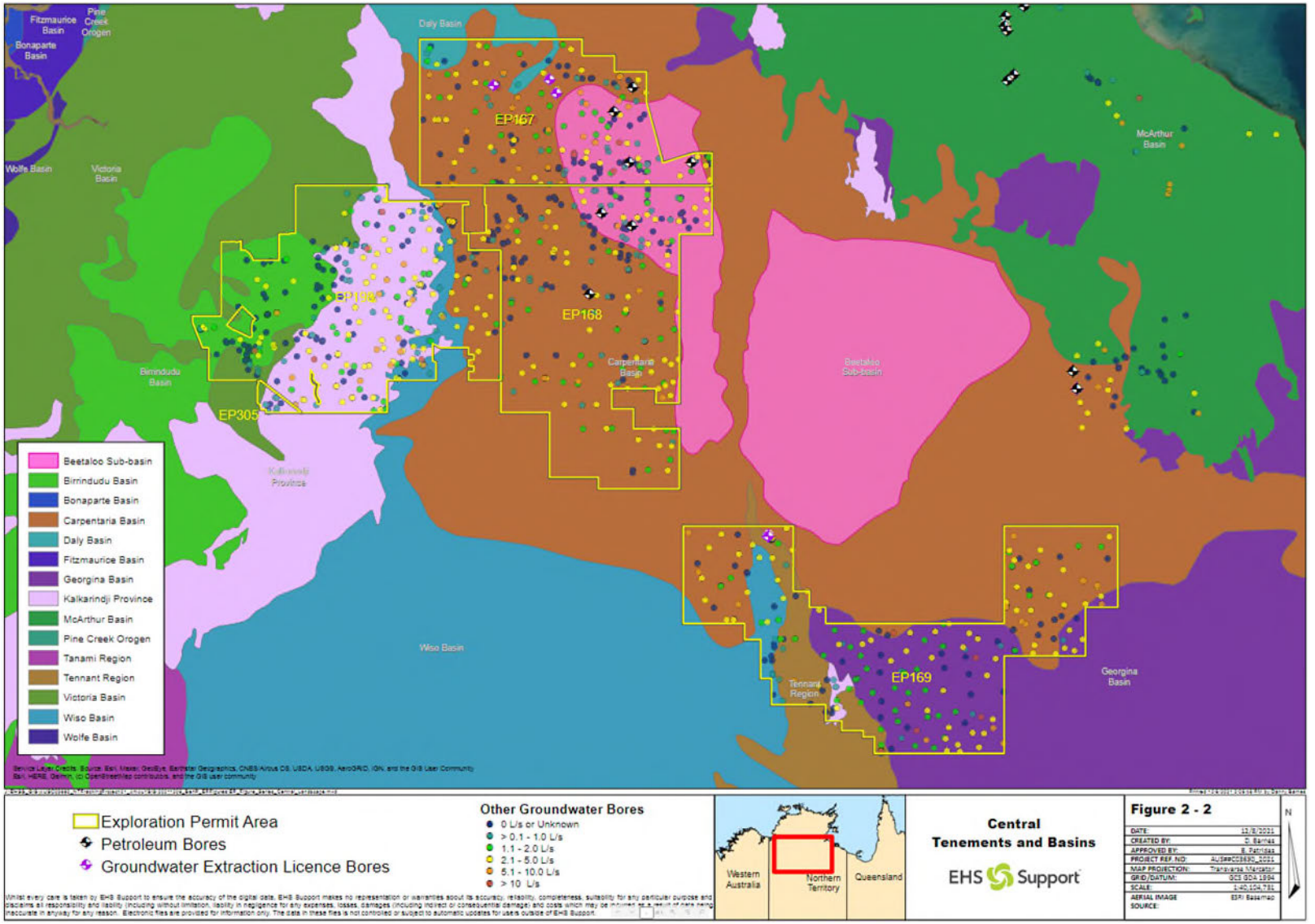


Figure 2-2 Western Tenements and Basins (EP167-9, EP198 and EP305)

2.2 Stratigraphic Overview in Each Exploration Permit

The shallow (<100 m) hydrostratigraphic sequence within each EP was evaluated by reviewing petroleum drillholes, where present, groundwater extraction licence well construction logs and other stock and domestic supply well construction logs. These shallow sequences are most susceptible to impacts associated by a release or "spill" of fluids. The breakdown of available information is presented in **Table 2-3**.

Table 2-3 Available Stratigraphic Information from Existing Drillholes and Wells

Exploration Permit	# of Petroleum Drillholes	# of Groundwater Extraction Licenced Wells	# of Other Stock and Domestic Supply Wells
EP184	7	0	32
EP187	2	2	40
EP167	4	3	213
EP168	3	0	223
EP169	0	5	301
EP198	0	0	361
EP305	0	0	10

Figure 2-3 shows the petroleum drillholes, groundwater extraction licenced wells and stock and domestic supply wells in each of the exploration permits.

2.2.1 Eastern Tenements

2.2.1.1 EP 184

2.2.1.1.1 Geological Setting

The regional geology of the McArthur River Basin is well summarised by Jackson et al. (1987), Plumb and Roberts (1992), Plumb et al. (1990), Madigan and Rawlings (1994) and Pietsch et al. (1994). The Middle Proterozoic McArthur Basin of Central Australia outcrops over an area of 200 000 km^2, in the Northern Territory, with a relatively unknown, but large, section which sub-crops below younger sequences.

The Northern McArthur Basin within EP184 is dominated by the Walker Trough and the Urapunga Fault Zone, a northwest trending, extensively faulted zone approximately 50 to 70 km wide. Gentle warping and folding can be related to the faults. Fold axis generally trend north-northwest and locally east-northeast and northwest to west-northwest. It is estimated that during deposition of the McArthur Basin a number of subsidence events due to rifting associated with extension along pre-existing basement structures probably occurred.

The basin contains up to 12 relatively undeformed and un-metamorphosed sedimentary rocks comprising clastics, evaporites and carbonates. The stratigraphy is subdivided into four stratigraphic groups separated by regional unconformities. The four stratigraphic groups of the Middle Proterozoic are the Tawallah Group, McArthur Group, Nathan Group, and the Roper Group. An unnamed sequence of Neo-Proterozoic sediments accumulated over the Roper Group.

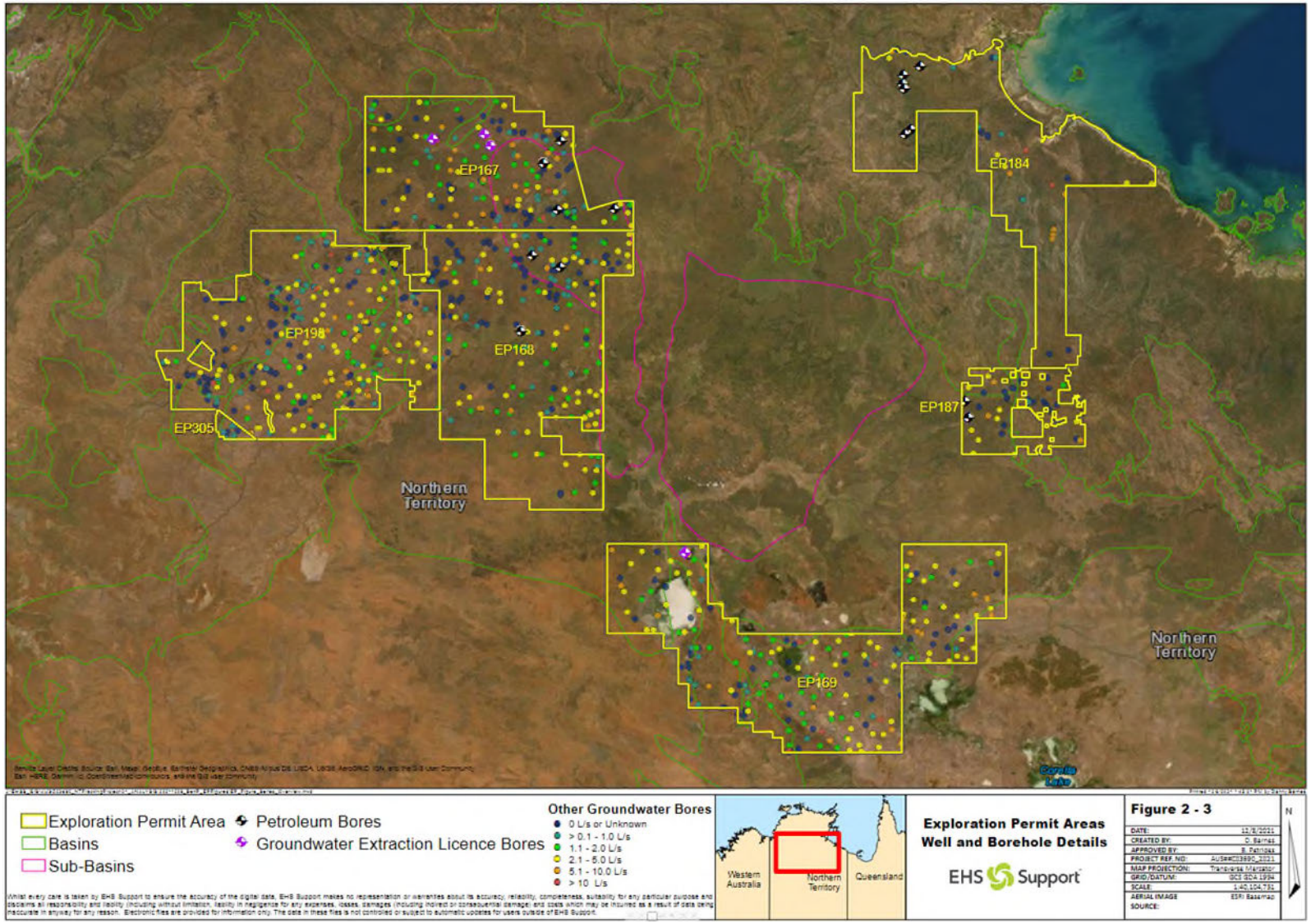


Figure 2-3 Exploration Permit Areas – Well and Borehole Details

The main structural features reflecting the tectonic evolution of the McArthur Basin are; east-west trending basement ridges such as the Murthy and the Urapunga Ridges; northwest-trending strike-slip faults, such as the Calvert, Mallapunyah and Bulman Faults; and north-trending high angle older normal faults with later inversion, such as the Emu, Tawallah and Four Arches faults.

Differential subsidence of the Walker Trough probably started during deposition of the Lower McArthur Group and continued, to a lesser extent, during the deposition of the Nathan Group (Jackson, et.al., 1987). Thickening of the Roper Group, to 5 km on the Bauhinia Shelf, west of the Abner Range area reflects a shift of the basin depocenter during the deposition of the Roper Group.

The Tawallah Group is the lowermost of the four major sequences; it is up to 4,500 m thick and represents the economic or effective basement. The Tawallah Group consists mainly of sandstones with subordinate finer grained clastics, volcanics and rare carbonates.

The McArthur and Nathan Groups overlay the Tawallah Group; they have a combined thickness of between 3,000 and 5,500 m. They are mostly stromatolitic and evaporitic dolostones interbedded with lesser siltstones and shales.

The McArthur and Nathan Group sediments were deposited in a variety of environments including marginal marine, lagoonal, lacustrine and fluvial. The McArthur and Nathan Groups are potentially a source of the hydrocarbons encountered in wells.

The uppermost unit, the Roper Group varies between 2,500 and 4,000 m in thickness. The Roper Group thickens to the southwest. It consists of alternating quartz arenites, siltstones and shales. The Roper Group unconformably overlies the McArthur and the Nathan Groups.

The sedimentary sequences within the Roper Group have significant lateral extent, with more uniform facies when compared to the underlying successions, of the Tawallah, McArthur and Nathan Groups. The estimated age of the Roper Group is at least 1,430 Ma. An un-named succession of sandstones and shales of probable Neo-Proterozoic age, overlays the Roper Group, these have a maximum thickness in excess of 600 m.

2.2.1.1.2 Stratigraphy

Within the McArthur Basin, limited petroleum exploration has been undertaken. However, stratigraphic interpretations have been inferred from Bureau of Mineral Resources (BMR) drilling in the Urapunga region (north of EP187, in the vicinity of EP184). This shows the Barkly Group and some of the Roper Group missing. Importantly, this means they are not in connection to the Cambrian Limestone Aquifers (CLA) comprising the Oolloo, Jindickin, Tindall, Anthony Lagoon and Gum Ridge aquifers, an important water resource found in the Beetaloo sub-basin. It is also likely in this area that the shallow aquifers are hosted in the Bukalorkmi Sandstone (formally the McMinn Formation) or Kyalla Shale. The Bukalorkmi Sandstone is only between 10 to 20m thick and comprises white, light grey to brown, fine to coarse-grained and locally granule-rich quartz sandstone. This Formation also hosts the Roper Field kimberlitic dykes and also supports contact springs. These springs are defined where a more permeable rock, such as sandstone, lies above a less permeable rock, such as siltstone or dolerite, and are often seen at the base of escarpments. Where springs occur as a result of fractured and karstic rocks (such as dykes), significant flows are possible. In addition, airlift tests undertaken in bores RN35878, RN35879, and RN036300 (screened in the Bukalorkmi Sandstone) airlifted 5 L/s, however pump tests undertaken on RN35879 and RN36300 recommended rates at 0.7 and 0.5 L/s respectively. The water quality from the

Bukalorkmi Sandstone aquifer had a pH between 6.3 and 7.2 and Electrical Conductivity (EC) of between 264 and 399 µS/cm (Matthews, 2008).

EP184 covers an area of approximately 11,161 km^2. Seven petroleum wells have been drilled in this EP, focussed in the north-western corner, south of the Roper River. Based on the basic well completion reports and the well construction logs from surrounding stock and domestic supply wells, the generalised lithology is described in **Table 2-4**. The fractured and weathered rocks are a minor groundwater resource with recorded yields up to 1 L/sec.

Table 2-4 EP184 – Generalised Stratigraphy

Depth From (mbgl)	Depth to (mbgl)	Lithology	Hydrogeological Unit
0	50	Interbedded siltstone/mudstone	Kyalla Member
50	120	Massive sandstone	Moroak Sandstone
>120		Mudstone and fine sandstone	Velkerri Formation of the Roper Group

2.2.1.2 EP187

Within and surrounding EP187, the shallowest hydrogeological unit of interest is the CLA defined as the Top Springs Limestone (also commonly referred to as the Tindal Limestone or Gum Ridge Formation) depending on which part of the basin you are in. The unit comprises massive and commonly dolomitised (and often fractured and karstic) limestone beds with minor siliclastic mudstone.

Santos exploration bore Tanumbirini-1 is located approximately 40 km west of EP187 and indicates that the Top Springs Limestone can be found at a depth of 52 mbgl with a thickness of 150m. **Figure 2-4** shows the location of Tanumbirini-1 and **Figure 2-5** shows the stratigraphy. However, it is anticipated that this formation shallows and thins towards EP187 where it potentially outcrops at the basin margin. Where the CLA is absent, the deeper Bukalorkmi Sandstone (formally referred to as the McMinn Formation) is a potential highly permeable aquifer.

In the vicinity of exploration bore Tanumbirini-1, the CLA is confined by Cretaceous siltstones mudstones, however underlying EP187, the CLA (Gum Ridge Formation) outcrops. The permeability of the CLA is highly dependent on the development of dissolution and fracture features (Fulton and Knapton, 2015). A review of water bores that intersect cavities or record circulation loss during drilling suggests that the karst development is widespread across the Beetaloo Sub-Basin and that aquifer permeability is generally not spatially correlated.

Fulton and Knapton, (2015), reported airlift yields range from 0.3 to 20 L/sec (average 3.5 L/sec), with the standing water level (SWL) in the Gum Ridge Formation ranging from 23 to 155 mbgl. Results from 21 pumping tests undertaken by WRD report a Transmissivity (T) range of 3 to 3,377 m^2/d. The lowest T values (less than 50 m^2/d) occur northwest of the basin where the CLA has limited saturated thickness and aquifer development is restricted to the unconformity with the underlying Antrim Plateau Volcanics (Yin Foo, 2000). Limited transmissivity would also be expected near the eastern basin boundary.

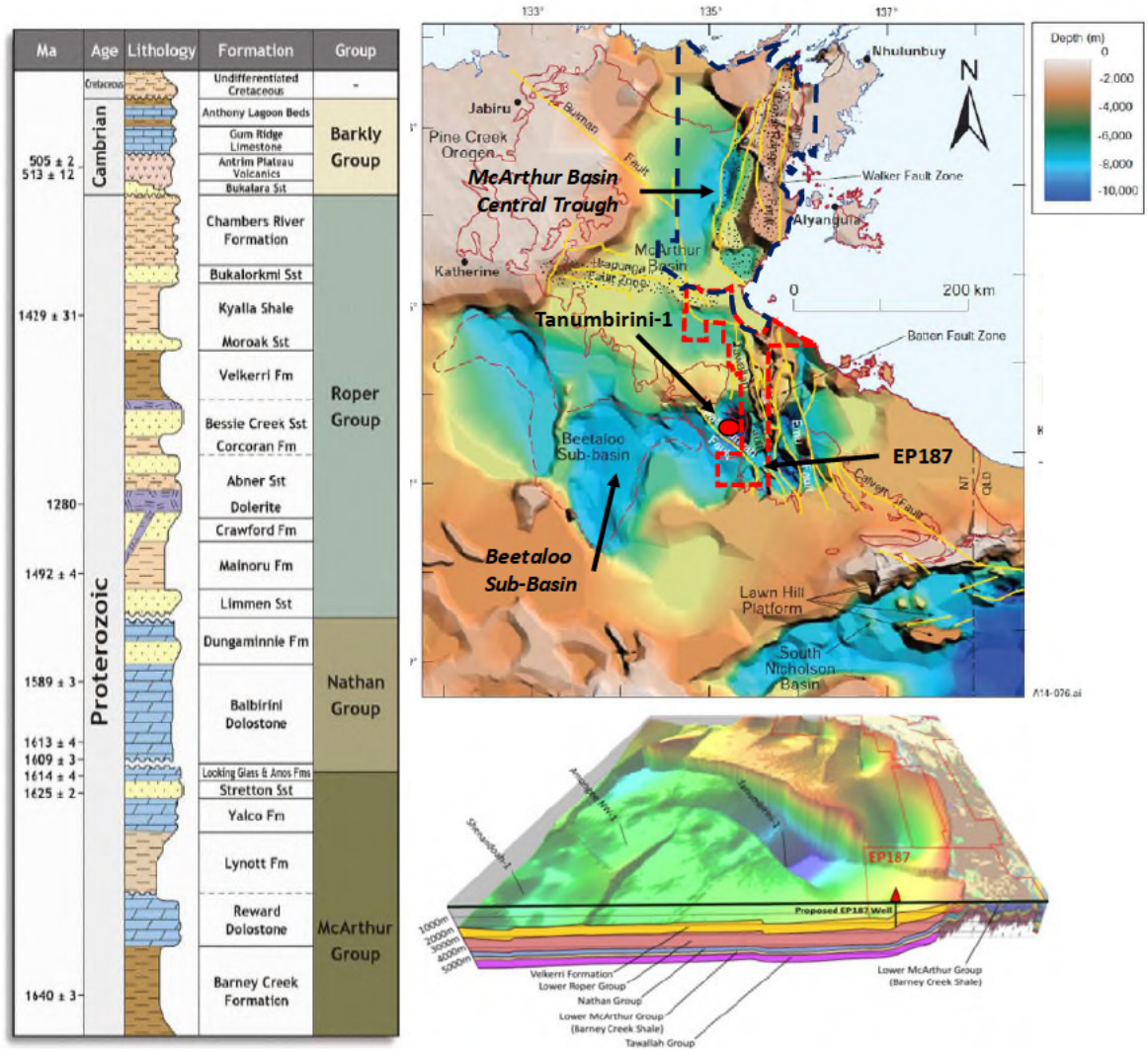


Figure 2-4 Location of the McArthur Basin and Beetaloo Sub Basin along with generalised stratigraphy within the area of Tanumbirini-1. Reference used: inGauge (2020) (geological cross-section), and Close et al (2016) (SEEBASE™ depth-to-basin image and stratigraphic column)

EP187 covers an area of approximately 2,986 km^2. Two petroleum wells have been drilled in this EP; Carpentaria 1 and Carpentaria 2 and based on the basic well completion reports the generalised lithology is described in **Table 2-5**. The major aquifer in the EP is the Gum Ridge Limestone or Tindall Limestone, which has a recorded yield of between 0.5 and 5 L/sec and the Anthony Lagoon Beds (which was identified during the drilling of Carpentaria 2 and is being monitored, see additional comments in **Section 2.2.2.3**).

Table 2-5 EP187 – Generalised Stratigraphy

Depth From (mbgl)	Depth to (mbgl)	Lithology	Hydrogeological Unit
0	50	Clay	-
50	100	Limestone	Gum Ridge Limestone/Anthony Lagoon Beds
>100		Sandstone	Bulkalara Sandstone

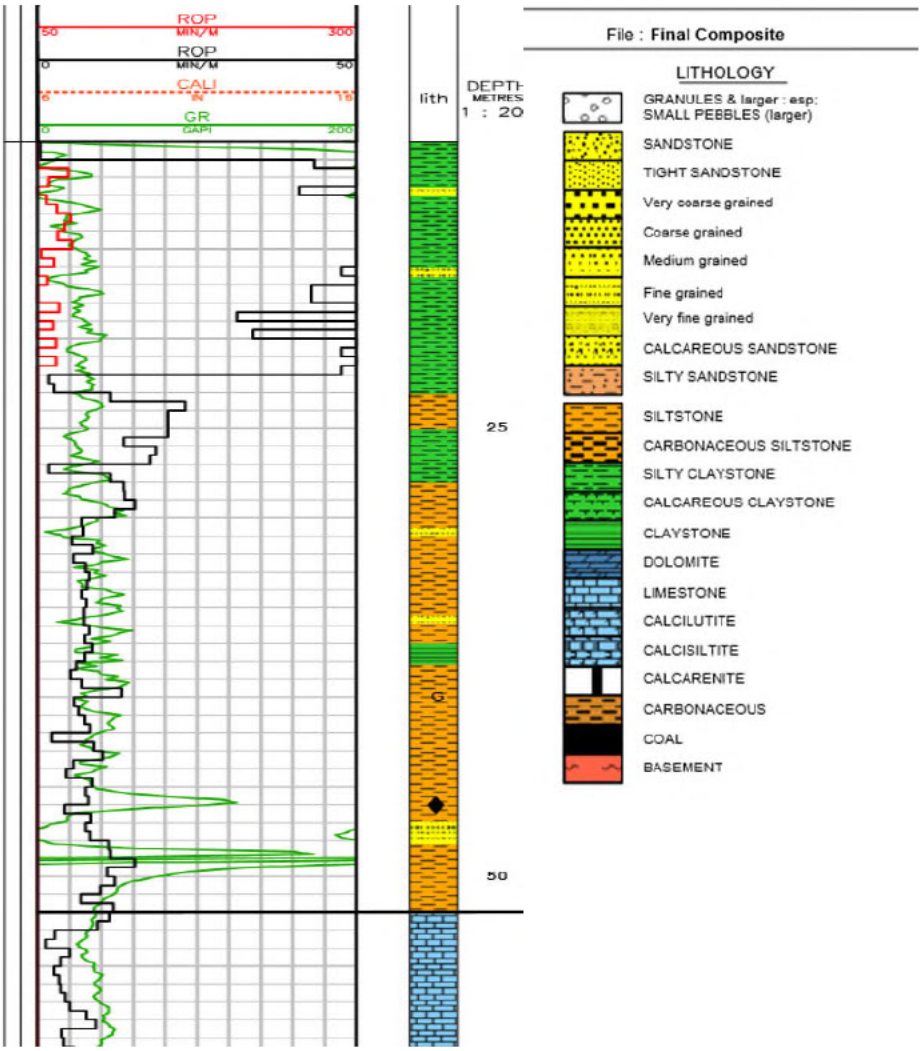


Figure 2-5 Shallow Lithology from well "Tanumbirini-1"

2.2.2 *Western Tenements*

2.2.2.1 EP167

EP167 covers an area of approximately 10,616 km^2. Four petroleum wells have been drilled in this EP; Sever 1, Wyworrie 1, Tarlee S3 and Birdum Creek 1, mostly within the Beetaloo sub-basin. Based on the basic well completion reports completed by Pangaea (NT) Pty Ltd and the well construction logs from the three groundwater extraction licenced wells, the generalised stratigraphy is described in **Table 2-6**. The major aquifer in the EP is the Tindall Limestone, which has a recorded yield of between 0.5 L/sec and 5 L/sec.

Table 2-6 EP167 – Generalised Stratigraphy

Depth From (mbgl)	Depth to (mbgl)	Lithology	Hydrogeological Unit
0	10	Clay	-
10	50	Limestone	Tindall Limestone
50	150	Basalt	Antrim Plateau Volcanics

2.2.2.2 EP168

EP168 covers an area of approximately 15,852 km^2. Three petroleum wells have been drilled in this EP, Tarlee 1, Tarlee 2 and Hidden Valley S2. Based on the basic well completion reports completed by Pangaea (NT) Pty Ltd, the generalised stratigraphy is described in **Table 2-7**. The major aquifer in the EP is the Tindall/Montejinni Limestone, which has a recorded yield of between 0.5 and 5 L/sec.

Table 2-7 EP168 – Generalised Stratigraphy

Depth From (mbgl)	Depth to (mbgl)	Lithology	Hydrogeological Unit
0	25	Clay	-
25	80	Limestone	Montejinni Limestone/Tindall Limestone Formation
>80		Basalt	Antrim Plateau Volcanics

2.2.2.3 EP169

EP169 covers an area of approximately 16,012 km^2. Petroleum wells have not been drilled within this EP, however there are a number of stock and domestic supply wells that have been drilled to ~150 mbgl. The Helen Springs 1:250,000 Hydrogeological Map (NT DIPE, 1992) provided additional conceptualisation supported by local groundwater well construction logs.

In the central and eastern part of the EP, the Anthony Lagoon Beds, comprising sandstone and dolomitic/siltstone/limestone and the Gum Ridge Formation comprising fossiliferous siltstone and chert and limestone form the major aquifer in the region (**Table 2-8**). Groundwater yields in these fractured and karstic rocks have been recorded between 5.0 and 15.0 L/sec.

Table 2-8 EP169 (Central and East) – Generalised Stratigraphy

Depth From (mbgl)	Depth to (mbgl)	Lithology	Hydrogeological Unit
0	10	Clay	-
5	100	Limestone	Anthony Lagoon Beds/Gum Ridge Formation

In the western and north-western part of the EP, outcropping sandstones and siltstones with minor dolomite of the Tomkinson Creek Beds also form aquifers in the region (**Table 2-9**). Groundwater yields in the Tomkinson Creek Beds have been recorded between 0.05 and 0.5 L/sec. Localised outcrop of the Helen Springs Volcanics and Montejinni Limestone have also been utilised.

Table 2-9 EP169 (West) – Generalised Stratigraphy

Depth From (mbgl)	Depth to (mbgl)	Lithology	Hydrogeological Unit
0	10	Clay	-
10	30	Gravel/Clay	-
30	100	Sandstone	Tomkinson Creek Beds

2.2.2.4 EP198

EP198 covers an area of approximately 15,341 km^2. Petroleum wells have not been drilled within this EP, however there are a number of stock and domestic supply wells that have been drilled to ~200 mbgl. In the central and eastern part of the EP, the Antrim Plateau Volcanics forms an aquifer in the region, comprising of basalt and interbedded sandstone. These volcanics are considered to be a regional aquitard in the region and is used as a local aquifer where groundwater supply from the limestone is not sufficient (Evans et al. 2020). This is underlain by the Jasper Gorge Formation/Stubb Formation comprising interbedded shale, siltstone and sandstone and the Weaner Formation (**Table 2-10**). Groundwater yields in the basalt have been recorded between 0 and 6 L/sec.

Table 2-10 EP198 (Central and East) – Generalised Stratigraphy

Depth From (mbgl)	Depth to (mbgl)	Lithology	Hydrogeological Unit
0	5	Clay	-
5	100	Basalt	Antrium Plateau Volcanics
<100		Sandstone	Jasper Gorge Formation/Stubb Formation

In the western part of the EP, outcropping sandstones and interbedded dolomitic siltstone of the Weaner Sandstone and Bynoe Formation also form aquifers in the region (**Table 2-11**). The Antrium Plateau Volcanics is also present in some areas in the west. Groundwater yields in the siltstone/dolomite have been recorded between 0 and 15 L/sec.

Table 2-11 EP198 (West) – Generalised Stratigraphy

Depth From (mbgl)	Depth to (mbgl)	Lithology	Hydrogeological Unit
0	5	Clay	-
5	100	Dolomite/Siltstone	Weaner Sandstone/Bynoe Formation

2.2.2.5 EP305

EP305 covers an area of approximately 222 km^2. Petroleum wells have not been drilled within this EP, however there are a number of stock and domestic supply wells that have been drilled to ~130 mbgl. These stock and domestic supply wells target the Antrim Plateau Volcanics with recorded yields ranging from 0.0 to 1.0 L/sec. The SWL has been recorded between ~20 and 80 mbgl. Based on a review of the well construction logs from the 10 licensed groundwater extraction wells, and the Victoria River Downs 1:250,000 Hydrogeological Map (NT DIPE, 1997), the generalised stratigraphy is summarised in **Table 2-12**.

Table 2-12 EP305 – Generalised Stratigraphy

Depth From (mbgl)	Depth to (mbgl)	Lithology	Hydrogeological Unit*
0	10	Clay	-
10	80	Basalt	Antrim Plateau Volcanics
80	150	Shale/sandstone	Jasper Gorge Sandstone

Depth From (mbgl)	Depth to (mbgl)	Lithology	Hydrogeological Unit*
>150		Dolomite/Limestone	Skull Creek Formation

* Based on Lithological mapping by M. Ahmad in 1972; Bore Report RN007339

3 Analytical Assessment (Methodology)

Liquid releases on a permeable soil surface undergo three main processes that control the extent of the release and the subsequent environmental impacts. These processes are:

- Overland flow (runoff);
- Evaporation; and
- Infiltration.

In this assessment, overland flow (also referred to as runoff) is assessed along with infiltration.

3.1 Lateral Spreading of Fluid/Runoff

Runoff of water as a fluid dynamical process has concurrently been an important research topic with surface water hydrology and is typically described with the use of the Saint Venant equations (Woolhiser and Liggett, 1967). However, only recently has runoff been coupled with surface infiltration at a spatial scale that can be applicable to point source flows, such as release from a pipeline. Esteves et al. (2000) contains a list of theoretical models that include the basic elements of a liquid release on land.

The approach adopted for this assessment is a progression of the Green and Ampt (1911) model (**Section 3.2.1**). In essence the Green-Ampt model approximates the curved soil moisture profiles allowing the calculation of the soils infiltration capacity. The remaining water balance component is therefore runoff. This is visually presented in **Figure 3-1**.

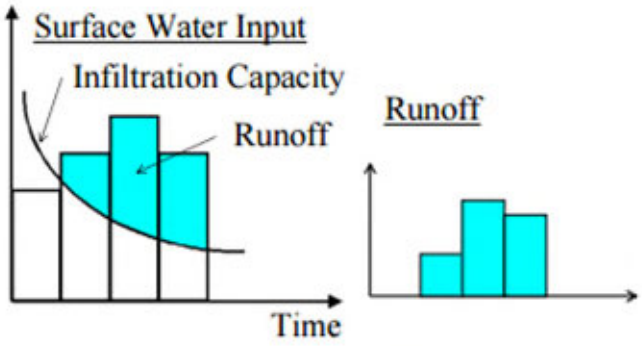


Figure 3-1 Conceptualisation of the Green-Ampt Model and the Remaining Runoff

Due to the regional approach and the complexity of this assessment, slight modifications to mathematical theory behind this and similar models were undertaken to predict the regional scale flow characteristics from a point source.

Whilst the Green-Ampt (1911) equation was used to assess the initial infiltration depths, modifications to the algorithm developed by Grimaz et al. (2007) and the Manning Kinematic Equation were adopted to model the remaining water assumed to be runoff. These analytical steps are provided in **Section 3.1.1**.

3.1.1 Water Pooling on Flat Surfaces

For instantaneous releases on flat surfaces (and assuming this water bypasses any bunded walls), the formulae (Equation 1) proposed by Grimaz et al. (2007) was used to estimate the area of the pool of liquid on flat ground. This method is used for oil spills but can allow for water by varying the liquid properties (primarily viscosity and permeability).

Equation 1 Grimaz et al. (2007)

$$A_{pool} \cong 2.3782 \frac{Q^{4/5}}{(k_i k_r)^{1/5}} \quad (1)$$

Where: *A_{pool} is the area of the pool of liquid on the surface [m^2]; Q is the total amount of liquid released [m^3]; k_i is the intrinsic permeability of soil [m^2]; k_r, is the relative permeability of the liquid [-].*

The values of k_r, which vary with different grades of water saturation of soil, are shown in **Table 3-1**. For the conservative nature of this assessment, a k_r value of 0.3 will be assumed.

Table 3-2 provides the intrinsic permeability values used for sand and clay soil profiles. Sand and clay were chosen as these represent the extremes of potential infiltration and therefore bound the conditions observed in soils within the Area of Interest.

Table 3-1 Relative Permeability k_r, for Different Scenarios of Accidental Release

Soil situation	k_r
Dry - long time without rainfall in warm regions and in hot seasons	1
Slightly wet - long time without rainfall in other regions or seasons	0.9
Very wet - from 2 hours to 2 days after strong rainfall	0.3
Completely saturated - during strong rainfall with ponds on surface	0

Table 3-2 Values of Intrinsic Permeability and Kinematic Viscosity for Sand and Clay

Soil situation	Soil type	k_i
k_i = intrinsic permeability of soil (m^2)	Sand	1.00E-08
	Clay	1.00E-13

3.2 Infiltration into Unsaturated Zone

The spilt fluid will not only tend to spread out over the surface of the soil and evaporate but will also penetrate into the ground (unless it is impermeable). Infiltration to the unsaturated zone, and in particular infiltration capacity and time for ponding to occur, can be determined using the infiltration equation of Green and Ampt (1911).

The infiltration rate actually experienced in a given soil depends on the amount and distribution of soil moisture and on the availability of water at the surface with a maximum rate at which the soil in a given condition can absorb water. This upper limit is called the infiltration capacity, f_c, and is a limitation on the rate at which water can move into the ground. If surface water input is less than

infiltration capacity, the infiltration rate will be equal to the surface water input rate (w). If irrigation (analogous to a release) intensity exceeds the ability of the soil to absorb moisture, infiltration occurs at the infiltration capacity rate until the soil is saturated and ponding and associated runoff occurs. Infiltration capacity declines over time until a steady state is reached.

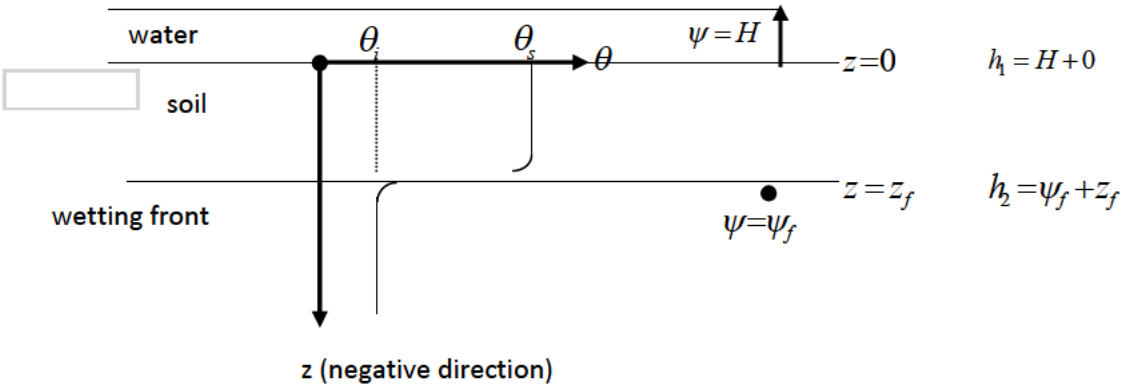
Several processes combine to reduce the infiltration capacity. The filling of fine pores with water reduces capillary forces drawing water into pores reducing the storage potential of the soil. Clay swells as it becomes wetter, and the size of pores is reduced. Coarse-textured soils such as sands have large pores which water can easily drain, while the fine pores in clays retard drainage. If the soil particles are held together in aggregates by organic matter or a small amount of clay, the soil will have a loose, friable structure that will allow rapid infiltration and drainage.

The calculation of infiltration at a point combines the physical conservation of mass (water) principle expressed through the continuity equation with quantification of unsaturated flow through soils, expressed by Darcy's equation. The downward hydraulic gradient inducing infiltration is from a combination of the effect of gravity, quantified by the elevation head, and capillary surface tension forces, quantified by the pressure head (negative due to suction) being lower at depth due to lower moisture content. If the water input rate is greater than the saturated hydraulic conductivity (i.e., w is greater than K_{sat}), at some point in time the water content at the surface will reach saturation. At this time, the infiltration capacity drops below the surface water input rate and runoff is generated. This time is referred to as the ponding time. After ponding occurs, water continues to infiltrate and a zone of saturation begins to propagate downward into the soil as the wetting front. After ponding, the infiltration rate is less than the water input rate and the excess water accumulates at the surface and becomes infiltration excess runoff. As time progresses and the depth of the zone of saturation increases, the contribution of the suction head to the gradient inducing infiltration is reduced, so infiltration capacity is reduced. Once the soil profile is completely saturated no further water can infiltrate.

3.2.1 Green and Ampt Infiltration Model

The Green and Ampt (1911) model (Equation 2) is an approximation of the infiltration process described above and was utilised to assess infiltration capacity and time for ponding for various soils.

Equation 2 Green and Ampt (1911)



$$q = -K_s \frac{dh}{dz} = -K_s \frac{h_2 - h_1}{z_2 - z_1} = -K_s \frac{(\psi_f + z_f) - (H + 0)}{z_f - 0} = -K_s \frac{\psi_f + z_f - H}{z_f} \qquad (2)$$

Where: *H = the depth of ponding, cm; Ks = saturated hydraulic conductivity (cm/s); q = flux at the surface (cm/h) and is negative; f = suction at wetting front (negative pressure head);* θ_i *= initial moisture content (dimensionless); and* θ_s *= saturated moisture content (dimensionless).*

The following assumptions are implicit in the Green-Ampt equation:

1. As water infiltrates, the wetting front advances at the same rate with depth, which produces a well-defined wetting front.
2. The volumetric water content remains constant above and below the wetting front as it advances.
3. The soil-water suction immediately below the wetting front remains constant with both time and location as the wetting front advances.

3.2.2 Darcy Infiltration Model

Once the soil has become permanently saturated (i.e., established) from a constant head driving behind the wetting front or when the Green and Ampt *flux (q) becomes constant*, Darcy's Law can be applied to determine the rate at which water can infiltrate vertically. This is shown in Equation 3.

$$qD = \frac{-K_{h,v}\frac{\Delta h}{\Delta l}}{n} \qquad (3)$$

Where: *qD = specific discharge of groundwater or Darcy Flux (m/day); Kh,v = average hydraulic conductivity (vertical [Kv] or horizontal [Kh]) of the saturated sediment (m/day);* $\Delta h / \Delta l$ *= hydraulic gradient driving the fluid (-); and* η *= effective porosity (-).*

3.3 Leaching within the Unsaturated Zone

3.3.1 VLEACH Unsaturated Zone Leaching Model

VLEACH is a 1-D finite difference vadose zone leaching model developed for the United States Environmental Protection Agency Office of Research and Development by CH2M Hill (CH2M Hill, 1990). VLEACH can simulate the behaviour of constituents in three phases: liquid phase, vapour phase and solid (sorption) phase.

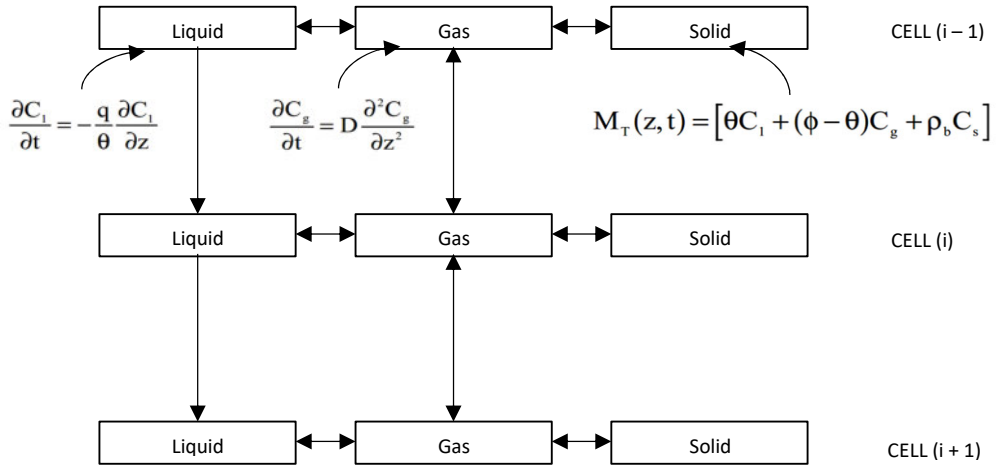


Figure 3-2 VLEACH process diagram

4 Analytical Assessment (Approach & Results)

This section presents the results of the assessment outlined in **Section 1.2**, and the methodology (described in **Section 3.1** and **Section 3.2**) for determining:

- Lateral spreading/overland flow (**Section 4.1**);
- Infiltration into unsaturated zone (**Section 4.2**);
- Infiltration rates under saturated flow conditions (**Section 4.3**); and
- VLEACH model results for each chemical constituent (**Section** Error! Reference source not found.).

4.1 Overland Flow

4.1.1 Overland Flow on Flat Surfaces

To assess the unmitigated risks from the improbable scenario where some fluids were to overflow the bunded area, a range of release scenarios are considered comprising:

1. Smaller release volumes of 1,000 L and 100,000 L, which would reflect small scale releases, and
2. An improbable release out of the bunded area (1,000,000 L).

Section 2 presents a summary of the recorded shallow lithology in each EP based on petroleum drillholes, licenced groundwater extraction wells and stock and domestic supply wells. For modelling purposes, the shallow stratigraphy in each EP has been simplified. It is noted that this simplification allows for a more conservative evaluation of infiltration, as most surficial sediments in the Areas of Interest are composed of either natural clays or clays derived from weathering of the host rock.

Table 4-1 presents the simplified stratigraphy in each EP adopted for modelling and model input parameters are provided in **Table 4-2**. It is noted that the shallow stratigraphy across the Areas of Interest are considered to be laterally equivalent and/or comprise similar hydraulic properties; these can be grouped into two main categories;

1) Low permeability formations including the Anthony Lagoon Beds, Chambers River Formation, Tomkinson Creek Beds, Kyalla Member and Atrium Plateau Volcanics
2) Higher permeability formations including the Bukalorkmi Sandstone, Gum Ridge Limestone, Tindall Limestone and Weaner Sandstone

For the purposes of assessing surface water pooling, soil properties reflective of a clay and more permeable sandier soils have been applied to Equation 1. These parameters are presented in **Table 3-1** and **Table 3-2.**

Table 4-1 Simplified Stratigraphy -Top 50 m Profile

Exploration Permit	Lithology	Hydrogeological Unit
EP167	Clay and Limestone	Tindall Limestone
EP168	Clay and Limestone	Tindall Limestone
EP169 (central and east)	Clay and Limestone	Anthony Lagoon Beds/Gum Ridge Formation
EP169 (west)	Clay and Sandstone	Tomkinson Creek Beds
EP184	Siltstone/Mudstone/Sandstone	Kyalla Member/Bukalorkmi
EP187	Clay and Limestone	Gum Ridge Formation/Anthony Lagoon Beds
EP198 (central and east)	Clay and Basalt	Antrim Plateau Volcanics
EP198 (west)	Dolomite/Siltstone	Weaner Sandstone/Bynoe Formation
EP305	Clay and Basalt	Antrim Plateau Volcanics

Table 4-2 Modelling Input Parameters

Parameter	Anthony Lagoon Beds / Chambers River Formation / Tomkinson Creek Beds / Kyalla Member / Atrium Plateau Volcanics	Bukalorkmi Sandstone / Gum Ridge Limestone / Tindall Limestone / Weaner Sandstone	Literature Source
Exploration Permit	EP169 (west), EP184 EP198 (central and east), EP305	EP167, EP168, EP169 (central and east), EP187	
Porosity	0.482*	0.4**	* Dingman, 1994 **Knapton, 2006
Hydraulic Conductivity (K_{sat}) (m/d)	$8.6x10^{-4}$	0.864	Freeze, R. A., & Cherry, J. A. (1979).
Air-Entry Tension (cm)	40.5	12.1	Dingman, 1994
Saturated Tension (cm)	30.78	9.2	Dingman, 1994
Intrinsic permeability (m^2)	$1x10^{-13}$	$1x10^{-8}$	Dingman, 1994

Dingman, S.L. 1994. Physical Hydrology Edition 5, Macmillan Publishing Company, 1994 ISBN 002329745X, 9780023297458 575 pages

Freeze, R.A. and Cherry, J.A. 1979. Groundwater. Prentice-Hall, Inc., Englewood Cliffs.

Knapton. 2006. Regional Groundwater Modelling of the Cambrian Limestone Aquifer System of the Wiso Basin, Georgina Basin and Daly Basin. Technical Report No. 29/2006A Department of Natural Resources, Environment & The Arts, Alice Springs.

Without the inclusion of bunding, a catastrophic release (1ML) could impact an area of up to 30.8 ha. In the event of smaller scale release 1,000 L or 100,000 L and prior to any bunds being established, these impacts would be highly localised to between 0.4 ha and 4.7 ha (effectively the equivalent area of the well pad).

Table 4-3 Model Results - Pooled Water Area

Stratigraphic Unit	Volume Released (L)	Volume Released (m^3)	Area (m^2)	Radius (m)	Comment
Anthony Lagoon Beds / Chambers River Formation / Tomkinson Creek Beds / Kyalla Member / Atrium Plateau Volcanics	1,000	1	1204.5	19.6	Releases of 1 to 100m^3 improbable to over topping bunding walls.
	100,000	100	47953.9	123.5	
	1,000,000	1,000	308568.8	310.3	
Bukalorkmi Sandstone / Gum Ridge Limestone / Tindall Limestone / Weaner Sandstone	1,000	1	120.4	6.2	Releases of 1 to 100m^3 improbable to over topping bunding walls.
	100,000	100	4795.4	39.1	
	1,000,000	1,000	30256.9	98.1	

4.2 Green and Ampt Infiltration Model

In addition to potential overland flow, infiltration into the sub-surface would occur. In the case of releases which are not contained within the bunded area, the infiltration rate would be slow due to the limited head of fluids within the release area, while in the bunded area the retention of release fluids would provide a higher head as liquids could be present up to the height of the surrounding walls.

The results of the Green and Ampt Infiltration equation are discussed below and shown in **Figure 4-1**.

Recalling from **Section 2** and **Section 4.1.1** above, there are two distinct hydrogeological units (siltstone/clay/basalt and limestone/permeable sandstone) that extend across the Areas of Interest. The assessment therefore is based upon the time to infiltrate through both these formations.

Assuming the sub-surface is similar to the lower permeable units as defined in **Table 4-1** and **Table 4-2**, the results indicate that the ground would become quickly saturated (the infiltration capacity of the soils are exceeded) and any spill will take approximately 158 years to move through the initial 50 m. This is based on a saturated hydraulic conductivity of a siltstone/clay/basalt (K = 0.000001 cm/s [0.00086 m/d]). As a comparison, if a limestone or permeable sandstone with an average saturated hydraulic conductivity of a fractured unit (K = 0.001 cm/s [0.864 m/d]) was present at surface, this travel time is greatly reduced to 115 days.

4.3 Darcy Infiltration Model

The results of the Darcy infiltration modelling are discussed below and shown in **Figure 4-1**. Adopting the same assumptions as presented in **Section 4.2**, (i.e., the sub-surface is similar to the units described in **Table 4-1** and hydraulic properties defined in **Table 4-2**) and that the water is available in the surface to act as a driving head (i.e., a consistent leak), the results indicate water will take approximately 80 years to move through the initial 50 m (siltstone/clay/basalt) or approximately 30 days if the sub-surface was equivalent to a limestone or permeable sandstone.

It should be noted that this evaluation is highly conservative as it assumes the sub-surface is completely saturated and has a constant driving head. However, in reality the driving head will be removed, either by evaporation or remediation, well before the predicted travel time is reached.

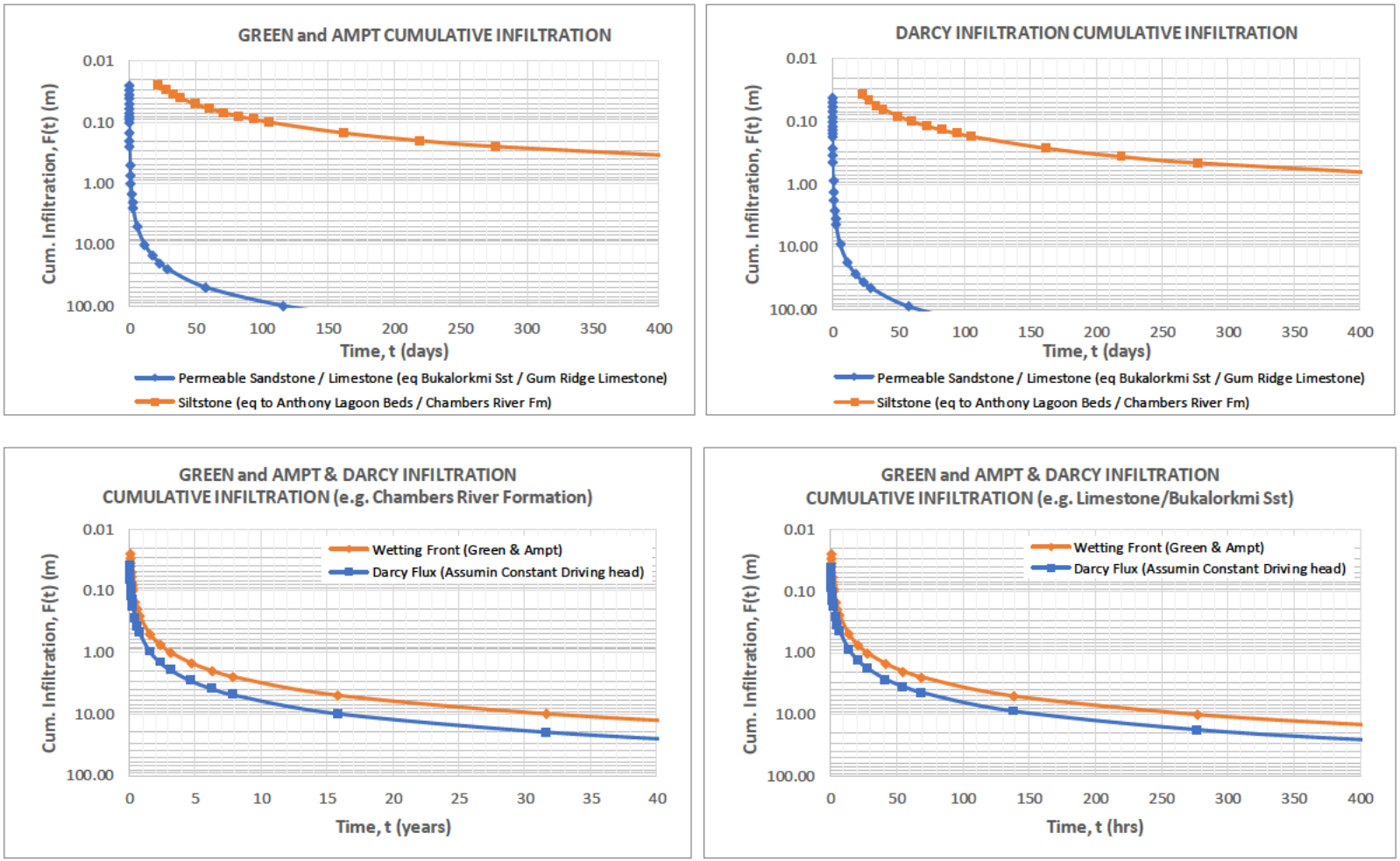


Figure 4-1 Results of the Green-Ampt Analytical Model for Limestone and Siltstone

Siltstone equivalent to the Anthony Lagoon Beds / Chambers River Formation / Tomkinson Creek Beds / Kyalla Member / Atrium Plateau Volcanics
Permeable sandstone equivalent to the Bukalorkmi Sandstone / Gum Ridge Limestone / Tindall Limestone / Weaner Sandstone

4.4 VLEACH Model

Based on the chemistry (e.g., drilling muds), leaching assessments were conducted on a scenario where drilling muds were stabilised (by blending with native soils to manage residual moisture) and compacted and placed below ground surface. Typically, the drilling muds are buried 1 to 2 m below ground surface to ensure the materials are below the rooting depth of crops and plants, and the area is graded to prevent ponding and preferential infiltration of water. The blend of drilling muds and cuttings produces a low permeability material (between $1x10^{-8}$ m/sec and $1x10^{-10}$ m/sec.) with a high cation exchange capacity (CEC). This results in metals and metalloids being strongly bound within the muds and the mud and cuttings exhibiting very low permeabilities. The conceptualisation of leaching from the buried drillings muds is provided in **Figure 4-2**.

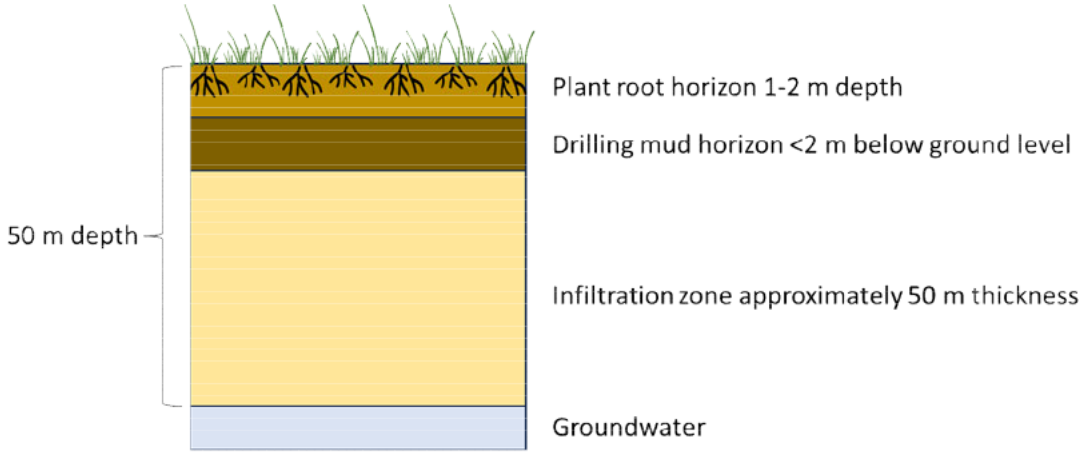


Figure 4-2 Conceptualisation of Drilling Mud Leaching

For the purposes of the modelling, organic compounds (methanol and glutaraldehyde) and chloride (from sodium chloride) migration were assessed through the soil profile. Methanol and glutaraldehyde are water soluble (unlike insoluble polymers and starch) and are subject to attenuation in the sub-surface through biodegradation and sorption. Chloride was used to evaluate conservative migration with no attenuation, i.e. no degradation or sorption.

The drilling mud chemistry is provided in **Table 4-4** and the properties of the modelled chemical constituents are presented in **Table 4-5**.

Table 4-4 Selected Drilling Mud Chemistry

Chemical Name	Concentration in Drilling Mud Solids (µg/kg)
Glutaraldehyde	300,000
Methanol	3,000
Chloride[1]	27,656,932

[1] Calculated from a sodium chloride concentration in drilling mud solids of 45,600,000 µg/kg

Table 4-5 Constituent Properties

Chemical Name	Concentration in drilling mud (mg/L)	Organic Distribution Coefficient[2] (mL/g)	Henry's Law Constant[1] (atm-m^3/mol)	Water Solubility[1] (mg/L)	Free Air Diffusion Coefficient[1] (m^2/day)
Methanol	3	0.014	0.0001937	1,000,000	1.296
Glutaraldehyde	300	0.07	0.0000108	85,500,000	0.096
Chloride	18,135[3]	1	1E-20	360,000[4]	1E-20

Although the drilling muds are conceptualised as stabilised with native soils, the unblended drilling mud concentrations have been used in the modelling.

The vadose zone is simulated as a homogeneous, isotropic horizon with the same physical properties throughout the layer. The depth to groundwater is estimated as 50 m bgl.

The behaviour of three constituents were simulated. An example of the input parameters for chloride is provided in **Table 4-6**.

Table 4-6 Chloride VLEACH Input Parameters

Input Parameter	Value	Unit
Number of polygons	1	-
Timestep	1	years
Simulation time	50	years
Output time interval	1	years
Profile time interval	1	years
K_{oc}	1	mL/g
Henrys constant	$1x10^{-20}$	dimensionless
Water solubility	218,284	mg/L
Free air diffusion coefficient	$1x10^{-20}$	m^2/day
Area	10.76	$feet^2$
Vertical cell dimension	164.05	feet
Initial Recharge rate	5	feet/year
Dry bulk density	1.6	g/cm^3
Effective porosity	0.4	dimensionless
Initial Volumetric water content	0.17	%
Soil organic carbon content	0.001	fraction
Concentration of recharge water	18,135	mg/L
Upper boundary condition for vapour	0	mg/L
Lower boundary condition for vapour	0	mg/L
Cell number	50	-
Total Plot time	50	years
Initial contaminant concentration	27,656,932	µg/kg

The VLEACH model results for each chemical constituent are presented in **Figure 4-3** and **Figure 4-4**

[2] GSI Chemical Properties Database (http://www.gsi-net.com/en/publications/gsi-chemical-database.html)
[3] Calculated from sodium chloride concentration in drilling mud fluids of 29,900 mg/L
[4] http://srdata.nist.gov/solubility/index.aspx

The results indicate that the organic constituents (methanol and glutaraldehyde) take approximately 100 years to move 20 m through the vadose zone sub-surface. Concentrations are very low once below 20 m depth.

Chloride has been simulated as a conservative species. Two input parameters were varied, volumetric water content (VWC) and recharge rate. The VWC affects the migration through the vadose zone by diluting the constituent and lowering the mass that could potentially reach the water table. The recharge rate increases the constituent migration and reduces the time taken to reach steady state conditions. The values of 17% VWC and a recharge rate between 0.1 and 0.5 m/yr are considered to be conservative values to represent the entire vadose zone and the vadose zone is expected to be drier especially at shallow depths. The time taken to reach steady-state conditions is therefore likely to be in excess of 20 to 50 yrs. The steady state concentration of chloride that could potentially discharge to groundwater is estimated as 29 mg/L[5] which is below the aesthetic criteria for drinking water.

[5] Calculated using a steady state chloride concentration of 18 ug/kg and a bulk density of 1.6 g/cm^3

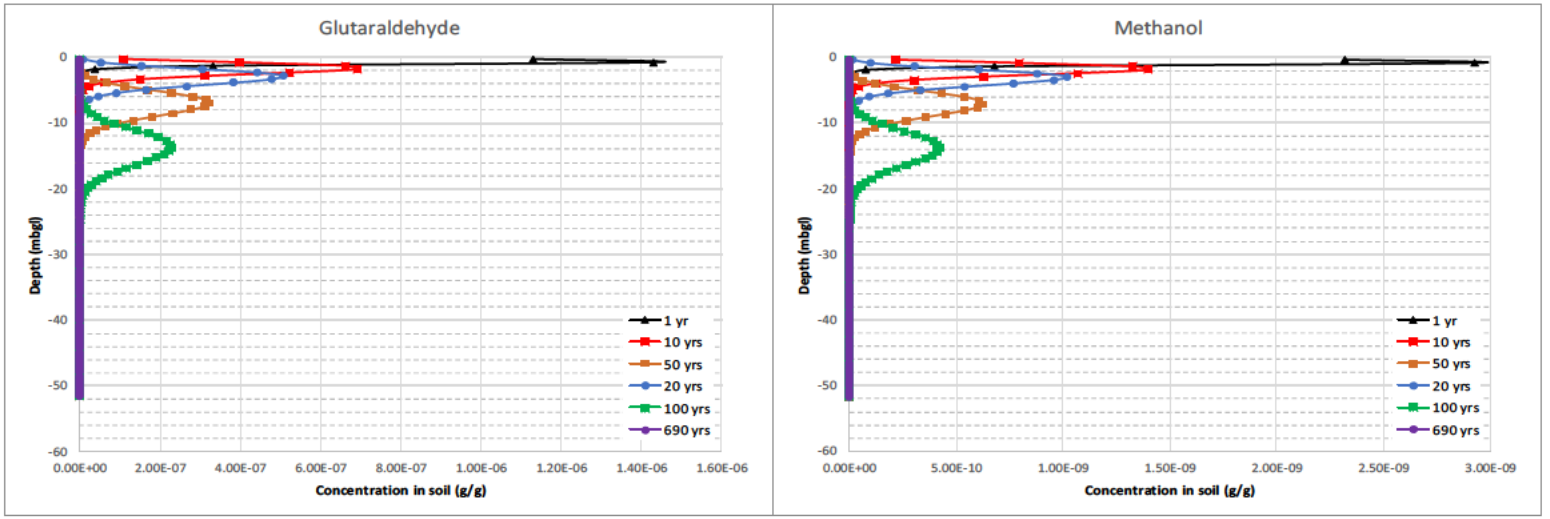


Figure 4-3 VLEACH Results – Organic Constituents

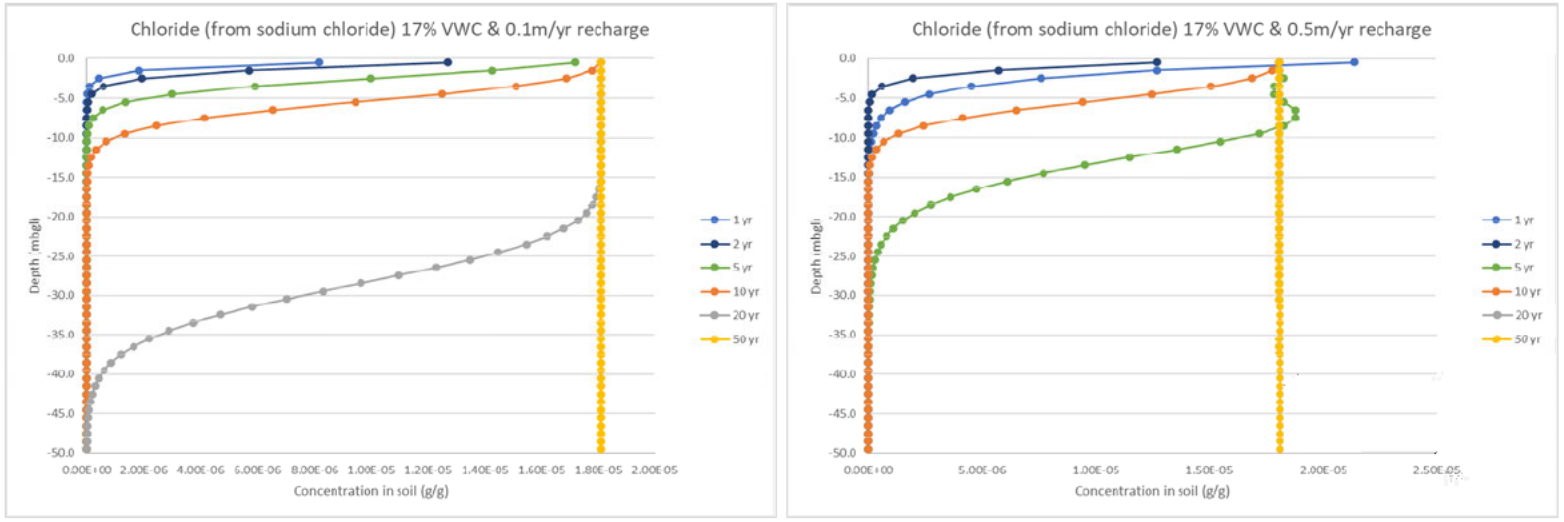


Figure 4-4 VLEACH Results – Chloride

5 Discussion

The results of this assessment present a very conservative estimate of the potential impacts to surface environmental receptors and groundwater. Its conservatism is inherent in the assumption that some of the scenarios considered that no risk mitigation measures were adopted and that the water releases were catastrophic.

In the context of smaller scale releases outside of the bunded area, this assessment indicates that spills of 1,000 L and 100,000 L, would only migrate a radial distance of 6 m and 124 m respectively, with the maximum area of impact being 4.7 ha. This also assumes flow over relatively impermeable siltstone.

In the context of potential impact to groundwater via infiltration, modelling using both Green and Ampt (1911) and Darcy's equations (1856) (to assess unsaturated and saturated soils) has been conducted based on highly conservative assumptions. It has been determined that water would take 158 years (through siltstone/clay/basalt) and 115 days if the surficial sequence is consistent with limestone/permeable sandstone to reach groundwater at a depth of approximately 50 m below ground level. However, the modelling does not consider the capacity of the formation to retain water. In this context and based on the finite volume of water in the compound, it is not anticipated that a single release would infiltrate to groundwater. Assuming the ground remained saturated (via an undetected consistent leak), water will take approximately 80 years to move through the initial 50 m (siltstone/clay/basalt) or approximately 30 days if the sub-surface was equivalent to a limestone or permeable sandstone.

The results of the VLEACH modelling indicate that the modelled organic constituents (methanol and glutaraldehyde) take a very long time to move through the sub-surface and organic concentrations are likely to be less than 1 x 10^{-7} g/g once below 20 metres depth. Note that both methanol and glutaraldehyde are readily biodegradable, and it is likely that these constituents would completely decompose within the predicted 100 years that it would take infiltration to reach 20 m depth[6]

Chloride concentrations are estimated to take a minimum of 20 years to reach steady state concentrations under a conservative scenario. The steady state concentration of chloride that could potentially discharge to groundwater is estimated as 29 mg/L[7] which is below the aesthetic criteria for drinking water. Further, assuming that there actually is a complete infiltration pathway that would allow chloride to reach groundwater at these concentrations, these concentrations would occur over a very localised area, and further dilution would readily occur in groundwater.

[6] Half-lives of glutaraldehyde and methanol vary depending on the biodegradation environment, but are on the order of days. Half-lives for glutaraldehyde have been measured at 7.7 and 10.6 hours in anaerobic and aerobic aquatic environment metabolism tests, respectively. Half-lives for methanol have been measured at approximately 5 days based on aerobic and anaerobic soil tests. (EHS Support, 2023)

[7] Calculated using a steady state chloride concentration of 18 ug/kg and a bulk density of 1.6 g/cm^3

6 Limitations

EHS Support Pty Ltd (EHS Support) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of inGauge and only those third parties who have been authorised in writing by EHS Support to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 20 September 2023.

The methodology adopted and sources of information used by EHS Support are outlined in this report. EHS Support has made no independent verification of this information beyond the agreed scope of works and EHS Support assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to EHS Support was false.

This report was prepared in December 2021 and is based on the information reviewed at the time of preparation. EHS Support disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

This report contains information obtained by inspection, sampling, testing or other means of investigation. This information is directly relevant only to the points in the ground where they were obtained at the time of the assessment. The borehole logs indicate the inferred ground conditions only at the specific locations tested. The precision with which conditions are indicated depends largely on the frequency and method of sampling, and the uniformity of conditions as constrained by the project budget limitations. The behaviour of groundwater and some aspects of contaminants in soil and groundwater are complex. Our conclusions are based upon the analytical data presented in this report and our experience. Future advances in regard to the understanding of chemicals and their behaviour, and changes in regulations affecting their management, could impact on our conclusions and recommendations regarding their potential presence on this site.

Where conditions encountered at the site are subsequently found to differ significantly from those anticipated in this report, EHS Support must be notified of any such findings and be provided with an opportunity to review the recommendations of this report.

Whilst to the best of our knowledge information contained in this report is accurate at the date of issue, sub-surface conditions, including groundwater levels can change in a limited time. Therefore, this document and the information contained herein should only be regarded as valid at the time of the investigation unless otherwise explicitly stated in this report.

7 References

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