Human Health and Ecological Risk Assessment – Hydraulic Stimulation Activities, Gloucester Gas Project

Prepared for : AGL Upstream Investments Pty Ltd

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Document History and Status

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Limitations

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Section 1 Introduction

1.1 General

Environmental Risk Sciences Pty Ltd (enRiskS) has been commissioned by AGL Upstream Investments Pty Ltd (AGL) to undertake a human health and ecological risk assessment (HHERA) for its hydraulic fracture stimulation activities to be undertaken within the Gloucester basin of New South Wales (NSW).

The study area comprises PEL 285 located within the Gloucester basin, NSW. The specific project to which this HHERA relates are the Waukivory pilot test wells. The existing wells are located 5 km south of Gloucester township. Activities expected to be conducted in the study area include exploration to evaluate potential gas reserves (and potential to be commercialised for delivery to gas markets) and provide more detailed geological information of the region.

The proposed activity includes the following:

- Perforating the wells at the target coal seams;
- Hydraulic fracture stimulation of the target coal seams; and
- Flowback of hydraulic fracture stimulation fluid (flowback water/fluid).

The NSW Trade & Investment Resources & Energy Code of Practice for Coal Seam Gas, Fracture stimulation activities (September 2012) requires that a Fracture Stimulation Management Plan (FSMP) be in place prior to the commencement of a fracture stimulation activity. The Code of Practice states that the FSMP should incorporate a risk assessment that meets the following requirements:

a) The FSMP must include a risk assessment complying with AS/NZS ISO 31000:2009 Risk management - Principles and Guidelines.
b) The risk assessment must identify risks associated with the fracture stimulation activity, the likelihood of each risk and the consequence of each risk.
c) The risk assessment must define appropriate management controls to ensure identified risks are constrained to acceptable levels.
d) At a minimum, the risk assessment must address risks associated with:
    i. workplace health and safety
    ii. public safety
    iii. chemical use
    iv. impacts on water resources
    v. land contamination
    vi. air pollution
    vii. noise & vibration
    viii. waste management (e.g. flowback water)
    ix. loss of well integrity
    x. induced seismicity
    xi. induced subsidence or other induced ground movements
    xii. conflicts with existing land uses

The HHERA presented in this report addresses requirements d(iii), the use of chemicals in fracture stimulation. The Code of Practice states that chemical additives used in fracture stimulation activities should be minimised as far as reasonably practicable, and should be selected and managed to minimise potential impacts on the environment. The use of additives containing BTEX (benzene, toluene, ethylbenzene and xylenes) compounds is banned in NSW. More specifically, in relation to the completion of the HHERA in relation to chemicals used in fracture stimulation activities the Code of Practice requires the identification of the following:

a) All chemicals to be injected as part of the fracture stimulation process
b) The Chemical Abstract Service (CAS) registry number for those chemicals
c) The volumes and concentrations of those chemicals
d) Potential risks to human health arising from exposure to those chemicals
e) The risk, likelihood and consequence of surface spills of these chemicals
f) Whether chemical concentrations at the point of injection will exceed:
    i. ANZECC 2000 guidelines\ for overlying groundwater and surface water uses that may be affected
    ii. ADWG 2004 if a drinking water supply may be affected
    iii. natural background concentrations if the water source is not effectively described by ANZECC or ADWG guidelines; or
    iv. if the chemical is not specified in ANZECC or ADWG guidelines and may have a toxic[6] effect, then assess whether the toxic effect is likely to exceed a trigger toxicity level determined in accordance with a suitable methodology such as those described in Section 2: OECD Guidelines for the Testing of Chemicals.
    v. The risk, likelihood and consequence of the injected chemicals affecting the beneficial use class of the target aquifer or any other aquifer
    vi. How those chemicals will be stored and managed

The HHERA presented in this report addresses the above requirements in relation to the fracture stimulation chemicals that may be used within the Gloucester Gas Project.

In addition to the above requirements the draft EPBC Act conditions in relation to the Stage 1 Gloucester Project requires the following:

1. Prior to commencement of the action, the person taking the action must provide the minister with the following details on any hydraulic fracturing agents or other reinjected fluids likely to be used:
    a) estimated number and location (mapped, and expressed in latitude, longitude and depth) of wells where the agent or fluid may be used;
    b) Chemical Abstracts Service Number;
    c) typical load;
    d) typical concentration; and
    e) toxicity as total effluent toxicity and ecotoxicity, based on methods outlined in the National Water Quality Management Strategy.

While the Waukivory Pilot test wells are not part of the Stage 1 Gloucester Gas Project and is the subject of a separate referral, this assessment will also address the requirements of the above condition above.

The assessment presented in this report only addresses chemicals associated with fracture stimulation activities. No other activities that may be undertaken in the Gloucester Gas Project have been evaluated or considered in this assessment.

1.2 HHERA Methodology

1.2.1 General Approach

The methodology adopted for the conduct of the HHERA is in accordance with the protocols/ guidelines recommended by enHealth ("*Health Impact Assessment Guidelines*" (2001) and "*Environmental Health Risk Assessment, Guidelines for Assessing Human Health Risks from Environmental Hazards*", 2012) and NEPM (Schedule B(4), "*Guideline on Health Risk Assessment Methodology*", 1999).

The framework for an ecological risk assessment is similar to the one adopted for the human health risk assessment and is consistent with guidance provided in NEPM ("*Guideline on Ecological Risk Assessment*", Schedule B(5)) and in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000).

In addition to the above the assessment has also considered the following:

- Methods for the calculation of drinking water guidelines as outlined in the National health and Medical Research Council, Australian Drinking Water Guidelines (NHMRC 2011).
- Methods for the assessment of toxicity in as outlined in the National Water Quality Management Strategy, as outlined in Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000).

These guidance documents have been endorsed by the NSW EPA for the conduct of HHERA's in NSW.

The HHERA presented in this report is primarily a qualitative assessment. The above guidance provides the basis for conducting both qualitative and quantitative assessments, however the guidance is more focused on quantitative evaluations. To assist in the qualitative evaluation of risk, a risk matrix approach has been adopted to assist in the ranking of key risk issues that need to be considered in evaluating the hydraulic fracture stimulation chemicals and activities.

The approach adopted is generally consistent with the requirements presented in Australian Standard/New Zealand Standard (AS/NZS) 4360:2004: Risk Management and AS/NZS ISO 31000:2009 Risk management - Principles and Guidelines, with some modification of the qualitative definitions to ensure they are relevant to the HHERA proposed.

This HHERA has considered the key aspects set out in Sections 1.2.2 to 1.2.5 in relation to the use of chemicals in hydraulic fracture stimulation activities.

1.2.2 Risk Issues

This general review is aimed at providing a general evaluation of the key aspects, relevant to the chemicals assessed, that affect the potential for exposures by humans or ecological receptors to occur. In relation to hydraulic fracture stimulation activities the risk issues that warrant consideration relate to:

- operational risks associated with the storage, handling and use of the chemicals; and
- human health and environmental risks associated with the potential for the surrounding environment, including humans, to be exposed to chemicals used during hydraulic fracture stimulation activities.

1.2.3 Consequence or Hazard

On the basis of the available information on the chemicals evaluated in this assessment, hazards associated with the chemicals have been evaluated with the potential for consequences to be of significance identified. The following aspects have been considered in this evaluation:

- Concentrations at the point of injection;
- Chemical and physical properties – evaluated in conjunction with other aspects below;
- Fate and transport in groundwater – presents consideration of the potential for the chemicals to have negligible, low, medium, high or very high potential to migrate to and move with groundwater, be persistent in the environment, bioaccumulate in aquatic species and/or the food chain;
- Human Toxicity – presents consideration of the potential for the chemicals to result in negligible, low, medium, high or severe acute and chronic human health effects that are relevant to operational exposures (in particular occupational) and offsite environmental environmental exposures;
- Ecological Toxicity – presents consideration of the potential for the chemicals to result in negligible, low, medium, high or severe toxicity to aquatic species.

On the basis of these properties, the following presents a summary of the categories and ranking system identified for the purpose of conducting a qualitative evaluation of potential consequences of exposure, both operational and environmental exposures.

Table 1 Summary of Consequence Categories and Ranking System

Rank	Consequence Descriptor	Occupational Exposures	Environmental Exposures		
			Potential for Off-Site Impacts – Fate and Transport	Off-Site Impacts to Human Health	Off-Site Impacts to the Ecosystem
1	**Negligible**	Generally low potential for adverse health effects during storage and handling	Chemical degrades rapidly under all conditions, is not bioaccumulative or taken up into the food chain	No adverse long-term health effects associated with low level environmental exposures	Negligible potential for adverse effects on aquatic ecosystem
2	**Low**	Minor nuisance effects such as odours, transient irritation effects, requires low level PPE	Chemical is somewhat mobile, degrades slowly (or only under some conditions), is not bioaccumulative or taken up into the food chain	Minor transient health effects or odour	Low potential for adverse effects on aquatic ecosystem
3	**Moderate**	Transient effects that may require medical treatment such as respiratory effects, more significant irritation effects that need to be managed with moderate level PPE	Chemical is mobile, degrades slowly, is not bioaccumulative or taken up into the food chain	Transient effects that may require medical treatment such as respiratory effects, more significant irritation	Moderate potential for adverse effects on aquatic ecosystem
4	**High**	Permanent health effects that require extended medical treatment and/or permanent disability and require a high level of PPE, monitoring and management	Chemical is mobile, persistent, has the potential for low to moderate bioaccumulation in aquatic species or food chain	Permanent health effects that require extended medical treatment and/or permanent disability	High potential for adverse effects on aquatic ecosystem
5	**Severe**	Death or significant injury likely to result in death - not to be used	Chemical is mobile, persistent, has the potential for high to very high bioaccumulation in aquatic species or food chain	Death or significant injury likely to result in death	Very high potential for significant adverse effects (including death of significant proportion of receptors) in ecosystem

1.2.4 Likelihood

The next step is to determine the likelihood of the hazard (i.e. exposure occurring at the receptor that may include human or ecological receptors) occurring. While the assessment of likelihood also needs to consider more site-specific aspects, more general information on hydraulic fracture stimulation activities is considered sufficient to provide a general measure of likelihood. The likelihood measure is only considered in the evaluation of environmental exposures as these exposures are dependent on the fate and transport of chemicals in the environment. The likelihood of occupational exposures (by workers involved in hydraulic fracture stimulation activities) are directly managed through the implementation of appropriate workplace health and safety policies and plans. These policies and plans are implemented and monitored by AGL and the principal contractor which results in the likelihood of occupation exposures occurring being managed at a level where such exposures are always considered to be highly unlikely. The assessment presented here has been used to identify those chemicals used in hydraulic fracturing activities that require more significant levels of protection under the occupational health and safety plan.

The measure is split into five descriptors ranging from hazards that are considered 'Very Likely' to hazards that would be considered 'Highly Unlikely' as outlined in **Table 2**.

Table 2 Summary of Likelihood Categories and Ranking System

Rank	Descriptor	Likelihood of Exposure
1	Highly unlikely	No connection between coal seam and receiving environment and management measures in place to prevent surface spills – i.e. there is no pathway of exposure
2	Unlikely	Unlikely connection between coal seam and receiving environment, no extraction and use of aquifers for any purpose. Unlikely for any surface spills to reach receiving environment.
3	Possible	Possible connection between coal seam and receiving environment, possible extraction and use of aquifer. Possible that surface spills to reach receiving environment.
4	Likely	Likely connection between coal seam and receiving environment, potential use of aquifer or discharge to ecosystem. Likely that surface spills to reach receiving environment.
5	Very likely	Confirmed connection between coal seam and receiving environment, confirmed use of aquifer or discharge to ecosystem. Very likely (confirmed) that surface spills to reach receiving environment.

1.2.5 Qualitative Characterisation of Risk

The final step in assessing hazard and risk is to combine the potential likelihood (of exposure occurring for a receptor) and consequences determined using the above ranking system and descriptors to evaluate the level of overall risk. The approach adopted in this HHERA is based on a qualitative risk matric approach generally consistent with AS 4360:2004 and AS/NZS ISO 31000:2009, where the following risk matrices have been considered for occupational and environmental risk issues.

Table 3 Matrix Adopted to Characterise Occupational Risk Issues

	Consequence				
	Negligible	Low	Moderate	High	Severe
Acute Hazards Associated with Storage and Use of Chemical	Generally low potential for adverse health effects during storage and handling	Minor nuisance effects such as odours, transient irritation effects, requires low level PPE	Transient effects that may require medical treatment such as respiratory effects, more significant irritation effects that need to be managed with moderate level PPE	Permanent health effects that require extended medical treatment and/or permanent disability and require a high level of PPE, monitoring and management	Death or significant injury likely to result in death - not to be used
	1	2	3	4	5

Table 4 Matrix Adopted to Characterise Environmental Risk Issues

				Consequence				
				Negligible	Low	Moderate	High	Severe
	Potential for Off-Site Impacts - Fate and Transport			Chemical degrades rapidly under all conditions, is not bioaccumulative or taken up into the food chain	Chemical is somewhat mobile, degrades slowly (or only under some conditions), is not bioaccumulative or taken up into the food chain	Chemical is mobile, degrades slowly, is not bioaccumulative or taken up into the food chain	Chemical is mobile, persistent, has the potential for low to moderate bioaccumulation in aquatic species or food chain	Chemical is mobile, persistent, has the potential for high to very high bioaccumulation in aquatic species or food chain
				1	2	3	4	5
	Off-Site Human Health Issues (chronic)			No adverse long-term health effects associated with low level environmental exposures	Minor transient health effects or odour	Transient effects that may require medical treatment such as respiratory effects, more significant irritation	Permanent health effects that require extended medical treatment and/or permanent disability	Death or significant injury likely to result in death
				1	2	3	4	5
	Off-Site Impacts to Aquatic Ecosystem			Very low potential for adverse effects on aquatic ecosystem	Low potential for adverse effects on aquatic ecosystem	Moderate potential for adverse effects on aquatic ecosystem	High potential for adverse effects on aquatic ecosystem	Very high potential for significant adverse effects on aquatic ecosystem
				1	2	3	4	5
				Negligible	Low	Moderate	High	Severe
Likelihood of Exposure at Receptor	Confirmed connection between coal seam and receiving environment, confirmed use of aquifer or direct discharge to environment/ecosystem	very likely	5	N	L	M	H	E
	Likely connection between coal seam and receiving environment, potential use of aquifer or discharge to local environment/ecosystem	likely	4	N	L	M	H	E
	Possible connection between coal seam and receiving environment, possible use of aquifer, limited management measures in place to prevent surface spillage (hence possible for surface spills to reach environment)	possible	3	N	L	M	M	H
	Unlikely connection between coal seam and a receiving environment, no use of aquifers for any purpose, management measures in place that make spills at ground surface unlikely	unlikely	2	N	L	L	L	L
	No connection between coal seam and receiving environment and management measures in place to prevent surface spills	highly unlikely	1	N	N	N	N	N

Table 5 Risk Outcomes

Rank	Description
N	Negligible risk - no adverse impacts
L	Low risk - potential for impacts is very low and potential for impacts to result in adverse effects is low. Risk issues identified can be effectively managed through implementation of appropriate management measures.
M	Medium risk - risk considered to be higher than identified in low risk category, risks should be quantified and management may be required
H	High risk - potential for significant exposures that have the potential to exceed acceptable risk levels for human health or ecological environments
E	Extreme risk - significant heath and/or ecological effects may occur

1.3 Study Area

The study area is located within PEL 285 located within the Gloucester basin, NSW (refer to **Figure 1**). Activities expected to be conducted in the study area include exploration to evaluate potential gas reserves (and potential to be commercialised for delivery to gas markets) and provide more detailed geological information of the region.

- The exploration process is defined by AGL in four main stages:
- Identifying prospects and leads through geological & geophysical desktop studies;
- Identifying hydrocarbon accumulations through the drilling of core and stratigraphic holes;
- Evaluating the potential size of the discovery through geophysical surveys such as seismic, magnetics, gravity and further core and stratigraphic drilling where necessary; and
- Evaluating the deliverability and commerciality of the discovery by gas flow testing to enable reserves certification and ultimately commercial project development investment decisions.

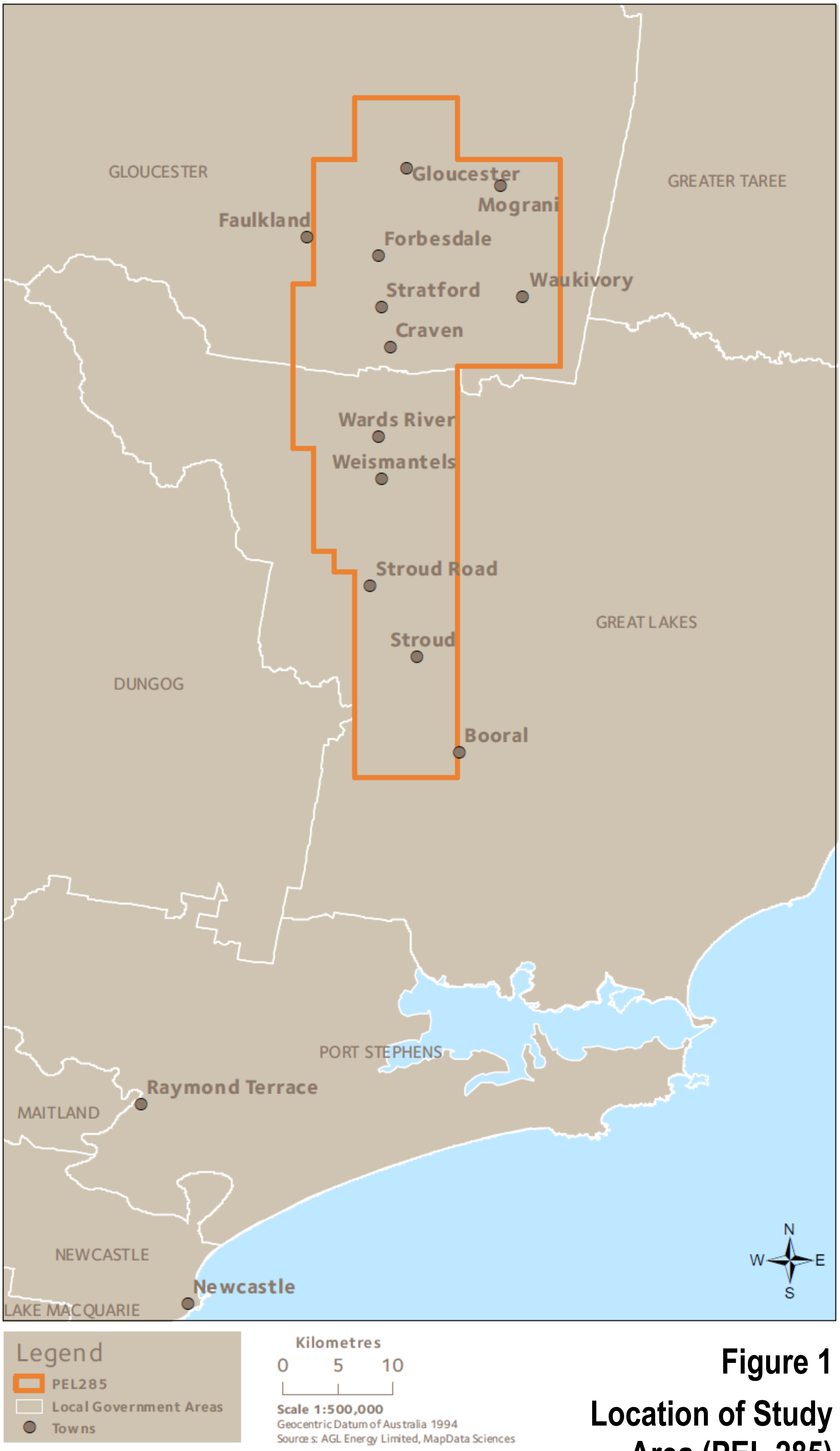
Core holes are drilled to identify and test gas saturation, composition and content. Seismic surveys are carried out to gather more regional information about the size, structure and geology of an area. Pilot wells and production testing determine the deliverability and flow rates of the gas reserves.

Once the preferred geological target areas have been identified, the site selection process then considers the environmental and social constraints of the area. These include community impacts, land use (existing and future), topography, subsurface geology, groundwater, water management, flora and fauna, archaeology, noise and traffic. This detailed design information becomes part of the environmental assessment and approvals process for the proposed exploration drilling activities.

The proposed fracture stimulation and pilot testing sites are located greater than 40m from any major watercourse or 20m from minor watercourse or drainage lines.

The current and proposed operations are in semi-rural or rural areas (also used for open cut coal mining operations) within the PEL, with most of the work proposed to be conducted on existing agricultural lands, predominantly used for beef cattle grazing.

The exploration holes proposed in this area are targeting the Gloucester Coal Measures.



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Geocentric Datum of Australia 1994
Sources: AGL Energy Limited, MapData Sciences

DATE PRODUCED: DECEMBER 2012

Figure 1

Location of Study Area (PEL 285)

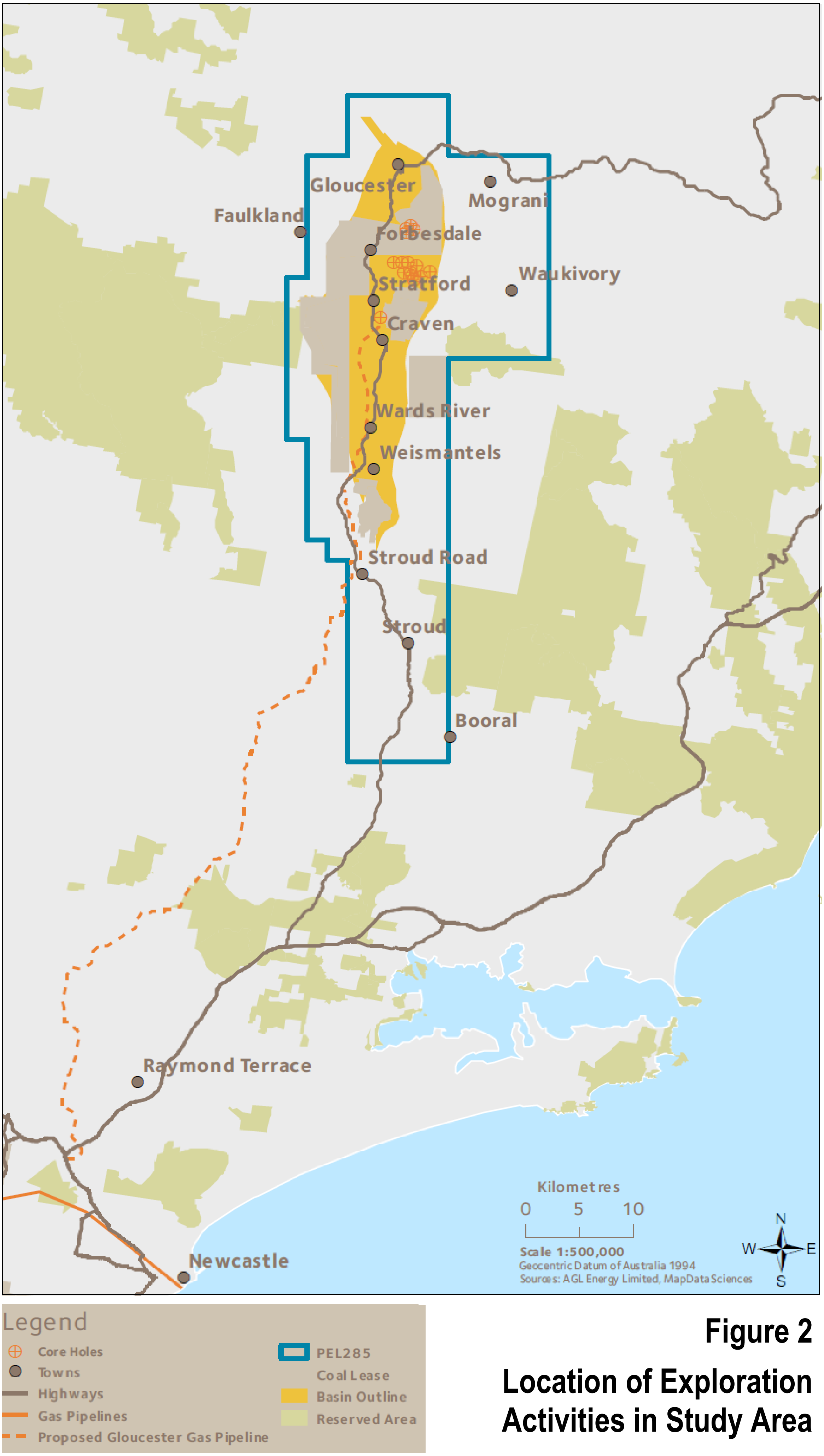

Figure 2

Location of Exploration Activities in Study Area

1.4 Geology

The coal seam methane resources in the study area are contained within rocks of Permian age.

The Gloucester Basin is divided up into three major stratigraphic units: the Alum Mountain Volcanics, the Dewrang Group and the Gloucester Coal Measures. The Dewrang Group and the Gloucester Coal Measures contain 15 laterally extensive coal units and represent the main coal seam gas targets.

Exploration activities in the study area are expected to target the Gloucester Coal Measures, which are located at depths from surface to over 1000m. Gas content of the coal is commonly of the order of 1-20m^3/tonne with gas content increasing with depth. However not all the coal seams may be suitable for gas production due to low permeability, but the location and distribution of relatively high and low permeability zones is poorly known at present. The presence of large basin wide thrust faulting may be a contributing factor.

The stratigraphy of the Gloucester basin is presented in **Figure 3** *(from* Lennox, M., 1991[1]*)*.

The Gloucester Basin is a north south trending synclinal shaped trough containing Permian volcanics and sediments. Basement comprises Carboniferous sedimentary rocks and volcanic units. The basin sequence is capped by Late Permian fluvial-deltaic sediments of the Dewrang Group and Gloucester Coal Measures. The top of the Permian section has been exposed to erosion.

Throughout the evolution of the Gloucester Basin, sandstones, mudstones, conglomerates and coals were deposited in fault-controlled troughs. The preserved basin stratigraphy is up to 4000m thick. Widespread Early Permian volcanic activity may be related to thermal upwelling beneath the base of the continental lithosphere in a retroarc basin setting. Due to the Late Permian fall in relative sea level, shallow water and fluvial conditions prevailed. The complex interplay of tectonics extensional faulting, high rates of sediment supply produced significant lateral stratigraphic variability throughout the Gloucester Basin.

The Gloucester Basin exhibits a complex structural history. Early normal and syn-depositional faults occur and in many cases have been reactivated by the later Hunter-Bowen orogenic events. The Gloucester Basin displays steep dips of up to 80° on its flanks, dipping towards the north-south trending basin axis and relatively flattening towards the centre of the basin. The basin is dissected by several major thrust structures.

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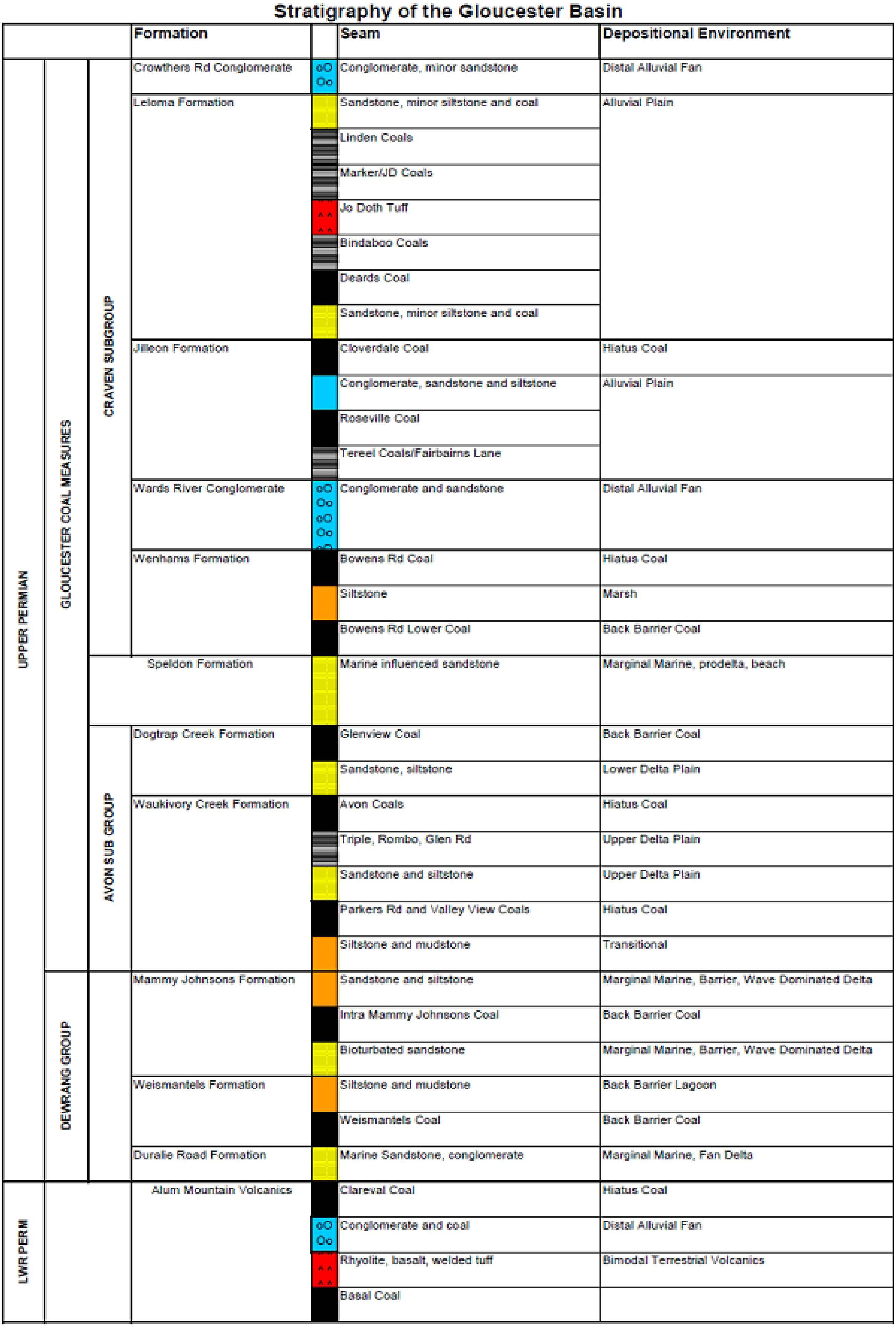
[1] Unpublished reference.



Stratigraphy of the Gloucester Basin

			Formation		Seam	Depositional Environment
UPPER PERMIAN	GLOUCESTER COAL MEASURES	CRAVEN SUBGROUP	Crowthers Rd Conglomerate	oO Oo	Conglomerate, minor sandstone	Distal Alluvial Fan
			Leloma Formation	🟨	Sandstone, minor siltstone and coal	Alluvial Plain
				▤	Linden Coals	
				▤	Marker/JD Coals	
				^ ^ ^ ^	Jo Doth Tuff	
				▤	Bindaboo Coals	
				⬛	Deards Coal	
				🟨	Sandstone, minor siltstone and coal	
			Jilleon Formation	⬛	Cloverdale Coal	Hiatus Coal
				🟦	Conglomerate, sandstone and siltstone	Alluvial Plain
				⬛	Roseville Coal	
				▤	Tereel Coals/Fairbairns Lane	
			Wards River Conglomerate	oO Oo oO Oo	Conglomerate and sandstone	Distal Alluvial Fan
			Wenhams Formation	⬛	Bowens Rd Coal	Hiatus Coal
				🟧	Siltstone	Marsh
				⬛	Bowens Rd Lower Coal	Back Barrier Coal
		Speldon Formation		🟨	Marine influenced sandstone	Marginal Marine, prodelta, beach
		AVON SUB GROUP	Dogtrap Creek Formation	⬛	Glenview Coal	Back Barrier Coal
				🟨	Sandstone, siltstone	Lower Delta Plain
			Waukivory Creek Formation	⬛	Avon Coals	Hiatus Coal
				▤	Triple, Rombo, Glen Rd	Upper Delta Plain
				🟨	Sandstone and siltstone	Upper Delta Plain
				⬛	Parkers Rd and Valley View Coals	Hiatus Coal
				🟧	Siltstone and mudstone	Transitional
	DEWRANG GROUP		Mammy Johnsons Formation	🟧	Sandstone and siltstone	Marginal Marine, Barrier, Wave Dominated Delta
				⬛	Intra Mammy Johnsons Coal	Back Barrier Coal
				🟨	Bioturbated sandstone	Marginal Marine, Barrier, Wave Dominated Delta
			Weismantels Formation	🟧	Siltstone and mudstone	Back Barrier Lagoon
				⬛	Weismantels Coal	Back Barrier Coal
			Duralie Road Formation	🟨	Marine Sandstone, conglomerate	Marginal Marine, Fan Delta
LWR PERM			Alum Mountain Volcanics	⬛	Clareval Coal	Hiatus Coal
				oO Oo	Conglomerate and coal	Distal Alluvial Fan
				^ ^ ^ ^	Rhyolite, basalt, welded tuff	Bimodal Terrestrial Volcanics
				⬛	Basal Coal	

Figure 3 Stratigraphy of Gloucester Basin

1.5 Surface Water and Groundwater

The study area is located within the Hunter-Central Rivers Catchment Management Area (CMA) which covers an area of approximately 22000 square kilometres. It is the Manning River Catchment that is the main coastal catchment within which the project activities will be undertaken. The main sub-catchment is the Avon River catchment immediately to the south of Gloucester. The Gloucester River and the Barrington River join with the Avon River just downstream of Gloucester. Pumps on the Barrington River are the water supply source for Gloucester. The catchment receives the majority of its rainfall in December and January with areas subject to localised intermittent flooding and drought periods throughout the year.

The Manning River catchment is regulated by the Water Sharing Plan for the Lower North Coast Unregulated and Alluvial Water Sources authorised under the *Water Management Act 2000.* This plan is the relevant water sharing plan for all unregulated water sources in the Karuah and Manning River catchments. The Plan includes the unregulated rivers and creeks, alluvial groundwater (which are above the tidal limit), and the tidal pool areas (which have not be previously covered by the *Water Act 1912*).

Groundwater resources within NSW are governed by Water Sharing Plans (WSPs) as administered under the *Water Management Act 2000* or where no Water Sharing Plans are established, by the *Water Act 1912*. The Water Sharing Plan for the Lower North Coast Unregulated and Alluvial Water Sources (noted above) is the relevant plan that covers alluvial water sources within the region. There is no WSP for the underlying porous rock groundwater systems at this time.

The level of connectivity, the relative level of impact and the timing of connection have been considered in developing both the unregulated river and the associated groundwater sharing plans for the area. For the purposes of water sharing, aquifer types have been grouped into four basic categories:

- Porous rock aquifers found in rock formations such as sandstone or limestone (soft sedimentary rocks). Groundwater occurs within the pore space within the rock matrix;
- Fractured rock aquifers found in rock formations such as granite or basalt (igneous or metamorphic rocks). Groundwater in these rocks occurs mainly within the fractures and joints;
- Coastal sand aquifers, where groundwater is contained in the pore spaces in the unconsolidated sand sediments; and
- Alluvial aquifers, where groundwater is contained in the pore spaces in the unconsolidated floodplain material.

Alluvial aquifers and coastal sand aquifers are generally of high value water resource that occurs in most areas of Australia and are predominantly used for irrigation, town, stock and domestic uses. Alluvial aquifers are generally shallower than sedimentary and fractured rock aquifers and water levels often fluctuate due to varying recharge and pumping rates. Being near surface with shallow water tables, there is a higher potential for alluvial and coastal sand aquifers to be susceptible to surface contamination and pollution.

The project area where exploration is proposed is mostly underlain by Gloucester Coal Measures. There are thin alluvial sediments along the Avon River and major tributaries such as Waukivory Creek. The alluvial sediments are shallow (less than 12m depth) and thin (compared to downstream alluvium along the Manning River alluvium) and have low yields and variable water quality. This aquifer is rarely used by local farmers because of reliable surface water sources. Recharge of the alluvial aquifer is predominantly from direct surface infiltration from rainfall, flood recharge, runoff from catchment areas with only a small contribution from bedrock aquifers. Groundwater quality in the alluvial aquifers ranges from fresh-brackish (typically at the top of the aquifer where recharge is from rainfall and flood recharge) to salty (typically from the underlying Permian strata).

Groundwater in the Permian sedimentary (porous) rocks across the Gloucester basin is a low value water resource and is rarely used for agricultural and other consumptive uses. If used it is mostly for limited stock and industrial water use. Rock permeabilities are generally low, aquifers are mostly bedding and fracture zones within the uppermost 75m, bore yields in rocks and fracture zones are very low and water quality is generally brackish to slightly saline.

On a more local scale, maximum drilling depth for water bores is typically up to 75 metres, however the depth of target coal seams to be fracture stimulated are approximately 300 - 1000 metres. Therefore this risk assessment focuses on the beneficial groundwater resources that are drilled through and isolated by these wells within the porous bedrock formations that underlie the project area.

In addition, early testing programs at Stratford suggested there was negligible connectivity between shallow aquifer zones and water bearing zones as a result of these extensive flow testing programs of the deep CSG coal seam targets.

Hence limited connectivity is expected between the more shallow groundwater (alluvial groundwater) and groundwater in the target Gloucester Coal Measures at the Waukivory pilot sites.

The local hydrogeology (including depth and quality of aquifers) are assessed as part of the environmental assessment and permitting process for each pilot test well.

1.6 Receiving Environment

The Gloucester Gas Project covers a large area that is utilised for a range of land uses. This includes rural and semi-rural areas and some rural township areas. Hence there is the potential for the general public who live and/or work within and adjacent to the study area to be exposed to chemicals used in CSG operations should they be present in surface water (creeks, local rivers and local dams), soil and groundwater. Groundwater resources in the study area comprise fresh to brackish water aquifers in the upper alluvial formations. These aquifers have the potential to be used for a range of limited beneficial uses that are likely to include stock watering, and some domestic purposes with some baseflow returns to the Avon River. The aquifers are not suitable for drinking water. There is the expectation in the local community that these shallow beneficial aquifers remain suitable for all these uses. The deeper water bearing zones in the coal measure rocks contain slightly saline water with very limited beneficial uses (being some stock and industrial applications). There is much less reliance on this water source.

The pilot test area comprises a wide range of terrestrial environments and aquatic environments (that are evaluated by AGL during the Environmental Assessment stage for the exploration activities). If chemicals used in the CSG operations have the potential to discharge into these environments then there may be the requirement to conduct more detailed evaluation of potential impacts. However this would only be relevant if there was a sufficiently elevated level of risk identified for these receptors.

Section 2 Hydraulic Fracturing Operations

2.1 General Description of Hydraulic Fracturing

CSG occurs in pore spaces/voids (cleats) commonly found in coal that is present as a series of interbedded layers within a thicker more variable layer of rock types that include sandstones, siltstones, mudstones and shales. The pore spaces within the coal rock mass are made up of fracture, joint plane and micro-fracture voids that impart a generally low permeability characteristic to the coal; limiting coal formation water flow under natural conditions. The procedure of CSG extraction involves the drilling of a series of production wells into the targeted coal seams and pumping out the coal formation water within the coal layers. This lowers the hydraulic pressure in the coal layers and allows desorption (release) of methane from the coal matrix. This methane gas is then free to flow towards the production well.

Hydraulic fracture stimulation has been used in the oil and gas industry since the 1950's as a technique for enhancing production. The basic premise behind fracturing is that is places a region of artificially high permeability within the formation from which fluid and/or gas is to be produced. It is particularly effective in formations with low-permeability. Hydraulic fracturing has evolved into a technique suitable to stimulate most wells under extremely varying circumstances. (Economides 2007).

Fracture stimulation creates a more efficient flow path for the CSG thereby increasing its production. Increasing the CSG produced by each well facilitates:

- Reduction in the number of wells required for drilling and production
- Minimising the surface or visual impact of the project
- Increasing the reservoirs economic lifetime
- Increases in the recoverable reserve.

The methodologies adopted by AGL encompass the life cycle of a hydraulic fracture stimulation, from planning to post-job monitoring.

During a hydraulic fracturing stimulation treatment, fluid is pumped down the wellbore into individual or small groupings of coal seams which have been selected and isolated from all other formations. The fluid being forced into the formation increases in pressure as it encounters resistance to flow through the formation. When the fluid pressure building in the formation generates a stress that is greater than the stress required to fracture the formation, a fracture is created. Coal formations contain existing fractures referred to as cleats. When hydraulically fracture stimulating a coal seam, the fracture often follows an existing cleat or pathway into the coal reservoir.

As pumping continues, the fracture extends from the wellbore and grows. Once the desired geometry of the fracture is created, proppant (fine grained sand) is added to the fluid and pumped into the fracture. When all the proppant is placed in the fracture, pumping is stopped. The pressure inside the fracture drops and the stress in the formation reduces such that the fracture closes. The closing fracture traps the proppant inside the formation and helps to maintain a permeable and conductive path through the formation to the wellbore. The permeable path left in the formation is the main objective of the fracture stimulation treatment. This proppant filled flow path enhances production by allowing CSG formation water and gas to flow from the formation to the wellbore with minimised resistance.

It is important to emphasise that the fracture stimulation initiates at the targeted coal seam/s and enhanced fractures do not migrate vertically to insect shallow aquifers or surface water resources, and fracture stimulation fluids are flowed back after the stimulation process. Consequently there are no exposure pathways for fracture stimulation fluids to enter groundwater systems particularly the shallow aquifers used for different consumptive uses. Typical hydraulic fracturing stimulations for AGL create fractures that are estimated to be 5-20 millimetres wide and extend laterally (fracture stimulation length) for 20 to 60 metres perpendicular to the minimum stress direction within the coal seam. The height of the fracture may vary but fractures are typically contained within the coal seam. The sealing rocks above and below the coal seam, which are significantly harder than the coal, limit the vertical height growth of the fracture

As discussed in **Sections 1.4 and 1.5** the Gloucester Gas Project operations primarily target the Gloucester Coal Measures that are at a depth that is below local and regional groundwater aquifers that may be used for a range of purposes that include irrigation and livestock. During the current exploration campaign, AGL will be using geophone monitoring data acquisition to monitor fracture growth geometry to confirm that it will not impact on these groundwater aquifers. In addition, the exploration well construction methodology (which must comply with DTIRIS – Minerals guidelines including Code of Practice for Coal Seam Gas – Well Integrity, industry best practice and the Water Act (1912) and the “Minimum Construction Requirements for Water Bores in Australia Ed 3” (NUDLC 2012)) adopted prevents the vertical interconnection of groundwater aquifers with deeper water bearing zones. The well construction does this by providing four barriers (two steel and two pressure-tested cement) between water from the CSG producing zones and groundwater aquifers.

It is an important aspect of the risk assessment that the aquifers of concern (that are relevant to the assessment of human health or environment risk issues) are identified and the potential for hydraulic connectivity between the target formation and the aquifers of concern is evaluated. The AGL Surface and Groundwater Management Sub Plan for the Waukivory pilot provides further detail on the groundwater monitoring program that has been implemented prior to fracture stimulation commencing, including establishment of a dedicated groundwater network and associated monitoring program to protect the shallowest aquifers used for water supply across the area.

2.2 Description of AGL Operations

2.2.1 Drilling Techniques

AGL employs multiple techniques to enhance gas production from its CSG operations; horizontal drilling, open-hole completions, under-reaming, cavitation and hydraulic fracture stimulation. The stimulation or production enhancement technique used depends on the properties of the coal reservoir, and the number of targeted coal seams in a well. Within AGL’s New South Wales CSG operations, 123 wells out of a total 160 wells drilled (as at September 2012) have been hydraulically fracture stimulated.

The pilot test wells are vertical wells. This means that the wells are drilled vertically to intercept the target coal seams. Wells have multiple casings with a conductor casing near surface, a surface casing to around 120 metres to exclude shallow aquifers and a production casing to full depth. All casings are pressure cemented in place. Cement quality is checked by running a Cement Bond Log.

2.2.2 Well Construction

The NSW DRE Code of Practice for Well Integrity has been adopted by AGL and complies with the American Petroleum Institute (API) standards and best practice for wells that will be fracture stimulated. All gas exploration and production wells have been and will be completed with multiple casings (and pressure cemented in place) to ensure that aquifers remain isolated.

Figure 4 presents cross-sectional illustrations of the existing well construction demonstrating the level isolation that is achieved with the construction methodology.

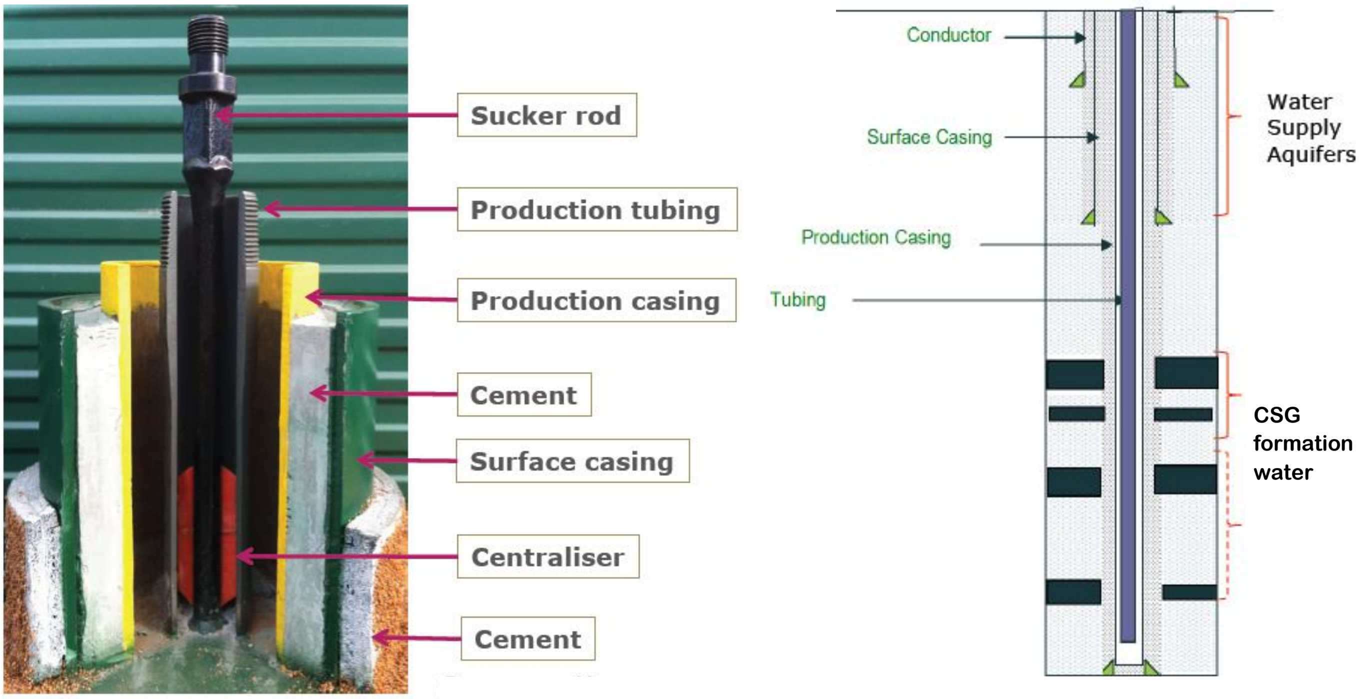


Figure 4 Typical Well Construction (from AGL)

2.2.3 Fracture Stimulation Fluids

The majority of the fracture stimulation fluid comprises water and sand (approximately 98 – 99.5%) however a small percentage of other chemicals are also used.

The additive options for hydraulic fracture stimulation process include:

- Treated water: A treated water fluid formation is a basic fluid for performing hydraulic fracture stimulations. The fluid is treated with a bactericide to minimise the risk of introducing foreign bacteria into the formation which can lead to the development of hydrogen sulphide (H_2S) in the well. H_2S often results from the bacterial breakdown of organic matter in the absence of oxygen and is a corrosive gas with potential to affect the steel casing of the well. The treated water fluid is aimed at minimising these risks. Clay stabiliser may be added to prevent swelling and migration of formation clays.
- Linear gel: This linear gel fluid formulation is a viscosified treated water. The viscosifying agent is a guar gum. Further additives include a breaker used to decrease the viscosity of the linear gel over time allowing more efficient flowback of the fracturing fluid following a hydraulic fracturing treatment. Linear gels are able to carry higher concentrations of proppant than water, thereby reducing the required volumes of water. They also reduce pumping friction and can reduce the required hydraulic pressure required.
- Cross-linked gel: This cross-linked gel fluid formulation is based on a linear gel. The cross-linked fluid has additional additives that cross-link the gel which further increases the viscosity of the gel. Cross-linked gels are used when high proppant concentrations are required or when low viscosity fluids are unable to maintain the desired fracture geometry.

It is expected that linear gel will be used for the pilot testing programs at Gloucester.

Fracture stimulations are specifically designed for each well and seek to avoid impacts on water resources, contain fractures within the targeted seam, and minimise additive or chemical use. Each design will be based on the requirements of the Code of Practice for Coal Seam Gas – Fracture Stimulation Activities, and incorporate the following:

- characteristics of geological formation, including the identification of rock types and conditions, aquifers and hydrocarbon-bearing zones;
- definition of distances to these aquifers from the target coal beds;
- identification of the characteristics of intervening strata, including porosity/ permeability and the extent of natural fracturing;
- determination of the geological stress fields and areas of faulting;
- determination of maximum pressures to be used for fracture stimulation, based on the characteristics of surrounding geology;
- modelling of the likely fracture propagation field, including extent and orientation; and
- discussion of any potential for the fracture propagation field to exceed the modelled field.

These fluids are derived from specific companies (as further evaluated in this report) and are based on knowledge of past operational successes and failures and results from fluid compatibility tests. The fluids main purpose is to create the fracture geometry and to transport proppant. Only the minimum volume of chemicals required to achieve this outcome is used during hydraulic fracture stimulation activities.

It is noted that BTEX (benzene, toluene, ethylbenzene and xylenes) products, and products that may contain BTEX, are not used in hydraulic fracture stimulation activities by AGL.

All fluids will be stored, transported and handled in accordance with legislative requirements, the manufacturer's specifications, contracting company's procedures and the AGL Dangerous Goods and Hazardous Materials Sub Plan.

Regulatory Requirements

Mandatory requirements of the Code of Practice require the identification CAS registry numbers, and volume and concentration of chemicals proposed to be used. It is noted that the chemicals proposed to be used in hydraulic fracture stimulation activities are all listed on the Australian Inventory of Chemical Substances (AICS). The AICS is maintained by the National Industrial Chemicals Notification and Assessment Scheme (NICNAS) and is a list of industrial chemicals used in Australia. Chemicals on the AICS can be imported or manufactured in Australia without being first notified to NICNAS as a new chemical. A listing on the AICS does not mean that the chemical has been assessed in detail by NICNAS. Only a small number of the chemicals listed on the AICS have been assessed in detail by NICNAS (where issues such as hazards, public health, workplace health and environmental effects associated with its proposed industrial use are evaluated in more detail). For chemicals listed on the AICS there is no requirement to notify NICNAS of their use in hydraulic fracturing.

For chemicals that have been assessed in detail by NICNAS, the use of the chemical for hydraulic fracture stimulation constitutes a new use and hence it is recommended (by NICNAS) that the chemical suppliers of these compounds notify NICNAS of their use and a secondary notification assessment may be required. None of the proposed chemicals for use in hydraulic fracture stimulation have been assessed in detail by NICNAS, however some (citric acid and sodium hydroxide) have been determined to be Priority Existing Chemicals, hence they may be undergoing or proposed to be evaluated in detail by NICNAS. If these chemicals are flagged for evaluation by NICNAS, use in hydraulic fracture stimulation should be included in the evaluation.

The Agricultural and Veterinary Chemicals Code Regulations 1995 (amended 1 July 2013) made under the Agricultural and Veterinary Chemicals Act 1994 and administered by the Australian Pesticides and Veterinary Medicines Authority (APVMA) has declared (Schedule 3 Part 3) that "*biocides to control organisms in water, used for the purpose of maintaining equipment associated with the extraction of coal seam gas in serviceable condition*" are not agricultural chemical products and as such do not require registration by APVMA for use as outlined in this assessment.

2.2.4 Hydraulic Fracture Stimulation Injection and Recovery

Where hydraulic fracture stimulation is undertaken, pumping schedules and job design are based on specific reservoir properties. If a well has low permeability, then the fracture design will want to maximise fracture penetration or fracture half-length within the coal seam. If a well has good permeability, then a shorter fatter fracture will be designed connecting back to the wellbore. To achieve the fracture design, various key criteria can be incorporated to optimise the execution result. This includes fluid viscosity, pump rate, proppant mass and proppant concentration. The fluid selected for the pumping schedule will be decided either from fluid compatibility tests or through historical information.

Proppant mass required for a hydraulic fracture stimulation is based on a factor of mass of proppant per net height of coal to stimulated. A typical range for this factor is ~ 3700 to 8200 kg of proppant /net meters of coal.

Depending on the fluid selected, the proppant concentration will vary. Maximum proppant concentrations are generally only a guideline for planning material quantities (water, proppant and chemicals) required to execute a stimulation. Often the maximum proppant concentration is decided during the treatment by observing the treating pressures. If a well has good permeability then proppant concentration will be increased, forming a shorter fatter fracture and maximising the differential pressure between the formation and wellbore. The onsite engineer monitors treating pressures in real time and will adjust the pumping rates and proppant concentration accordingly. The total volume of fluids and proppant are measured and recorded for every job.

The fluids injected during fracture stimulation, with the exception of the sand proppant, are returned to the surface soon after completion of the hydraulic fracturing operation as flowback fluids. Flowback fluids comprise injected hydraulic fracturing fluids as well as formation water from the target coal seam. AGL operations manage the flowback fluids including capturing the fluid in above ground storage tanks or lined ponds. No flowback water is stored in any unlined dams or other reservoirs where there is a direct connection to the local environment. Flowback water is characterised and transported to licensed disposal facilities.

Flowback fluids can be monitored so as to determine when all the flowing fluid has transitioned from injected fracture stimulation fluid to formation water.

2.3 Fracture Issues

Reservoir stimulation is critically important for economically recovering coal seam gas in most operations. Hydraulic fracture stimulation technology is widely applicable to a range of coal seam conditions. Fracture geometry is important in determining the effectiveness of gas recovery. Coal contains natural fractures known as cleats, which extend vertically and horizontally in a coal seam, giving coal its “blocky” nature. However, these cleats do not individually extend vertically or laterally over large distances. Consequently it is essential to create and maintain open fractures which widely transect these natural cleats in the coal to promote the transport of fluids from the coal reservoir. The propagation and orientation of these fractures is controlled primarily by the orientation of the major fracture system in the coal, and the orientation of the horizontal stress field existing in the coal.

There is evidence that the confinement of hydraulically created fractures in the coal seam, and minimising penetration into the roof and floor of the seam depends very largely on the in-situ strength contrast (relative hardness) between the coal and the bounding rock layers.

The Gloucester Gas Project is in the exploration phase and activities proposed in the study area are expected to include geotechnical and seismic studies to identify the nature of fractures within the target coal seams and overlying materials. A geophone monitoring study will also be conducted in a nearby well during the fracture process to monitor the geometry of fracture growth in the first well to be fracture stimulated.

There is a risk that faults offer the potential for communication between rock strata. However, the pressure or force of overlaying geological layers, combined with overall regional compression of the Gloucester Basin, reduces that risk.

In addition, the geological structure of the Gloucester basin within the Stage 1 Development, where AGL activities are proposed, has been carefully examined to identify areas where faulting has occurred. Areas where high angle faults occur have been avoided as they compartmentalise the coal seams and restrict the drainage radius of any proposed wells. Low angle vertical faults, while also contributing to compartmentalisation, do not break up the reservoir to the same degree as high angle faults and can be safely accommodated during the drilling and hydraulic fracture stimulation of wells.

Notwithstanding the low risk that low angle faults pose, AGL has mapped the fault zones in the vicinity of the Waukivory pilot wells through the use of 3D seismic and wellbore imagers. This allows AGL to target coal seams for hydraulic fracture stimulation that are not located adjacent to these fault zones, thereby further reducing the risk.

Additional mitigation will include real time monitoring of the fracture movement captured by the use of a geophone network in a nearby monitoring well~~s~~ for the first well that will be treated. This allows AGL to accurately tailor its fracture treatment program for the remaining three wells where the geophone network is unable to be used. Real-time monitoring will still be conducted utilising the methods described in the FSMP. The geophone network detects vibrations of the fracture pathway and relays this information back to the hydraulic fracture stimulation engineer to monitor the progress, including whether the fracture pathway is migrating into unscheduled locations. The hydraulic fracture stimulation engineer can adjust the way the fracture is progressing based on this real time information by changing the pump rate or, if necessary, shutting down the activity.

On the basis of the available information there is a very low probability that strata above and below the coal seams would be affected. AGL will carefully engineer and manage their hydraulic fracture stimulation activities to ensure that produced fractures would not significantly penetrate the strata both above and below the coal seams, and the possibility of them affecting fresh water alluvial aquifers, located more than 200m above the fracture stimulation interval, is negligible.

2.4 Potential Impact of Operations

The focus of this report is on the potential for chemicals used in hydraulic fracturing operations to be of concern to human health or the environment. Hence AGL hydraulic fracturing operation methods and procedures (outlined above and presented in the AGL Fracture Stimulation Management Plan) have been reviewed further in conjunction with the available information on the study area to identify and evaluate the potential for impacts to occur and be of potential significance. **Table 6** presents a summary of the potential Impacts identified.

Other impacts associated with CSG operations (associated with earthworks, traffic and construction) are separately evaluated and managed/addressed by AGL. While these activities have the potential to result in impacts to the environment, they are not related to the use of hydraulic fracturing chemicals and are not further evaluated in this assessment.

Table 6 Summary of Potential Risks and Likelihood - Hydraulic Fracture Stimulation Activities

Development Phase and Potential Impacts	Likelihood*	Comments and Management Measures
Well Construction/Hydraulic Fracture Stimulation/Production		
Risk that CSG operations result in contamination of upper aquifers that are relevant to regional beneficial uses (irrigation, stock water, baseflow returns to streams)	1	As outlined in **Section 1.4**, the underlying geology creates a hydraulic barrier between the target Coal Measures and the upper alluvial and naturally fractured rock aquifers. It is noted that gas production would be severely compromised if water inflow from other formations were to occur; hence best practice is to ensure no communication between the gas production zone and overlying or underlying water bearing zones.
Risk that hydraulic fracture stimulation of target coal seam results in vertical fractures that result in increased permeability or interconnectivity between target coal seam and upper aquifers resulting in contamination of these upper, more shallow aquifers where regional beneficial uses (irrigation, stock water, baseflow returns to streams) may be important	1	As outlined in **Section 2.2.2** the methodology for well construction makes it highly unlikely that any interconnection between aquifers will be created during well construction. The target coal seam is expected to be well isolated. Wells have been drilled and casing has been pressure cemented consistent with the current Code of Practice - Well Integrity standards. Cement Bond Logs are run to ensure coal seam is well isolated.
Risk that storage and handling of hydraulic fracture stimulation fluids may result in exposure by workers involved in fracture stimulation activities	1	AGL occupational health and safety protocols are employed to manage and mitigate workplace exposure risks.
Risk that accidental spillage of hydraulic fracturing fluids may result in exposures by workers and/or runoff to the adjacent environment (terrestrial or local aquatic environments where present)	2	AGL operational procedures are in place to minimise the potential for these impacts to occur. In accordance with the AGL Dangerous Goods and Hazardous Materials Sub Plan, fluids are stored in bunded areas with onsite spill kits, all onsite personnel wear necessary PPE, well siting requirements ensures that fracture stimulation wells are not located within 40 m of a creek, flowback water is stored within lined ponds or aboveground tanks that are not affected by rainfall (including flooding), a Soil and Surface Water Management Plan, Emergency Response Plan and Flood Management Plan has been developed and implemented by AGL for all operations to mitigate the potential for any runoff to adjacent environments.
Risk that accidental release of flowback water from CSG well or from storage tanks resulting in exposure to workers and/or runoff to the adjacent environment (terrestrial or local aquatic environments where present)	2	

* Refer to **Table 2** for description of these indicators

On the basis of the above, the pathways by which chemicals used in hydraulic fracturing activities may be released to the environment where exposures may occur by aquatics and terrestrial receptors, workers and other members of the public is via accidental spill and releases of fluids, products and flowback water. These accidental spills and releases occur as a result of aboveground operations and may result in direct exposures. No pathways of exposure have been identified by which subsurface operations associated with hydraulic fracturing can result in the discharge or release of chemicals to an overlying freshwater aquifer that may be used for any beneficial use or discharge to a receiving waterbody.

Based on the implementation of a range of risk management measures by AGL, accidental spills and releases of these chemicals/fluids is considered to be unlikely.

While unlikely, the potential for chemicals released to result in harm to human health or the environment has been evaluated further in the following section.

Section 3 Chemical Hazard Assessment

3.1 General

The review presented in this report has focused on chemicals proposed to be used in future hydraulic fracture stimulation activities in the study area.

3.2 Consideration of National Water Quality Management Strategy

The National Water Quality Management Strategy provides policies, processes and national guidelines for the purpose of managing water resources to meet current and future needs in Australia. The overall policy objective of the strategy is "*achieve sustainable use of the nation's water resources by protecting and enhancing their quality while maintaining economic and social development*."

This strategy and associated guidelines, address a wide range of issues associated with water quality. More specifically guidelines have been established to assist in the assessment, protection and management of beneficial use and environmental water quality. The guidelines refer to effluent quality in the context of discharges from a water treatment plant, industry or a process. Effluent more broadly is considered to be any wastewater discharge. Hence in this context water that is used in the hydraulic fracturing process, in particular, the flowback water that is extracted from the well, can be considered to be effluent. The produced water that follows is considered more of a resource as it can be beneficially reused.

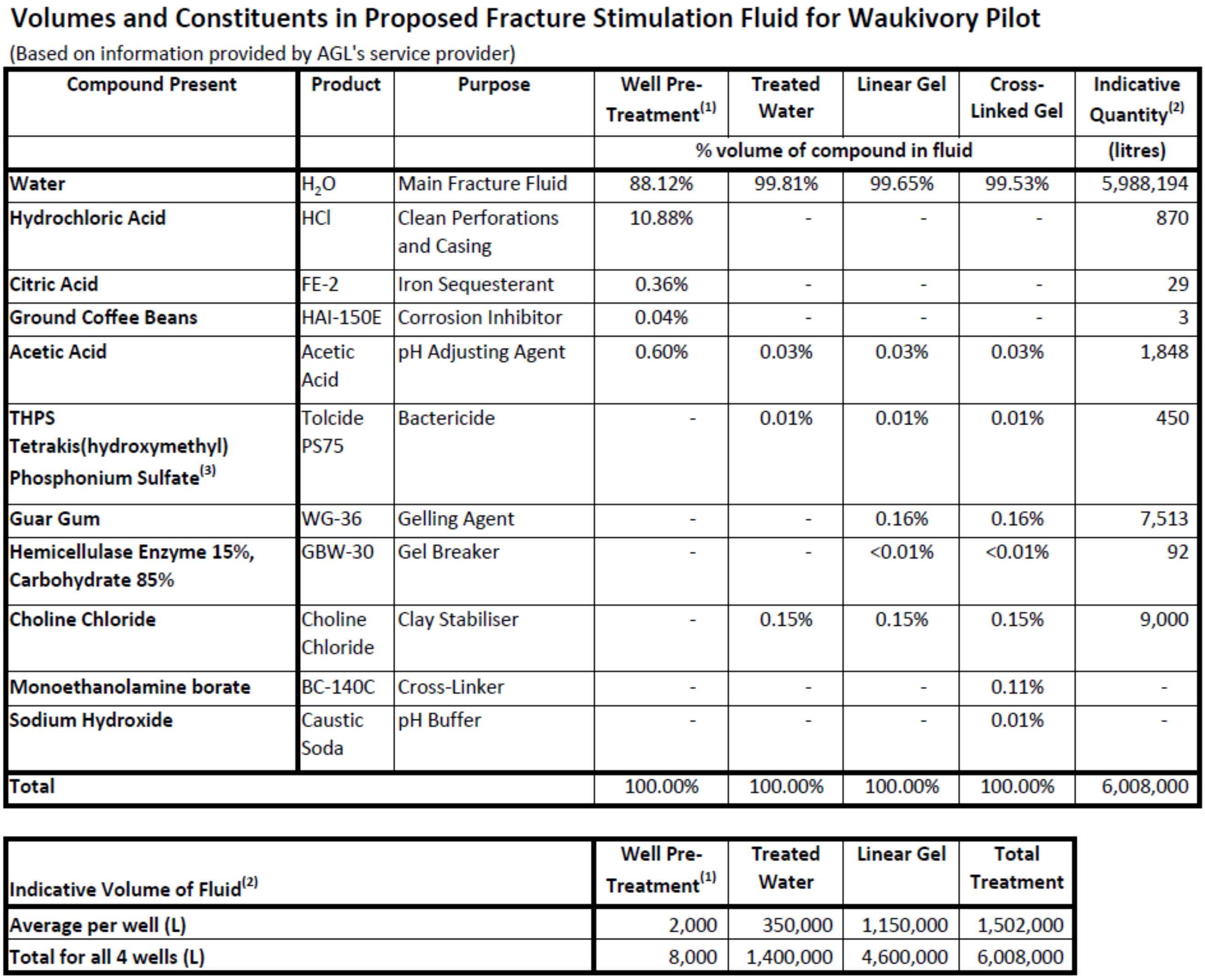
Effluent discharges from a process are required to be assessed and evaluated in accordance with the relevant guidelines within the National Water Quality Management Strategy. For most effluents, including those from hydraulic fracturing, the relevant guideline is the ANZECC & ARMCANZ Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ 2000). These guidelines are relevant to the assessment of effluent discharges into an environment and include water quality criteria that are based on the protection of fresh or marine environments as well as a framework for the assessment of other stressors and toxicants where guidelines are not available.

The assessment of potential effects associated with effluent discharges incorporates evaluation of toxicity as well as the management of discharges. Regardless of toxicity if an effluent does not discharge to an aquatic environment through effective management of wastewater, then the objectives of the National Water Quality Management Strategy are effectively met. Similarly if the toxicity of the effluent discharge is sufficiently low to meet the desired level of protection for the environment then the objectives are effectively met. Both these aspects, potential for discharge to an environment and toxicity are evaluated in this assessment consistent with the requirements of the National Water Quality Management Strategy.

Within the ANZECC (2000) guidelines a tiered approach to the assessment of effluent toxicity is presented. This ranges from the default approach of comparing water quality with available water quality guidelines relevant to the level of environmental protection, derivation of water quality guidelines where published values are not available, evaluation of local reference data (i.e. background information on the local environment) and collecting local biological effects data (such as conducting more specific ecological tests including direct toxicity assessment). Where effluents being discharged to an environment are being evaluated it is important that more detailed local biological effects testing be undertaken. However, where effluent is not discharged to the environment (or the potential for discharge is essentially low to negligible (associated with accidental spills only) as is the case in this assessment, refer to **Section 2.4**) it is appropriate that the potential toxicity of the effluent be evaluated just using the standard approach based on the water quality guidelines (published or derived from available studies). This approach has been adopted in this assessment, where the toxicity of the individual chemical and the chemicals as a mixture have been evaluated, as outlined in the following section. Further refinement of the risk assessment is not necessary given the low potential for this effluent to reach the environment (being either local surface water resources or the underlying shallow groundwater).

3.3 Chemical Information

The following chemicals are proposed to be used by AGL during the fracture stimulation activities.



Volumes and Constituents in Proposed Fracture Stimulation Fluid for Waukivory Pilot

(Based on information provided by AGL's service provider)

Compound Present	Product	Purpose	Well Pre-Treatment(1)	Treated Water	Linear Gel	Cross-Linked Gel	Indicative Quantity(2)
			% volume of compound in fluid				(litres)
Water	H_2O	Main Fracture Fluid	88.12%	99.81%	99.65%	99.53%	5,988,194
Hydrochloric Acid	HCl	Clean Perforations and Casing	10.88%	-	-	-	870
Citric Acid	FE-2	Iron Sequesterant	0.36%	-	-	-	29
Ground Coffee Beans	HAI-150E	Corrosion Inhibitor	0.04%	-	-	-	3
Acetic Acid	Acetic Acid	pH Adjusting Agent	0.60%	0.03%	0.03%	0.03%	1,848
THPS Tetrakis(hydroxymethyl) Phosphonium Sulfate(3)	Tolcide PS75	Bactericide	-	0.01%	0.01%	0.01%	450
Guar Gum	WG-36	Gelling Agent	-	-	0.16%	0.16%	7,513
Hemicellulase Enzyme 15%, Carbohydrate 85%	GBW-30	Gel Breaker	-	-	<0.01%	<0.01%	92
Choline Chloride	Choline Chloride	Clay Stabiliser	-	0.15%	0.15%	0.15%	9,000
Monoethanolamine borate	BC-140C	Cross-Linker	-	-	-	0.11%	-
Sodium Hydroxide	Caustic Soda	pH Buffer	-	-	-	0.01%	-
Total			100.00%	100.00%	100.00%	100.00%	6,008,000

Indicative Volume of Fluid(2)	Well Pre-Treatment(1)	Treated Water	Linear Gel	Total Treatment
Average per well (L)	2,000	350,000	1,150,000	1,502,000
Total for all 4 wells (L)	8,000	1,400,000	4,600,000	6,008,000

Quantity of Proppant - quartz silica sand	Total Treatment
Average per well (kg)	206,750
Total for all 4 wells (kg)	827,000

Notes:

[1] Well pre-treatment is conducted to clean casing and perforations prior to fracture stimulation.

[2] The volumes of each fluid are indicative only and actual volumes cannot be determined until fracture stimulation treatment occurs. This is because during the fracture stimulation treatment AGL monitors the fracture growth using a variety of diagnostic tools. This allows AGL to analyse the fracture geometry and fine-tune the final volumes. In addition, information gained from the initial treatments will enhance design of subsequent treatments.

[3] As an alternative to using THPS as a bactericide, AGL may use product BE-7 (a mixture of sodium hypochlorite and sodium hydroxide) in treated water, that will be used in the linear gel and cross-linked gel recipes at a concentration by volume of 0.015% sodium hypochlorite and 0.001% sodium hydroxide, which will represent a total volume of 900 litres sodium hypochlorite and 60 litres of sodium hydroxide. The HHERA Table 8 has also assessed these compounds in the alternative bactericide.

To assist in the evaluation of the potential for the chemicals used in hydraulic fracture stimulation operations to be of concern with respect to the human health or the environment, the following information has been compiled and reviewed:

Physical/Chemical Data

Physical and chemical information on the chemicals were obtained from the following sources:

- Material Safety Data Sheets (MSDS) provided by AGL's service provider for the products proposed to be used in hydraulic fracturing operations (included in **Appendix B**);
- Hazardous Substances Databank (HSDB), accessed from February 2012 to March 2013;
- Published chemical reviews or assessment reports (as referenced for each chemical);
- Modelled from the USEPA (2009) EPISUITE (Estimation Programs Interface Suite, Version 4.10, 2011). This program incorporates USEPA peer-reviewed modelling programs for the estimation of physical/chemical data, environmental fate and ecotoxicity data for organic chemicals.

Environmental Fate and Transport

Fate and Transport of the fracturing chemicals in the environment have been evaluated on the basis of the following:

- Volatility of the compound – potential for the chemical to partition to the vapour phase from water (based on Henry's Law constant) or soil (based on vapour pressure) and hence be present in air at any significant concentration;
- Mobility in the environment – potential to migrate to and discharge to a receiving environment has been evaluated on the basis of the solubility of the compound in water (more soluble compounds prefer to stay in solution and be more mobile) and Koc (the potential for the compound to adsorb to organic matter present in soil or sediments, limiting mobility);
- Potential to accumulate in the food chain or aquatic/terrestrial species – the potential for chemicals to bioaccumulate has been assessed on the basis of calculated bioconcentration

factors (BCF). Where these are not available the potential for chemicals to be considered bioaccumulative has been based on the nature of the chemical to be absorbed and eliminated;
- Potential for degradation in the environment – the potential for degradation to less toxic (or in some cases more toxic) species is of importance. Some chemicals rapidly degrade to non-toxic compounds that regardless of mobility in the environment, will never be of concern. However there are other compounds that degrade more slowly and hence will remain in the environment for longer (potentially resulting in exposure and harm) or they may degrade to more toxic compounds that are more persistent in the environment. The potential for degradation in surface soil and surface water is of most relevance for this assessment.

The overall ranking of potential fate in the environment has been conducted on a qualitative basis using the measures outlined in **Table 1.**

Human Toxicity

The assessment of potential risk issues for human receptors needs to consider:

- occupational risks by workers who may be exposed during use of the chemicals/fluids or managing spill/release incidents. These issues more specifically relate to acute exposures and hazards;
- chronic (long-term) health effects that may be relevant to exposures by all members of the public in the event that concentrations of chemicals are present in soil or groundwater in an area where exposure can occur on a regular basis.

These health effects have been evaluated on the basis of published information from peer-reviewed sources, as identified and selected using enHealth (2012) guidance. It is noted that a number of chemicals have very limited data available and hence the studies available have been further evaluated for the purpose of determining the potential for adverse health effects to be of significance.

Where available, published guidelines for soil and water quality (stock, limited domestic or irrigation water quality) have been identified. More specifically published drinking water guidelines (i.e. concentrations in water that are safe for all members of the population to consume every day for a lifetime) have been identified and considered in this assessment. Where these guidelines are not available and the available published reviews have identified a suitable Tolerable Daily Intake (TDI) or No Observed Adverse Effects Level (NOAEL) this value has been presented and used to derive a preliminary drinking water guideline following guidance provided by the National Health and Medical Research Council (NHMRC, 2011) for the derivation of the Australian Drinking Water Guidelines. This has been undertaken on the basis of the following:

$$Preliminary\ Guideline\ (DWGp) = \frac{TDI\ x\ Body\ Weight\ x\ \%intake}{Water\ Consumption}$$

$$TDI = \frac{NOAEL}{Safety\ Factor}$$

Based on guidance provided by NHMRC (2011), a provisional guideline has been derived on the basis of a body weight of 70 kg, water consumption rate of 2 L/day and a %intake of chemicals from drinking water of 10% (assuming most of the chemicals considered are not common chemicals in the diet). The safety factor adopted would typically depend on a wide range of factors, however for the purpose of this assessment a default factor of 1000 has been adopted (to address intraspecies and interspecies variability and limitations/uncertainties with the database).

All relevant published drinking water guidelines or calculated preliminary drinking water guidelines are presented in **Appendix A**.

The comparison with drinking water guidelines (assuming water consumption) is the most stringent evaluation that is relevant for human health. There is no intention that the water will be used for, or contaminate, drinking water. The only possible exposure pathway is via an accidental spill, as dealt with in the risk analysis table (see **Table 6**).

Where drinking water guideline is available or a preliminary drinking water guideline can be calculated (using the above approach), this has been compared with the potential for the contaminant concentration that is likely to be present in hydraulic fracture stimulation fluids (prior to any dilution). This comparison has then been used in the determination of the potential consequences of exposure (should it occur).

It is noted that there are a number of chemicals where no suitable human health guidelines are available or relevant, hence the evaluation of these chemicals has been undertaken on a qualitative basis only.

The overall ranking of potential acute (occupation) and chronic health effects has been conducted on a qualitative basis using the measures outlined in **Table 1.**

Environmental Toxicity

The potential for adverse effects to a receiving environment to occur has been evaluated on the basis of the available published information/studies in relation to acute and chronic toxicity to species in the environment. Most of the available data relates to aquatic toxicity and this has therefore been assumed to be protective of terrestrial effects.

Toxicity values for ecological receptors for fresh or marine water quality guidelines that are relevant to a 95% protection level have been adopted from Australian guidelines, specifically ANZECC (2000). Where these guidelines are not available, toxicity values derived from relevant ecological studies (referred to as Tox(eco) values) have been identified. These are threshold concentrations in water relevant for the assessment of potential adverse effects in a range of ecological species (refer to **Appendix A** for further detail on the range of Tox(eco) values available for each of the chemicals considered in this assessment).

Where available, and relevant, the identified water quality guideline or Tox(eco) has been compared with the potential concentration that is likely to be present in hydraulic fracture stimulation fluids (prior to dilution). This comparison has assisted in the determination of the potential consequences of exposure (should it occur).

It is noted that there are a number of chemicals where no suitable guidelines are available for evaluating ecotoxicity, hence the evaluation of these chemicals has been undertaken on a qualitative basis only.

The overall ranking of potential environmental effects has been conducted on a qualitative basis using the measures outlined in **Table 1.**

<u>Characterisation of Potential Risk</u>

The potential for risks to be of concern has been evaluated on the basis of the following:

- the handling of chemicals prior to use in hydraulic fracture stimulation activities has been assessed on the basis of potential workplace health and safety risks using the risk ranking as presented in **Table 1**. This evaluation identified chemicals that require additional personal protective equipment (PPE) and care to ensure workers who use the chemicals above-ground are adequately protected;
- in the event of a spill above-ground prior to injection of the fracturing fluid into the well, the potential for adverse human health and environmental risks has been assessed using a worst-case approach assuming that the maximum concentrations present in the fracturing fluid are present in an area where exposure by humans (in drinking water) or the environment may occur, and there is no dilution of the concentrations in any other water body or degradation of any chemicals. This worst-case assessment has been undertaken by calculating a Hazard Index (HI) using the following equations:

$$HI\,(human\ health) = \frac{concentration\ in\ fracturing\ fluid}{drinking\ water\ quality\ guideline}$$

$$HI\,(environmental) = \frac{concentration\ in\ fracturing\ fluid}{water\ quality\ guideline\ or\ Tox(eco)}$$

This calculation has been undertaken to enable a ranking of the potential worst-case consequences of effects should a spill occur (and there is no dilution or degradation).

The final ranking of a human health or environmental hazard has been undertaken on a qualitative basis and has considered the calculated HI as well all available information in relation to the nature of the adverse effects identified following exposure, and the potential for such exposures to occur over a long period of time (i.e. more than a year where the exposure is considered to be chronic) based on the behaviour of the chemical once it is in the environment. This is important as most of the human health and ecological guidelines adopted are based on chronic (long-term) exposures to these chemicals.

The final risk ranking has then been determined on the basis of the consequences as outlined in **Table 1**.

- evaluation of potential risks based on the consequences (as calculated above) and likelihood of the event (connection between groundwater aquifers or a spill) occurring (based on the likelihood descriptors as outlined in **Table 2**). This evaluation takes into account policies and procedures adopted by AGL in the conduct of all aspects of fracture stimulation activities and utilises the risk matrix as described in **Table 4**.

3.4 Summary of Chemical Reviews

3.4.1 General

Appendix A presents a summary of all the available information considered in relation to the parameters outlined in **Section 3.2** and the values relevant to the assessment of potential hazard as outlined in **Section 3.3**.

It is noted that there are a number of products used in hydraulic fracture stimulation activities that are insoluble solids where the only hazard relates to occupational exposures during use. For the products proposed to be used this includes quartz silica including crystobalite (sand) which is used to prop open fractures in the subsurface (not expected to be present in flowback water) and the inhibitor (ground coffee beans, refer to MSDS for the product FE-2).

Some of these products require specific use of personal protective equipment (PPE) to ensure worker health and safety. Use of such PPE is addressed at an operational level by AGL. If spilled, these solids do not leach or migrate and can be readily and easily cleaned up (as per AGL operational requirements). Hence no further detailed evaluation of impacts to human health or the environment has been presented for these products.

3.4.2 Occupational Assessment of Hazard

Based on the available data **Table 7** presents a summary of the hydraulic fracture stimulation chemicals that are ranked from 1 (negligible) to 4 (high) and require varying levels of PPE to ensure occupational exposures are appropriately addressed.

Table 7 Summary of Occupational Hazard Analysis of Chemicals used in Hydraulic Fracturing Activities

Compound	Occupational Hazard Ranking
Moderate to High Hazards – Transient to permanent health effects that may require medical treatment (or disability) and require moderate to high level of PPE, monitoring and management	
Hydrochloric acid	3-4
Sodium hypochlorite	3-4
THPS (Phosphonium, Tetrakis (Hydroxymethyl)-Sulfate)	3-4
Sodium hydroxide	3-4
Moderate Hazards – Transient effects that may require medical attention and include respiratory and more significant irritation effects that need to be managed with moderate level PPE.	
Citric acid	3
Acetic acid	3
Hemicellulase enzyme concentrate	3
Low to Moderate Hazards – minor nuisance effects including low level irritation that requires to low level PPE to more transient effects that may require medical attention and include respiratory and more significant irritation effects that need to be managed with moderate level PPE	
Monoethanolamine Borate	2-3
Negligible to Low Hazards – low to minor nuisance effects including low level irritation that may require low level PPE	
Guar gum	2
Choline chloride	1-2

* Refer to **Table 1** for descriptions of these ranking scores

3.4.3 Human Health and Environmental Hazard Assessment

In relation to hazards to human health and the environment in the event that hydraulic fracturing fluids containing the chemicals evaluated are spilled at the ground surface (prior to injection into the well), a worst-case assessment of potential hazards has been undertaken based on potential impacts to human health (non-occupational) and the environment. This has been undertaken following the approach outlined in **Section 3.3**.

The detailed information relevant to each chemical considered is summarised in **Appendix A**. **Table 8** presents a summary of key ranking and quantitative values presented in **Appendix A** as well as the calculated HI for human health and environmental hazards. It is noted that the HI calculated for human health and environmental hazards is a worst-case calculation relevant to potential exposure that may occur prior to any dilution, sorption to soil/sediments or degradation in the environment.

Table 8 Summary of Human Health and Environmental Hazard Analysis of Chemicals used in Hydraulic Fracturing Activities – Based on Chemicals at Point of Injection

Compound	Concentration in hydraulic fracture stimulation fluid before injection in well (mg/L)	Potential for Off-Site Migration (fate and transport in environment)	Human Health Evaluation – Worst-case			Ecological Health Evaluation – Worst-case		
			Drinking Water Guideline (mg/L)	HI	Hazard Ranking	Water Quality Guideline or Tox(eco) (mg/L)	HI	Hazard Ranking
Citric acid	5991	2	15	400	2	85 to1535[T]	70 to 4	2
Hydrochloric acid	128,205	2	Based on pH	NA	2-3	Based on pH	NA	3
Guar gum	2397	1	NA	NA	1	NA	NA	1
Hemicellulose enzyme concentrate	4.5	1	NA	NA	1	NA	NA	1
Acetic acid	314	2	NA	NA	1	32 to 300[T]	10 to 1	2
THPS (Phosphonium, Tetrakis (Hydroxymethyl)-Sulfate)	110	2	0.126	870	4	0.06 to 24[T]	>1500 to 4.5	4
Sodium hypochlorite	181	2	0.3 for chlorite	600	3	0.028 to 0.71[T]	>6000 to 250	4
Sodium hydroxide	12 to 103 (X-link gel)	1-2	Based on pH	NA	2-3	Based on pH	NA	3
Monoethanolamine borate	0 to 1250 (X-link gel)	2-3	4 (boron)	0 - 312	3	0.37 (boron) to 5000[T]	>3000 to 0.25	3
Choline chloride	1632	2	12250	0.1	1	3.5[T]	466	3

Notes:

Refer to **Appendix A** for more detail on each chemical and explanations on the basis for the risk ranking selected for fate and transport in the environment, human health and environmental hazards.

T = range of concentrations based on the range of data available from relevant ecotoxicological studies considered as Tox(eco) values (refer to **Appendix A** for further details on these values).

NA = not applicable on the basis of the following reasons:

- The only effects identified relate to the pH of the chemical (acid or alkali) and hence there are no quantitative human health or ecological values that are based on a concentration of the chemical in water. No HI can be calculated. The ranking of risk has therefore been undertaken on a qualitative basis as presented in **Appendix A**.

- The compound is not toxic to humans and/or the environment at any dose in all the studies undertaken. Hence there are no quantitative values that can be used to calculate a HI.

To further assist in understanding the approach outlined in **Table 8**, the following presents a worked example for citric acid:

- In relation to the behaviour of citric acid in the environment the following was concluded in **Appendix A**:

  The compound does not sorb to soil or particles in the water column, is readily and rapidly degraded and does not bioaccumulate - potential for discharge to receiving environment is low – this is risk ranking 2 (as per ***Table 1****)*

- In relation to evaluating human health hazards the following was undertaken:
  - The review conducted in **Appendix A** did not identify any published drinking water guidelines for citric acid, however a preliminary drinking water guideline of 15 mg/L could be derived (as outlined in **Section 3.3**)
  - The concentration of citric acid in hydraulic fracturing fluids was 5991 mg/L.
  - The calculated HI (using the equations in **Section 3.3**) is 5991/15 = 399.4, which can be rounded up to 400.
  - Based on this value and with consideration of the nature of the human health effects relevant for ingestion of citric acid the following was concluded, in **Appendix A**, in relation to ranking of the hazard:

    While the concentration in hydraulic fracturing water may exceed the provisional guideline, citric acid is used in many food products with no upper limit set by the WHO or FSANZ,, hence the risks have been considered low – this is risk ranking 2 (as per ***Table 1****)*

- In relation to evaluating environmental hazards the following was undertaken:
  - The review conducted in **Appendix A** did not identify any published water quality guidelines (for fresh or marine waters), however the available ecotoxicological studies identified a range of Tox(eco) values that ranged from 85-1535 mg/L.
  - The concentration of citric acid in hydraulic fracturing fluids was 5991 mg/L.
  - The calculated HI (using the equations in **Section 3.3**) ranges from 5991/85 = 70, to 5991/1535 = 3.9 which can be rounded up to 4.
  - Based on this value and with consideration of the nature of the ecological effects relevant for the presence of citric acid in the environment concluded, in **Appendix A**, in relation to ranking of the hazard:

    As citric acid is readily degraded the potential for ecological impacts is considered to be low – this is risk ranking 2 (as per ***Table 1****)*

On the basis of **Table 8**, in the event that hydraulic fracture stimulation fluid were spilled at the ground surface and were released into the environment the following presents a summary of the chemicals that have been identified to pose a high to negligible risk to human health (non-occupational) or the environment.

Table 9 Summary of Human health and Environmental Hazard Rankings for Hydraulic Fracturing Chemicals (in the event of surface spill)

Consequence Descriptor	Off-Site Impacts to Human Health	Off-Site Impacts to the Ecosystem
Negligible (1)	No adverse long-term health effects associated with low level environmental exposures:	Negligible potential for adverse effects on aquatic ecosystem:
	Guar gum Hemicellulose enzyme concentrate Acetic acid Choline chloride	Guar gum Hemicellulose enzyme concentrate
Low (2)	Minor transient health effects or odour:	Low potential for adverse effects on aquatic ecosystem:
	Citric acid	Citric acid Acetic acid
Moderate (2-3 and 3)	Transient effects that may require medical treatment such as respiratory effects, more significant irritation:	Moderate potential for adverse effects on aquatic ecosystem:
	Hydrochloric acid Monoethanolamine borate Sodium hypochlorite Sodium hydroxide	Hydrochloric acid Monoethanolamine borate Sodium hydroxide Choline chloride
High (3-4 and 4)	Permanent health effects that require extended medical treatment and/or permanent disability:	High potential for adverse effects on aquatic ecosystem:
	THPS (Phosphonium, Tetrakis (Hydroxymethyl)-Sulfate)	Sodium hypochlorite THPS (Phosphonium, Tetrakis (Hydroxymethyl)-Sulfate)

Review of **Tables 8 and 9** indicates that most of the chemicals utilised in hydraulic fracturing operations are associated with negligible to low/moderate hazards to human health and/or the environment. There are some chemicals that are of greater concern (including sodium hypochlorite, THPS, sodium hydroxide, monoethanolamine borate, hydrochloric acid and choline chloride) should they be released directly to an environment (where they may be present in undiluted fracturing fluids) where exposure may occur. The overall risk of the use of these chemicals depends not only on theses hazards, but the likelihood that exposure may occur. This is further discussed in the following section.

Section 4 Risk Characterisation/Assessment

The evaluation of potential risks associated with the use of chemicals in proposed hydraulic fracture stimulation activities in the Gloucester Gas Project has been evaluated on the basis of the risk assessment matrix presented in **Section 1.2.5** and the following information:

- available information in relation to the study area;
- chemicals proposed to be used in hydraulic fracture stimulation activities;
- the likelihood that chemicals used in hydraulic fracture stimulation activities may be discharged to an environment where there is the potential for some level of exposure (human or ecological) (presented in **Table 6**); and
- the hazards (human health and ecological) identified for these chemicals (summarised in **Tables 7 to 9**).

While a range of hazards have been identified in relation to the behaviour of the evaluated chemicals in the environment, occupational/acute hazards, chronic health effects and ecological impacts, the likelihood that any of these chemicals may be discharged into an environment where any level of exposure may occur has been evaluated as highly unlikely (no exposure pathway is present) or unlikely (in relation to the potential for accidental spills or releases of chemicals in fluids or flowback water). These evaluations are summarised on the risk matrix presented in **Table 10** (refer to **Tables 3 and 5** for risk definitions).

Table 10 Summary of Overall Risk Ranking for Chemicals used in Hydraulic Fracture Stimulation Activities

				Consequence				
				Negligible	Low	Moderate	High	Severe
		Potential for Off-Site Impacts - Fate and Transport		Chemical degrades rapidly under all conditions, is not bioaccumulative or taken up into the food chain	Chemical is somewhat mobile, degrades slowly (or only under some conditions), is not bioaccumulative or taken up into the food chain	Chemical is mobile, degrades slowly, is not bioaccumulative or taken up into the food chain	Chemical is mobile, persistent, has the potential for low to moderate bioaccumulation in aquatic species or food chain	Chemical is mobile, persistent, has the potential for high to very high bioaccumulation in aquatic species or food chain
				1	2	3	4	5
		Off-Site Human Health Issues (chronic)		No adverse long-term health effects associated with low level environmental exposures	Minor transient health effects or odour	Transient effects that may require medical treatment such as respiratory effects, more significant irritation	Permanent health effects that require extended medical treatment and/or permanent disability	Death or significant injury likely to result in death
				1	2	3	4	5
		Off-Site Impacts to Aquatic Ecosystem		Very low potential for adverse effects on aquatic ecosystem	Low potential for adverse effects on aquatic ecosystem	Moderate potential for adverse effects on aquatic ecosystem	High potential for adverse effects on aquatic ecosystem	Very high potential for significant adverse effects on aquatic ecosystem
				1	2	3	4	5
				Negligible	Low	Moderate	High	Severe
Likelihood of Exposure at Receptor	Confirmed connection between coal seam and receiving environment, confirmed use of aquifer or direct discharge to environment/ecosystem	very likely	5	N	L	M	H	E
	Likely connection between coal seam and receiving environment, potential use of aquifer or discharge to local environment/ecosystem	likely	4	N	L	M	H	E
	Possible connection between coal seam and receiving environment, possible use of aquifer, limited management measures in place to prevent surface spillage (hence possible for surface spills to reach environment)	possible	3	N	L	M	M	H
	Unlikely connection between coal seam and a receiving environment, no use of aquifers for any purpose, management measures in place that make spills at ground surface unlikely	unlikely	2	N	L	L	L	L
	No connection between coal seam and receiving environment and management measures in place to prevent surface spills	highly unlikely	1	N	N	N	N	N

On the basis of the assessment presented, the following can be concluded in relation to risks associated with the proposed use of chemicals in hydraulic fracture stimulation activities:

- Risks to human health and the environment are considered to be negligible or low;
- The highest identified risk level is low which is considered to be a level of risk that can be adequately managed through the implementation of existing operational management measures. This is currently conducted as outlined in the Fracture Stimulation management Plan NSW (prepared by AGL 2013) and associated management plans. The identified level of risk is supported by reviews of former operations where controls have been implemented to ensure that should a spillage occur it would be minor in nature.
- No significant risk issues have been identified that require detailed quantification of risk.
- Based on the available information there are no pathways by which hydraulic fracture stimulation fluids injected into the CSG well can migrate to any freshwater body that may be of importance with respect to future beneficial uses of these freshwater aquifers or the discharge of water into aquatic environments. Hence there is no specific requirement identified for the detailed assessment of chemical recovery in flowback water. However, good environmental practice in CSG operations supports that AGL adopt a suitable approach to demonstrate chemical recovery in flowback water. AGL propose to monitor flowback water chemistry to determine when transition to produced water occurs. Flowback water will be chatacterised and lawfully disposed of to an appropriate facility.

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Appendix A Proposed Hydraulic fracturing Chemical Summaries

Volumes and Constituents in Proposed Fracture Stimulation Fluid for Waukivory Pilot

(Based on information provided by AGL's service provider)

Compound Present	Product	Purpose	Well Pre-Treatment(1)	Treated Water	Linear Gel	Cross-Linked Gel	Indicative Quantity(2)
			% volume of compound in fluid				(litres)
Water	H_2O	Main Fracture Fluid	88.12%	99.81%	99.65%	99.53%	5,988,194
Hydrochloric Acid	HCl	Clean Perforations and Casing	10.88%	-	-	-	870
Citric Acid	FE-2	Iron Sequesterant	0.36%	-	-	-	29
Ground Coffee Beans	HAI-150E	Corrosion Inhibitor	0.04%	-	-	-	3
Acetic Acid	Acetic Acid	pH Adjusting Agent	0.60%	0.03%	0.03%	0.03%	1,848
THPS Tetrakis(hydroxymethyl) Phosphonium Sulfate(3)	Tolcide PS75	Bactericide	-	0.01%	0.01%	0.01%	450
Guar Gum	WG-36	Gelling Agent	-	-	0.16%	0.16%	7,513
Hemicellulase Enzyme 15%, Carbohydrate 85%	GBW-30	Gel Breaker	-	-	<0.01%	<0.01%	92
Choline Chloride	Choline Chloride	Clay Stabiliser	-	0.15%	0.15%	0.15%	9,000
Monoethanolamine borate	BC-140C	Cross-Linker	-	-	-	0.11%	-
Sodium Hydroxide	Caustic Soda	pH Buffer	-	-	-	0.01%	-
Total			100.00%	100.00%	100.00%	100.00%	6,008,000

Indicative Volume of Fluid(2)	Well Pre-Treatment(1)	Treated Water	Linear Gel	Total Treatment
Average per well (L)	2,000	350,000	1,150,000	1,502,000
Total for all 4 wells (L)	8,000	1,400,000	4,600,000	6,008,000

Quantity of Proppant - quartz silica sand	Total Treatment
Average per well (kg)	206,750
Total for all 4 wells (kg)	827,000

Notes:

(1) Well pre-treatment is conducted to clean casing and perforations prior to fracture stimulation.

(2) The volumes of each fluid are indicative only and actual volumes cannot be determined until fracture stimulation treatment occurs. This is because during the fracture stimulation treatment AGL monitors the fracture growth using a variety of diagnostic tools. This allows AGL to analyse the fracture geometry and fine-tune the final volumes. In addition, information gained from the initial treatments will enhance design of subsequent treatments.

(3) As an alternative to using THPS as a bactericide, AGL may use product BE-7 (a mixture of sodium hypochlorite and sodium hydroxide) in treated water, that will be used in the linear gel and cross-linked gel recipes at a concentration by volume of 0.015% sodium hypochlorite and 0.001% sodium hydroxide, which will represent a total volume of 900 litres sodium hypochlorite and 60 litres of sodium hydroxide. The HHERA Table 8 has also assessed these compounds in the alternative bactericide.

Chemical summaries for compounds identified in hydraulic fracturing fluids

List of acronyms:

Utilised in evaluation of human health effects:

LD50	Lethal dose required to cause death in 50% of the (non-human) species evaluated (used to evaluate acute toxicity of chemicals)
TDI	Tolerable daily intake
NOAEL	No observed adverse effect level
DWG	Drinking water guideline
pDWG	Preliminary drinking water guideline (calculated where no published value is available)

Utilised in evaluation of environmental effects:

PNEC	Predicted no-effect concentration
EC	Effects concentration, typically expressed as the concentration that results in effects in a percentage of test organisms in a given population under a defined set of conditions. Hence there are the following levels of effects concentrations: EC50 = this is also known as the median effective concentration and is the statistically derived concentration of a substance in an environmental medium expected to produce a certain effect in 50% of test organisms
LC	Lethal concentration, typically expressed as the concentration that results in death of a percentage of test organisms in a given population under a defined set of conditions. LC50 = this is the statistically derived concentration of a substance in an environmental medium expected to produce death in 50% of test organisms

EC50/LC50 are often used in ecotoxicology as an indicator of the toxicity of a compound to the environment.

NOEC	No observed effect concentration (NOEC) – the highest concentration of a compound to which organisms are exposed in a full life-cycle or partial-cycle (short-term) test that causes no observable effects on the test organisms. This is often used to estimate chronic toxicity of chemicals.

In the main report the various ecotoxicological measures available have been more generally referred to as **Tox(eco)** values, which is an abbreviation for toxicity (ecological species) value.

Compound		**Citric acid**	
Proposed concentration in hydraulic fracturing fluid (mg/L)		5991 mg/L (approx.)	AGL
MSDS Available		Yes	
Listed on AICS		Yes	
NICNAS Evaluation		Not assessed but listed as Priority Existing Chemical	
CAS No.		77-92-9	M
Molecular Formula		C6-H8-O7	H
Colour/ Form		white powder or granules	M
Odour/ Taste		odourless, strong acidic taste	M
Odour Threshold		NA	
Corrosive		No	M
Explosive		No	M
Irritation		Mild irritant to skin and eyes	M
Stability		Stable	M
Incompatibility		organic acids, strong alkalis, strong oxidisers	M
Solubility		water, ethanol, ether, ethyl acetate	
Solubility (mg/L in water (20-25^{o}C)		3.83E+05	H
Molecular weight		192.12	H
pH		2 to 2.2	M
Vapour Pressure (mmHg at 20-25^{o}C)		1.70E-08	H
Vapour Density (air = 1)		NA	
Henry's Law (atm.m^{3}/mol at 20-25^{o}C)		4.30E-14	H
Volatility potential	**Soil**	Very low	
	Water	very low	
Log Kow		-1.64	H
Koc		3.1	H
Soil Adsorption/ Mobility		highly mobile	
Potential for bioaccumulation (BCF)		3.2 - low	H
Degradation potential	**Soil**	May be biodegraded with degradation observed in sludge over 1-42 days	H
	Water	Readily biodegradable in aquatic environments (within 5 days)	H
Comments			
Ranking - Fate and Transport		The compound does not sorb to soil or particles in the water column, is readily and rapidly degraded and does not bioaccumulate - potential for discharge to receiving environment is low	**2**

Compound		**Citric acid**	
Human Health			
General		Citric acid is a water soluble organic solid. It is a natural substance that appears as an intermediate in the basic physiological citric acid or Krebs cycle in every eukaryote cell. Citric acid has been produced for many years in high volumes. It has wide dispersive use, being added to processed food and beverages, used in pharmaceutical preparations and in household cleaners as well as in special technical applications.	OECD
Acute Effects		Based on many experimental data in animals and on human experience, citric acid is of low acute toxicity. The primary acute effects are related to irritation of the eyes, respiratory tract and skin. LD50 ranges from 2700 to 12000 mg/kg	H, M, OECD
Occupational Inhalation Guidelines (mg/m3)	**TWA**		
	STEL	NA	
Ranking - Occupational Risk Issues		On the basis of the chemical properties and acute toxicity of the compound - occupational hazard ranking determined as moderate where appropriate PPE is required for the use of this chemical	**3**
Chronic Effects		On the basis of the chemical properties and acute toxicity of the compound - occupational hazard ranking determined as low where appropriate PPE is required for the use of this chemical	
		Citric acid is recognised by Food Standards Australia New Zealand (FSANZ) and the WHO JECFA as safe as a multipurpose food additive. No upper limit of concentrations has been established in food products.	
Classifications		Acetic acid has not been classified by International Agency for Research on Cancer (IARC) or the United States Environment Protection Agency (USEPA). The few studies that are available have not shown that acetic acid is carcinogenic, mutagenic or teratogenic in animal studies.	
Guidelines	**Soil**	NA	
	Drinking water	NA	
	NOAEL	4000 mg/kg/day based on repeated dose oral study	OECD
	NOAEL	425 to 7500 mg/kg/day based on reproductive effects	OECD
	DWGp	15 mg/L (calculated on the basis of the lowest NOAEL and equation in report, however note that the available studies in relation to effects are limited hence this calculation is conservative.	

Compound		**Citric acid**	
Ranking - Chronic Health Impacts		While the concentration in hydraulic fracturing water may exceed the provisional guideline, citric acid is used in many food products with no upper limit set by the WHO of FSANZ, hence the risks have been considered low.	**2**
Ecological			
General		A large number of studies are available in relation to the ecological toxicity of citric acid. Citric acid is extremely widespread in nature and widely distributed in plants and animal tissues and fluids. The following presenting a general summary	OECD
Aquatic toxicity data (mg/L)	**LC50 = 440-1516**	acute toxicity to fish species	OECD, M
	EC50 = 85-1535	acute toxicity to aquatic invertebrates	OECD
	EC = 1 -300	toxicity to aquatic plants	OECD
	NOEC = 80 - 625	chronic toxicity in aquatic invertebrates and fish	OECD
	Tox(eco)	85 to 1535 mg/L	
Published Guidelines	**Fresh water**	NA	
	Marine water	NA	
Ranking - Ecological Impacts		As citric acid is readily degraded the potential for ecological impacts are considered to be low	**2**

OECD 2000, Citric Acid. SIDS Initial Assessment Report, UNEP November 2000.
M = data available on MSDS (refer to Appendix B)
H = data available from HSDB (accessed in February 2012)
S = occupational guidelines available from Safework Australia (retrieved February 2012)

Compound		**Hydrochloric acid**	
Proposed concentration in hydraulic fracturing fluid (mg/L)		128205 mg/L (approx.)	AGL
Listed on AICS		yes	
NICNAS		Not assessment but is classified under NOHSC	
CAS No.		7647-01-0	M
Molecular Formula		Cl-H	H
Colour/ Form		clear, colourless to slightly yellow fuming liquid	M
Odour/ Taste		sharp pungent and irritating odour	M
Odour Threshold		7 mg/m^3	USEPA
Corrosive		Corrosive to metals	M
Explosive		Will react with most metals to evolve hydrogen gas which when mixed with air may result in fire or explosion if ignited	M
Irritation		Irritating to skin and eyes, respiratory system and mouth, oesophagus and stomach, with potential for severe burns	M
Stability		stable	M
Incompatibility		metals	M
Solubility (mg/L in water (20-25^{o}C)		82.3 g/100g	H
Molecular weight		36.46	H
pH		<1	M
Vapour Pressure (mmHg at 20-25^{o}C)		26	M
Vapour Density (air = 1)		1.3	M
Henry's Law (atm.m^3/mol at 20-25^{o}C)		4.90E-10	H
Volatility potential	**Soil**	will evaporate	
	Water	low	
Log Kow		NA	
Koc		NA	
Soil Adsorption/ Mobility		dissociates	
Potential for bioaccumulation (BCF)		negligible	H
Degradation potential	**Soil**	rapidly dissociate to chloride and hydronium ions	
	Water	rapidly dissociates to chloride and hydronium ions	
Ranking - Fate and Transport		The compound does not sorb to soil or particles in the water column, is readily and rapidly dissociated and does not bioaccumulate - potential for discharge to receiving body is low	**2**

Compound		**Hydrochloric acid**	
Human Health			
General		Health effects from exposure to hydrochloric acid are principally associated with acute exposures in occupational environments. In addition many of the effects reported are associated with the pH of the acid rather than the effects of the compounds themselves.	OECD
Acute Effects		There are few detailed studies reported for human exposure. The irritation of hydrogen chloride to mucous is so severe that workers evacuate from the work place shortly after detecting its odour. A relation between concentrations from accidental exposure and health effects have not been reported in detail. The acute oral lethal dose for 50% of the species (LD50) values were determined to be 238-700 mg/kg bw for rats, and the inhalation lethal concentration in air for 50 % of the species (LC50) values were determined to be 23.7-60.9 mg/L (5min), 5.7-7.0 mg/L (30min) and 4.2-4.7 mg/L (60min) for rats, 20.9 mg/L (5min), 3.9 mg/L (30min) and 1.7 mg/L (30min) for mice. Hydrogen chloride is corrosive to the skin and severe effects can be expected from exposure to the eyes. No skin sensitisation has been reported.	OECD, M
Occupational Inhalation Guidelines (mg/m^3)	**TWA**	NA	S
	Peak	7.5	S
Ranking - Occupational Risk Issues		On the basis of the chemical properties and acute toxicity of the compound - occupational hazard ranking determined as moderate to high where appropriate PPE is required for the use of this chemical	**3-4**
Chronic Effects		The available data suggests that effects associated with the low pH of the acid is of most significance in relation to long-term effects. Local irritation effects are most common in long term studies. No evidence of carcinogenic effects were reported during oral, dermal or inhalation studies. No reliable studies are available in relation to the assessment of reproductive or developmental toxicity. Protons and chloride ions are normal constituents in the body fluid of animal species, low concentrations of HCl gas/mist or acid solution do not seem to cause effects. In addition the gastric glands secrete HCl acid into the stomach.	OECD
Classifications		International Agency for Research on Cancer (IARC) has classified hydrochloric acid as a group 3 carcinogen - not classifiable	
Guidelines	**Soil**	NA	
	Drinking water	NA	
	pDWG	NA – not calculated as no health effects identified for the ingestion of this chemical other than those associated with pH.	
Ranking - Chronic Health Impacts		Chronic effects associated with ingestion and dermal contact with this chemical are considered to be low to moderate	**2-3**

Compound		**Hydrochloric acid**	
Ecological			
General		The hazard of hydrochloric acid for the environment is caused by the proton (pH effect). For this reason the effect of hydrochloric acid on the organisms depends on the buffer capacity of the aquatic ecosystem. Also the variation in acute toxicity for aquatic organisms can be explained for a significant extent by the variation in buffer capacity of the test medium. For example, LC50 values of acute fish toxicity tests varied from 4.92 to 282 mg/L. It is not considered useful to calculate a guideline for hydrochloric acid because factors such as the buffer capacity, the natural pH and the fluctuation of the pH are very specific for a certain ecosystem. There is a possibility that the emission of hydrochloric acid could locally decrease the pH in the aquatic environment.	OECD, M
Aquatic toxicity data (mg/L)	**EC50**	Lowest values for pH 4.4 to 5.3 based on short-term studies with algae, invertebrates and fish	H
	Tox(eco)	NA – only effects are associated with pH	
Published Guidelines	**Fresh water**	NA	
	Marine water	NA	
Ranking - Ecological Impacts		The potential for ecological effects is considered to be low, however the buffering capacity of the receiving environment may vary and hence the potential for adverse effects is considered to be moderate	**3**

OECD 2002, OECD SIDS Hydrogen Chloride, SIDS Initial Assessment Report, August 2002
USEPA IRIS evaluation of hydrogen chloride
M = data available on MSDS (refer to Appendix B)
H = data available from HSDB (accessed in February 2012)
S = occupational guidelines available from Safework Australia (retrieved February 2012)

Compound		**Guar gum**	
Proposed concentration in hydraulic fracturing fluid (mg/L)		2397 mg/L (approx.)	AGL
MSDS Available		yes	
Listed on AICS		yes	
NICNAS		Not assessed	
CAS No.		9000-30-0	M
Molecular Formula		NA	
Colour/ Form		off-white solid	M
Odour/ Taste		bean odour	M
Odour Threshold		NA	
Corrosive		No	
Explosive		Airborne dust may be explosive	M
Irritation		May cause eye, skin and respiratory irritation. May cause allergic respiratory reaction	M
Stability		stable	M
Incompatibility		strong oxidisers	M
Solubility		forms gel in water	
Solubility (mg/L in water (20-25oC)		forms gel in water	M
Molecular weight		approx 220000	H
pH		6.5 to 7.5	M
Vapour Pressure (mmHg at 20-25oC)		NA	
Vapour Density (air = 1)		NA	
Henry's Law (atm.m3/mol at 20-25oC)		NA	
Volatility potential	**Soil**	no	
	Water	no	
Log Kow		NA	
Koc		NA	
Soil Adsorption/ Mobility		NA	
Potential for bioaccumulation (BCF)		NA	
Degradation potential	**Soil**	Readily degradable in the environment	
	Water		
Comments		Guar gum is a high molecular weight polysaccharide (sugar complex) extracted from the seeds of the guar plant. It is extensively used as a thickener, stabiliser, suspending agent and binder of free water in many food products including non-alcoholic beverages, frozen dairy desserts, baked goods, gelatine, puddings, meat and meat products, condiments a relishes, breakfast cereals, cheeses, milk products, soups, sweet sauces, gravies, snack foods and processed vegetables. It is also used ion medications, in the paper and textile industries and as a flocculant in mining (including hydraulic fracturing and gelling and waterproofing explosives). As a natural sugar complex, if released into the environment guar gum would be readily dispersed and rapidly biodegraded resulting in no impacts to the aquatic and terrestrial environments.	
Ranking - Fate and Transport		On the basis of the chemical properties of guar gum the potential for discharge to a receiving environment is consider to be negligible	**1**

Compound		**Guar gum**	
Human Health			
General		Guar gum is very poorly absorbed and digested in the human body, is considered non-toxic and hence is used extensively as filler in food products. No adverse effects associated with human exposures to this product have been identified.	
Acute Effects		Acute effects are primarily associated with eye, skin and respiratory irritation. LD50 (oral) identified to be 6770 mg/kg in rats.	H, M
Occupational Inhalation Guidelines (mg/m3)	**TWA**	NA	
	STEL	NA	
Ranking - Occupational Risk Issues		On the basis of the chemical properties and acute toxicity of the compound - occupational hazard ranking determined as low where appropriate PPE is required for the use of this chemical	**2**
Chronic Effects		No adverse effects have been observed in chronic rat studies where guar gum was administered at a dietary concentration of 5% for 24 months. No carcinogenic effects have been observed in any of the available studies. As this compound is widely used in food products with no safety concern, no TDI is available.	
Classifications		NA	
Guidelines	**Soil**	NA	
	Drinking water	NA	
	pDWG	NA – not calculated as no adverse health effects identified	
Ranking - Chronic Health Impacts		The potential for long term human health impacts, should exposure occur, is considered to be negligible	**1**
Ecological			
General		No data is available in relation to ecological effects of guar gum, however as it is a natural sugar complex that is rapidly degraded in the environment, no adverse effects are relevant to terrestrial and aquatic environments.	
Published Guidelines	**Fresh water**	NA	
	Marine water	NA	
Ranking - Ecological Impacts		On the basis of the available information on the nature of the compound, ecological effects have been determined to be negligible.	**1**

M = data available on MSDS (refer to Appendix B)
H = data available from HSDB (accessed in February 2012)
S = occupational guidelines available from Safework Australia (retrieved February 2012)

Compound		**Acetic acid**	
Proposed concentration in hydraulic fracturing fluid (mg/L)		314 (approx.)	AGL
Listed on AICS		yes	
NICNAS		No assessment by NICNAS but is classified under NOHSC	
CAS No.		64-19-7	M
Molecular Formula		C2-H4-O2	H
Colour/ Form		Colourless liquid in aqueous solution	M
Odour/ Taste		Pungent, sour, vinegar-like odour with burning taste	M
Odour Threshold		range from 0.21 to 1ppm, detection at 24.3ppm	H
Corrosive		Corrosive to eyes and skin	M
Explosive		NA	
Irritation		irritation occurs at 25 mg/m^3 in air	M
Stability		stable as an aqueous solution	M
Incompatibility		oxidising agents that include nitrates, carbonates, hydroxides, oxides, phosphates, metals. Amines and perchloric acid	M
Solubility (mg/L in water (20-25oC)		NA	H
Molecular weight		60.05	H
pH		1.38	M
Vapour Pressure (mmHg at 20-25oC)		11.7 to 15.7	M,H
Vapour Density (air = 1)		2.1	H
Henry's Law (atm.m3/mol at 20-25oC)		1.00E-07	H
Volatility potential	**Soil**	low	H
	Water	no	
Log Kow		-0.17	H
Koc		6.5 to 228	H
Soil Adsorption/ Mobility		Not expected to sorb to soil, suspended solids or sediment. Highly mobile in the environment where the compound is expected to remain present in the dissociated form.	H
Potential for bioaccumulation (BCF)		3.2 - low	H
Degradation potential	**Soil**	Rapidly biodegrades under aerobic and anaerobic conditions. A range of data are available that suggest: • in soil 75% degradation occurs in 14 days; • in sludge 90% degradation occurs in 3 days; • acetic acid degrades 12.3% per hour in estuarine waters, 1% per hour in coastal water and 0.06% in seawater; and • in a biofilm column study, 95% removal of acetic acid under aerobic conditions and 99% removal under methanogenic conditions was observed	H
	Water		
Ranking - Fate and Transport		The compound does not sorb to soil or particles in the water column, is readily and rapidly degraded and does not bioaccumulate - potential for offsite risk issues is low	**2**

Compound		**Acetic acid**	
Human Health			
	General	Health effects from exposure to acetic acid are principally associated with acute exposures in occupational environments. Acetic acid is absorbed from the gastrointestinal tract and through the lungs. It is readily metabolised by most tissues and may give rise to the production of ketones as intermediates.	H
	Acute Effects	Acetic acid is a strong eye, skin, and mucous membrane irritant. Prolonged skin contact with glacial acetic acid may result in tissue destruction (HSDB). Inhalation exposure (8 hours) to acetic acid vapours at 10 ppm could produce some irritation of eyes, nose, and throat; at 100 ppm marked lung irritation and possible damage to lungs, eyes, and skin might result. Immediately dangerous to life or health (IDLH) vapour concentrations of 1,000 ppm cause marked irritation of eyes, nose and upper respiratory tract and cannot be tolerated. These predictions were based on animal experiments and industrial exposure. Skin sensitisation to acetic acid is rare, but has occurred	H
Occupational Inhalation Guidelines (mg/m3)	**TWA**	25	S
	STEL	37	S
	Ranking - Occupational Risk Issues	On the basis of the chemical properties and acute toxicity of the compound - occupational hazard ranking determined as moderate where appropriate PPE is required for the use of this chemical	**3**
	Chronic Effects	There are no data that suggest that long-term exposures to low concentrations of acetic acid results in adverse health effects. There are no chronic toxicity reference values available for acetic acid.	
		Acetic acid is recognised by Food Standards Australia New Zealand (FSANZ) and the US Food and Drug Administration (FDA) as safe as a multipurpose food additive, as a substance migrating to food from cotton and cotton fabrics used in dry-food packaging, as a substance migrating to food from paper and paperboard products, and as a general purpose food additive for animal feed.	
	Classifications	Acetic acid has not been classified by International Agency for Research on Cancer (IARC) or the United States Environment Protection Agency (USEPA). The few studies that are available have not shown that acetic acid is carcinogenic, mutagenic or teratogenic in animal studies.	
Guidelines	**Soil**	NA	
	Drinking water	NA	
	pDWG	NA – not calculated as no health effects identified other than those associated with pH	

Compound		**Acetic acid**	
Ranking - Chronic Health Impacts		Chronic effects considered to be negligible as pH will be rapidly neutralised once in the environment	**1**
Ecological			
General		Limited data is available in relation to ecotoxicological data for acetic acid. The MSDS available notes that acetic acid is on the “OSPAR List of Substances/Preparations Used and Discharged Offshore which are considered to pose little or no risk to the environment”.	M,H
Aquatic toxicity data (mg/L)	**LC50**	=100 to 300, for shrimp over 48 hr exposure in aerated water	H
	LC50	= 32 for Artemia salina	M
	LC50	=75, Lepomis macrochirus (Bluegill sunfish), 96 hour static bioassay	H
	LC50	=251, Gambusia affinis (Mosquito fish), 96 hour static bioassay at pH 6.9-8.7 and 16-25^{o}C	H
	EC50	=6000, Daphnia magna, 24 hour endpoint: immobilisation (static bioassay neutralised to pH 8.0 and 20 ^{o}C)	H
	Tox(eco)	32 – 300 mg/L (based on LC50)	
Published Guidelines	**Fresh water**	NA	
	Marine water	NA	
Ranking - Ecological Impacts		Potential concentrations in hydraulic fracturing fluid is similar to the Tox(eco) concentrations, however where diluted in the seam groundwater, concentrations are expected to be lower. Hence the potential for adverse effects to aquatic ecosystems is considered low	**2**

M = data available on MSDS (refer to Appendix B)
H = data available from HSDB (accessed in February 2012)
S = occupational guidelines available from Safework Australia (retrieved February 2012)

Compound		**Hemicellulase Enzyme Concentrate**	
Proposed concentration in hydraulic fracturing fluid (mg/L)		4.5 (approx.)	AGL
MSDS Available		yes	
Listed on AICS		yes	
NICNAS		Not assessed	
CAS No.		9025-56-3	M
Molecular Formula		NA	
Colour/ Form		brown liquid	M
Odour/ Taste		sweet organic odour	M
Odour Threshold		NA	
Corrosive		No	M
Explosive		NA	
Irritation		May cause allergy or asthma symptoms or breathing difficulties if inhaled	M
Stability		stable	M
Incompatibility		oxidizing materials and acids	M
Solubility		soluble in water	
Solubility (mg/L in water (20-25oC)		NA	
Molecular weight			
pH		3.5-5	M
Vapour Pressure (mmHg at 20-25oC)		NA	
Vapour Density (air = 1)		NA	
Henry's Law (atm.m3/mol at 20-25oC)		NA	
Volatility potential	**Soil**	no	
	Water	no	
Log Kow		NA	
Koc		NA	
Soil Adsorption/ Mobility		NA	
Potential for bioaccumulation (BCF)		Low	H
Degradation potential	**Soil**	All the enzymes rapidly degrade aerobically and it is highly likely that they will be anaerobically decomposed like biomass in general.	HERA
	Water		

Compound		**Hemicellulase Enzyme Concentrate**	
General		There are several different kinds of cellulases (produced by fungi, bacteria and protozoans) that differ structurally and mechanistically, that are enzymes that catalyse the hydrolysis of cellulose. Enzymes that hydrolyse hemicellulose are usually referred to as hemicellulase and are usually classified under cellulase in general. Hemicellulase is a type of enzyme that catalyse the hydrolysis of cellulose, or degrades the plant cell wall polymer hemicellulose. Hemicellulose is any of several heteropolymers (matrix polysaccharides), such as arabinoxylans, present along with cellulose in almost all plant cell walls. While cellulose is crystalline, strong, and resistant to hydrolysis, hemicellulose has a random, amorphous structure with little strength. It is easily hydrolysed by dilute acid or base as well as myriad hemicellulase enzymes.	HERA
		Hemicellulase is used commercially in baking products and in various other food preparation technologies. It is used in cake mixes, baked goods, and frozen dough. The enzyme enhances the quality of the dough and helps with storage life. This type of enzyme is also produced by microorganisms that live in the human digestive tract and degrade dietary hemicellulose, which humans are incapable of digesting. It is taken by some as a supplement to aid in digestion.	HERA
Ranking - Fate and Transport		On the basis that this compound readily and rapidly degrades in the environment and does no bioaccumulate - potential for offsite risk issues is negligible	**1**
Human Health			
General		Health effects from exposure to this compound are principally associated with acute exposures in occupational environments.	M
Acute Effects		On the basis of the information presented in the MSDS, the product has been shown to result in adverse effects where inadequate PPE is worn. Inhalation exposures may result in irritation effects of the mucous membranes of the nose and throat resulting in coughing, dizziness and headache. May cause respiratory sensitisation with asthma-like symptoms in susceptible individuals. Those individuals with pre-existing respiratory impairment or disease are advised to avoid exposure. Dermal exposures may result in irritation, skin rash and dermatitis. It is noted to be a potential skin sensitiser. Ingestion may result in headache, nausea, vomiting, gastrointestinal irritation and diarrhoea	M
Occupational Inhalation Guidelines (mg/m3)	**TWA**	NA	
	STEL	NA	
Ranking - Occupational Risk Issues		On the basis of the chemical properties and acute toxicity of the compound - occupational hazard ranking determined as moderate where appropriate PPE is required for the use of this chemical	**3**

Compound		**Hemicellulase Enzyme Concentrate**	
Chronic Effects		Other than occupational risk issues, noted above, no chronic studies are available that specifically address exposures to hemicellulose. Given that the enzyme is rapidly and completely degraded it is considered unlikely that it would be present in any environment where long-term exposures by humans may occur. If it were present it is considered unlikely to be present at concentrations that were identified as of concern in occupational environments. It is noted that this type of enzyme is also produced by microorganisms that live in the human digestive tract and degrade dietary hemicellulose, which humans are incapable of digesting. As proteins, enzymes are readily biodegraded in the gastrointestinal tract resulting in negligible bioavailability. The enzyme is taken by some as a supplement to aid in digestion and hence at concentrations that may be present in an environment (such as surface water or irrigation water) the enzyme is not considered to be toxic. More general information from repeated toxicity studies on cellulose (HERA, 2005) did not identify any significant effects, including no evidence of mutagenic activity, associated with ingestion of the enzyme. No carcinogenic potential would be predicted for this class of substance on the basis that there are no data suggesting carcinogenic outcomes from public literature, it has been demonstrated that the systemic bioavailability of enzymes is expected to be low and toxicologically insignificant, and as proteins, enzymes are readily biodegraded in the gastrointestinal tract resulting in negligible bioavailability.	
Classifications		NA	
Guidelines	**Soil**	NA	
	Drinking water	NA	
	pDWG	NA – not calculated as no adverse health effects identified in relation to exposure to this compound	
Ranking - Chronic Health Impacts		Chronic effects considered to be negligible	**1**

	Compound	**Hemicellulase Enzyme Concentrate**	
	Ecological		
	General	No data is available specifically in relation to ecotoxicological data for Hemicellulase Enzyme Concentrate. More generally in relation to the aquatic toxicity of cellulases (HERA 2005), the limited studies available indicate a low toxicity to aquatic species. The LD50 was found to be greater than 100 mg/L with a number of studies showing no effects at the highest levels of exposure relevant to the bioassays conducted. Given that the enzyme is rapidly and completely degraded, and the protein is expected to be rapidly converted within any species in a receiving environment, it is considered unlikely that it would be present in any environment where environmental exposures may occur.	HERA
Aquatic toxicity data (mg/L)	**LC50**	NA	H
	LC50	NA	H
	LC50	NA	H
	LD50	>100mg/L	HERA
	EC50	NA	H
Published Guidelines	**Fresh water**	NA	
	Marine water	NA	
Ranking - Ecological Impacts		Potential concentrations in hydraulic fracturing fluid are lower than available LD50 concentrations. Hence the potential for adverse effects to aquatic ecosystems is considered negligible.	**1**

HERA, 2005. α-Amylases, Cellulases and Lipases, Human & Environmental Risk Assessment on ingredients of household cleaning products, Edition 1.0, November 2005.
M = data available on MSDS (refer to Appendix B)
H = data available from HSDB (accessed in February 2012)
S = occupational guidelines available from Safework Australia (retrieved February 2012)

Compound		**Monoethanolamine Borate**	
Proposed concentration in hydraulic fracturing fluid (mg/L)		0 to 1250 mg/L (approx.)for proposed products	AGL
Listed on AICS		yes	
NICNAS		Not assessed	
CAS No.		26038-87-9	M
Molecular Formula		C2-H8-B-N-O3	M
Colour/ Form		blue liquid	M
Odour/ Taste		amine odour	M
Odour Threshold		NA	
Corrosive		considered corrosive	M
Explosive		NA	
Irritation		may cause irritation to eye, skin and respiratory system	M
Stability		Stable	M
Incompatibility		Strong oxidizers, dehydrating agents	M
Solubility (mg/L in water (20-25^{o}C)		approx 1x10^{-6} (2-aminoethanol)	
Molecular weight		104.9	M
pH		7.9	M
Comments		Very little data is available for this compound. Compound also a synonym of boric acid (CAS 10377-81-8) with 2-aminoethanol ester. This compound is also referred to as a borate ester. In relation to this compound data available for boric acid, 2-aminoethanol and borate esters. While a summary of some of the information for boric acid is presented in the following a review of boric acid is presented in the following summary.	
Vapour Pressure (mmHg at 20-25^{o}C)		0.404 for 2-aminoethanol	H
Vapour Density (air = 1)		2.1 for 2-aminoethanol	H
Henry's Law (atm.m^{3}/mol at 20-25^{o}C)		3.25x10^{-8} for 2-aminoethanol	H
Volatility potential	**Soil**	low	H
	Water	negligible	H
Log Kow		-1.31 for 2-aminoethanol	H
Koc		5 for 2-aminoethanol	H
Soil Adsorption/ Mobility		Likely to sorb to soil and sediments, however the compound may be partially mobile in soil	H
Potential for bioaccumulation (BCF)		low for all component compounds considered	H
Degradation potential	**Soil**	NA	
	Water	NA	
Ranking - Fate and Transport		A large level of uncertainty applies to the evaluation presented here, however there is the potential for this compound to be at least partially mobile in the environment, however it is not expected to bioaccumulate.	**2-3**

Compound		**Monoethanolamine Borate**	
Human Health			
General		Refer to the boric acid chemical summary for general and acute toxicity information on that component compound	
Acute Effects		Potential for 2-aminoethanol or ethanolamine to be irritating to the skin, eyes and respiratory system. Acute exposures have been associated with central nervous system depression, increased blood pressure, salivation, pupillary dilation with large doses associated with sedation, coma and death.	H
Occupational Inhalation Guidelines (mg/m3)	**TWA**	10 for boric acid	S
	Peak	NA	
Ranking - Occupational Risk Issues		On the basis of the chemical properties and acute toxicity of the compound - occupational hazard ranking determined as low to moderate where appropriate PPE is required for the use of this chemical	**2-3**
Chronic Effects		Refer to the boric acid chemical summary for chronic toxicity of that component. In relation to 2-aminoethanol, repeated inhalation studies have shown behavioural changes, reduced body weight and pathological lesions to the lung, liver, kidneys, spleen and testes in a number of species. Insufficient data is available to evaluate carcinogenicity and in the studies available, the compound has not been shown to be mutagenic.	EU, NSF
Guidelines	**Soil**	3000 to 15000 mg/kg for residential to industrial land use	NEPM
	Drinking water	4 mg/L for boron	NHMRC
		2.4 mg/L for boron	WHO
	Irrigation	0.5 mg/L for boron	ANZECC
	Oral TDI	0.16 mg/kg/day for boron	NHMRC
		0.17 mg/kg/day for boron	WHO
		0.2 mg/kg/day for boron	USEPA
		0.04 mg/kg/day for monoethanolamine	NSF
		0.05 mg/kg/day for monoethanolamine in food	EU
Ranking - Chronic Health Impacts		On the basis of the available information in relation to long-term health effects of boron, and consideration of 2-aminoethanol, the compound has been ranked as moderate risk	**3**

Compound		**Monoethanolamine Borate**	
Ecological			
General		Refer to the boric acid chemical summary for ecological toxicity of that component. In relation to 2-aminoethanol, few detailed reviews are available, however the following range of effects levels are available from the USEPA PAN Pesticides Database.	
Aquatic toxicity data (mg/L)	**LC50 and EC50**	31 mg/L to 5000 mg/L for 2-aminoethanol	US
Published Guidelines	**Fresh water**	0.37 mg/L for boron based on 95% protection, high reliability trigger level for slightly-moderately disturbed ecosystems.	ANZECC
	Marine water	NA	
Ranking - Ecological Impacts		Potential concentrations in hydraulic fracturing fluids are below the available LD50 and EC50 concentrations (up to 5000 mg/L) established for aquatic species for 2-aminoethanol. However the concentration exceeds the ANZECC fresh water guideline for boron. The contribution of boric acid to the overall toxicity is not known, hence the potential for adverse effects has been conservatively considered to be the same as determined for boric acid/boron.	**3**

NSF International. 2008. Ethanolamine. CAS # 141-43-5. Oral Risk Assessment Document. January.
EU 2000. Opinion of the Scientific Committee on Food on the 10th additional list of monomers and additives for food contact materials. European Commission, 11 July 2000
M = data available on MSDS (refer to Appendix B)
H = data available from HSDB (accessed in February 2012)
S = occupational guidelines available from Safework Australia (retrieved February 2012)

Compound		**Boric Acid**	
Listed on AICS		yes	
NICNAS		Not assessed	
CAS No.		10043-35-3	M
Molecular Formula		B-H3-O3	H
Colour/ Form		white granules	M
Odour/ Taste		odourless	M
Odour Threshold		NA	
Corrosive		yes	M
Explosive		NA	
Irritation		mild irritant to eyes, dust may be mechanically irritating	M
Stability		stable under recommended conditions	M
Incompatibility		strong bases	M
Solubility (mg/L in water (20-25oC)		5.00E+04	H
Molecular weight		61.833	H
pH		5.1	M
Vapour Pressure (mmHg at 20-25oC)		5.24E-18	US
Vapour Density (air = 1)		NA	US
Henry's Law (atm.m3/mol at 20-25oC)		NA	
Volatility potential	**Soil**	no	
	Water	no	
Soil Adsorption/ Mobility		Boron compounds in water may be adsorbed by soils and sediments. The extent of boron adsorption depends on the pH of the water. The greatest adsorption is observed at pH 7.5-9.0. Since the adsorption of boron is expected to be most significant for soils that contain high concentrations of amorphous aluminium and iron oxides and hydroxides, sediments with these characteristics may also strongly adsorb boron compounds.	H
Potential for bioaccumulation (BCF)		Review of bioconcentration data for boron by ATSDR (2010) suggests that in marine and freshwater plants, fish and invertebrates boron is not significantly bioconcentated.	ATSDR
Degradation potential	**Soil**	NA	
	Water	NA	
Comments		In aqueous solution, boron is normally present as boric acid and borate ions, with the dominant form of inorganic boron as undissociated boric acid in natural aqueous systems. In aqueous solution, boric acid acts as an electron acceptor (Lewis acid), accepting hydroxide from water to form (B(OH)4)- ion. In concentrated solutions (>0.1 M boric acid) polymeric species are formed.	H
Ranking - Fate and Transport		Overall, the potential for off-site impacts is considered to be low to moderate depending on the pH of the groundwater, the potential for boric acid and boron ions to be discharge to an aquatic environment and the nature of the boron ions present.	**2-3**

Compound		**Boric Acid**	
Human Health			
General		Boron is a naturally-occurring element that is widespread in nature; the average concentration in the earth's crust has been estimated to be 10 ppm. Boron in the environment is always found chemically bound to oxygen, usually as alkali or alkaline earth borates, or as boric acid. Boron is not transformed or degraded in the environment, but depending on environmental conditions (e.g., pH, moisture level), changes in the specific form of boron and its transport can occur. Boron is regarded as an essential trace mineral that affects the absorption, excretion, and metabolism of calcium, magnesium, and phosphorus in the body. Consequently, boron plays an important role in keeping bones and joints healthy, and may be important in treating and/or preventing osteoporosis and arthritis. Hence adverse effects are associated with both deficiency and elevated exposures. Numerous studies have shown that boric acid and borax are absorbed from the gastrointestinal tract and from the respiratory tract, as indicated by increased levels of boron in the blood, tissues, or urine or by systemic toxic effects of exposed individuals or laboratory animals. Absorption is poor through intact skin.	ATSDR
Acute Effects		The primary health effects associated with inhalation exposure of humans to boron are acute respiratory irritation. Acute-duration exposures of mining and processing workers to 0.44–3.1 mg boron/m^3 (5.7–14.6 mg particulates/m^3) as sodium borate dusts has been associated with mild irritation of the eyes, throat, and nose, as well as cough and breathlessness. Human case reports have shown that boron can be lethal following short-term oral exposure at high doses, although the dose estimation can be quite imprecise and variability in human responses to acute exposure is quite large. The minimal lethal dose of ingested boron (as boric acid) was reported to be 2–3 g in infants, 5–6 g in children, and 15–20 g in adults (ATSDR 2010). Other effects associated with acute toxicity for both borax and boric acid in animals given single large doses orally include depression, ataxia, convulsions, and death; kidney degeneration and testicular atrophy are also observed (WHO 2009).	ATSDR, WHO
Occupational Inhalation Guidelines (mg/m3)	**TWA**	10	S
	STEL		

Compound		**Boric Acid**	
Ranking - Occupational Risk Issues		On the basis of the chemical properties and acute toxicity of the compound - occupational hazard ranking determined as moderate where appropriate PPE is required for the use of this chemical	**3**
Chronic Effects		Limited human studies have not identified significant adverse health effects associated with exposures to boron. Animal studies have identified the reproductive system and developing foetus are the most sensitive targets of boron toxicity. Adverse developmental effects have been identified for acute-and intermediate-duration exposures. Decreases in the number of live foetuses and litters, decreases in body weight, and increases in the occurrence of external, visceral, and cardiovascular malformations were observed. Other systemic effects have been observed in orally exposed animals. Consistently observed effects following intermediate and chronic exposure include haematological alterations (decreases in haemoglobin levels and splenic haematopoiesis), desquamated skin, chronic inflammation and coagulative necrosis of the liver have also been observed (ATSDR 2010).	A
		No epidemiology studies have identified an association between boron exposure and development of cancer. However, some investigators have suggested that boron exposure in drinking water may be associated with lower incidences of some types of cancer in humans. *In vitro* genotoxicity assays have given predominantly negative results.	
Classifications		The International Agency for Research on Cancer (IARC), the National Toxicology Program (NTP), and EPA have not classified boron for human carcinogenicity.	
Guidelines	**Soil**	3000 to 15000 mg/kg for residential to industrial land use	NEPM
	Drinking water	4 mg/L for boron	NHMRC
		2.4 mg/L for boron	WHO
	Irrigation	0.5 mg/L for boron	ANZECC
	Oral TDI	0.16 mg/kg/day for boron	NHMRC
		0.17 mg/kg/day for boron	WHO
		0.2 mg/kg/day for boron	USEPA
Ranking - Chronic Health Impacts		On the basis of the available information in relation to long-term health effects of boron the compound has been ranked as moderate risk	**3**

Compound		**Boric Acid**	
Ecological			
General		The main species present in freshwaters, depending on pH, are borates e.g. B(OH)4- and boric acid B(OH)3, a weak acid, and the main removal mechanism is adsorption onto suspended clays or sediments, particularly on contact with seawater. Boron is an essential element required by aquatic plants. Boron is an important buffer for maintaining the pH of seawater	ANZECC
Published Guidelines	**Fresh water**	0.37 mg/L for boron based on 95% protection, high reliability trigger level for slightly-moderately disturbed ecosystems.	ANZECC
	Marine water	NA	
Ranking - Ecological Impacts		In relation to boron, the available data suggest it is moderately toxic to freshwater aquatic species.	**3**

ATSDR, 2010. Toxicological Profile for Boron, Agency for Toxic Substances and Disease Registry, November 2010.
ANZECC, 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. National Water Quality Management Strategy. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, 2000
NEPM 1999. Health Based Investigation Levels.
NHMRC, 2011. (National Health and Medical Research Council and the Agriculture and Resource Management Council of Australia and New Zealand). Australian Drinking Water Guidelines - 6. National Water Quality Management Strategy.
WHO, 2009. Boron in Drinking Water, Background document for development of WHO Guidelines for Drinking-water Quality, 2009

M = data available on MSDS (refer to Appendix B)
H = data available from HSDB (accessed in February 2012)
S = occupational guidelines available from Safework Australia (retrieved February 2012)

Compound	**Choline Chloride**	
Proposed concentration in hydraulic fracturing fluid (mg/L)	1632 (approx.)	AGL
Listed on AICS	yes	
NICNAS	Not assessed	
CAS No.	67-48-1	M
Molecular Formula	$C_5H_{14}NO.Cl$	S
Colour/ Form	White crystalline solid or colourless liquid	S
Odour/ Taste	Amine-like odour	S
Odour Threshold	NA	
Corrosive	no	M
Explosive	no	M
Irritation	Not significantly irritating to skin	E
Stability	stable at room temperature	M
Incompatibility	reacts with strong oxidants	M
Solubility (mg/L in water (20-25oC)	1.0E+06	S
Molecular weight	139.63	H
pH	NA	
Vapour Pressure (mmHg at 25oC)	4.9E-10	S
Vapour Density (air = 1)	NA	
Henry's Law (atm.m3/mol at 20-25oC)	2.06E-11	EPI
Volatility potential **Soil**	no	
Water	no	
Log Kow	-5.16	H (EPI)
Koc	2.3	S
Soil Adsorption/ Mobility	Will not adsorb to soil or sediments and hence may be mobile based on Koc values. The compound will not readily volatilise from soil or water.	S
Potential for bioaccumulation (BCF)	<1 - low	S
Degradation potential **Soil**	Considered to be readily biodegradable with 93% biodegradation occurring within 14 days.	S
Water		
Ranking - Fate and Transport	Overall, if released into the environment, choline chloride is considered to be mobile, being readily soluble in water and will poorly adsorb to particulates. However the compound is readily biodegradable and is not bioaccumulative in aquatic species or the food chain.	**2**

Compound		**Choline Chloride**	
Human Health			
General		Choline is an endogenous compound within the body. In addition it is a dietary component and found in foods as free choline and as esterified forms such as phosphocholine, glycerophosphocholine, sphingomyeline, and phosphatidylcholine. It functions as a precursor for acetylcholine, phospholipids, and the methyl donor betaine and is important for the structural integrity of cell membranes, methyl metabolism, cholinergic neurotransmission, transmembrane signaling, and lipid and cholesterol transport and metabolism.	S
Acute Effects		The critical adverse effect from high intake of choline is hypotension, with corroborative evidence on cholinergic side effects (e.g., sweating and diarrhoea) and fishy body odour. After inadequate dietary intake decreased choline stores and liver damage (as assessed by elevated alanine aminotransferase) may develop. Animal studies with choline chloride show a low acute toxicity after oral uptake (with a range of LD50s of 3150 – ≥5000 mg/kg bw determined in different studies). No acute toxicity attributable to choline was observed in humans following oral doses of ≥3000 mg choline magnesium trisalicylate/day.	S
Occupational Inhalation Guidelines (mg/m^3)	**TWA**	NA	
	STEL	NA	
Ranking - Occupational Risk Issues		On the basis of the chemical properties and acute toxicity of the compound - occupational hazard ranking determined as negligible to low.	**1-2**
Chronic Effects		Based on the available data the following is noted in relation to chronic/repeated exposures to choline chloride: • no adverse effects have been observed on chronic animal studies associated with intakes up to 500 mg/kg bw/day. • The compound does not show a mutagenic, clastogenic or DNA damaging potential. • No developmental effects have been observed. • Limited effects have been observed on fertility, but not at normal levels of exposure (from the diet and formed from natural metabolic processes). Choline chloride is considered to be of low toxicity. This is not unexpected in view of its presence in the diet and its production in metabolic processes in the body; it fulfils key roles in nerve transmission, cell membrane integrity, and lipid metabolism. It is noted that inadequate choline levels are also associated with chronic effects that include liver damage.	**S**

Compound		Choline Chloride	
Guidelines	**Soil**	NA	
	Drinking water	NA	
	TDI	Adequate daily intakes for choline is 8 mg/kg/day for infants, which is also relevant for adult males and lactating women. For choline chloride the TDI is 11.2 mg/kg/day (1.4 times higher)	EU
	Upper Limit	Tolerable upper limit established by the US for adults is 3500 mg/day or 58 mg/kg/day	S, EU
	DWGp	39 mg/L based on the TDI and equation in report, and 12250 mg/L based on the tolerable upper limit and equation in report	C
Ranking - Chronic Health Impacts		On the basis of the available information in relation to the chronic human toxicity of choline chloride is has been ranked as Category 1 (negligible)	**1**
Ecological			
General		The following aquatic acute and chronic effect concentrations for freshwater as well as for marine species are available: Fish *Oryzias latipes* LC50 (96h) > 100 mg/l (nominal and measured) *Limanda limanda* LC50 (96h) > 1,000 mg/l (nominal) Invertebrates *Daphnia magna* EC50 (48h) = 349 mg/l (nominal and measured) *Daphnia magna* NOEC (21d) 30.2 mg/L (nominal and measured) *Crangon crangon* EC50 (48h) > 1,000 mg/l (nominal) Algae *Pseudokirchneriella subcapitata* ErC50 (72h) > 1,000 mg/L (nominal and measured), 72h NOEC (growth rate) 32 mg/l. Based on these data choline chloride is considered unlikely to be harmful to aquatic organisms. Based on the available data, choline chloride is expected to exert toxicity by a non-specific mode of action. An acute **PNEC$_{aqua}$ of 3.5 mg/L** can be derived on the basis of the Technical Guidance Document for the EU risk assessment procedure. The chronic value is equivalent.	S
Published Guidelines	**Fresh water**	NA	
	Marine water	NA	

Compound	Choline Chloride	
Ranking - Ecological Impacts	On the basis of the available information, if choline chloride were released directly into the environment, it is considered to be of low toxicity to aquatic environments, however the concentration proposed in the fracturing fluids is higher than the PNEC. The compound readily degrades in the environment and hence unlikely to remain long enough to be of concern in relation to chronic effects. Based on the potential for concentrations to be higher than the PNEC the potential for ecological impacts have been evaluated to be low to moderate.	**2-3**

EU 2003. Opinion of the Scientific Committee on Cosmetic Products and Non-Food Products Intended for Consumers concerning Choline Chloride.
M = data available on MSDS (refer to Appendix B)
H = data available from HSDB (accessed in January 2013)
S = OECD SIDS evaluation for choline chloride (October 2004)
C = calculated

Compound		**Sodium Hypochlorite**	
Proposed concentration in hydraulic fracturing fluid (mg/L)		181	AGL
Listed on AICS		yes	
NICNAS		Not assessed but listed as Priority Existing Chemical	
CAS No.		7681-52-9	M
Molecular Formula		Na-O-Cl	H
Colour/ Form		greenish yellow liquid	M
Odour/ Taste		chlorine like sweetish disagreeable odour	M
Odour Threshold		NA	
Corrosive		Corrosive to most metals including aluminium, copper, brass, bronze, carbon steel, Hastelloy, Inconel, lead, Monel, nickel and stainless steel type 400 series. Not corrosive to tantalum, titanium and zirconium	M
Explosive		Anhydrous Sodium Hypochlorite is very explosive. Primary amines and calcium hypochlorite or sodium hypochlorite react to form normal chloramines, which are explosive. Interaction of ethyleneimine with sodium (or other) hypochlorite gives the explosive N-chloro-compound. Removal of formic acid from industrial waste streams with sodium hypochlorite solution becomes explosive at 55 deg C. Several explosions involving methanol and sodium hypochlorite were attributed to formation of methyl hypochlorite, especially in presence of acid or other esterification catalyst. Use of sodium hypochlorite solution to destroy acidified benzyl cyanide residues caused a violent explosion, thought to have been due to formation of nitrogen trichloride	M
Irritation		Can cause irritation of the eyes, skin, respiratory and gastrointestinal tract. Exposure to high levels can result in severe corrosive damage to the eyes, skin, respiratory and gastrointestinal tissues and can be fatal	M
Stability		Stable however stability decreases with concentration, heat, light exposure, pH level and contamination with heavy metals	M
Incompatibility		Ether, ammonia acids, reducing agents, oxidisable materials, combustible materials (wood, cloth, organic materials) heavy metals (iron, copper and their alloys), dirt, magnesium, aluminium, tin and manganese. Does not polymerize	M
Solubility (mg/L in water (20-25oC)		29.3 g/100 g	H
Molecular weight		74.44	H
pH		12 for 10% solution	M
Vapour Pressure (mmHg at 20-25oC)		12.1	M
Vapour Density (air = 1)		0.9	H
Henry's Law (atm.m3/mol at 20-25oC)		2.21E-05	H
Volatility potential	**Soil**	low	
	Water	low	
Soil Adsorption/ Mobility		highly mobile	

Compound		**Sodium Hypochlorite**	
Potential for bioaccumulation (BCF)		no issues identified	SDA
Degradation potential	**Soil**	Compound is rapidly consumed through oxidation reactions to form chlorides. Some chlorinated compounds may be formed of which the low MW compounds are rapidly degraded but high MW compounds may be more persistent. Breakdown is rapid in the presence of sunlight with half-life from seconds to hours.	SDA
	Water		
Ranking - Fate and Transport		Overall, of released into the environment, sodium hypochlorite does not sorb to solid particles in the water column, is rapidly converted to lighter, readily degradable chlorinated compounds. Studies on the chlorinated by-products of sodium hypochlorite did not identify any bioaccumulative compounds. Hence sodium hypochlorite and associated by-products are not considered to be bioaccumulative in aquatic species or the food chain. The potential for migration to a receiving environment is considered to be low.	**2**
Human Health			
General		Health effects from exposure to sodium hypochlorite are principally associated with acute exposures in occupational environments. Although sodium hypochlorite solution itself is only moderately toxic, it liberates chlorine gas when acidified e.g. if mixed with acidic cleaning agents. Mixing sodium hypochlorite with ammonia-based solutions gives rise to chloramine compounds. Both chlorine and chloramines are strong respiratory irritants hence contribute to the toxic effects.	H
Acute Effects		Ingestion of small volumes of sodium hypochlorite causes burns to the mouth and throat, gastrointestinal irritation, nausea and vomiting. Larger volumes (approximately 300 ml in adults; 100 ml in children) may also cause abdominal and retrosternal pain and diarrhoea. Inhalation of chlorine gas causes burning of the throat and lungs, eye and nose irritation, chest tightness and coughing. At higher levels of exposure, tachypnoea, cyanosis and swelling of the airway may occur. Pulmonary oedema and respiratory failure may arise in severe cases, the onset of which may take up to 36 hours. In most cases symptoms are usually resolved in 1 – 4 weeks. However, in some instances pulmonary damage may lead to long-term Reactive Airways Dysfunction Syndrome (RADS), a chemical irritant-induced type of asthma following an acute respiratory exposure to an irritant gas. In addition, Acute Respiratory Distress Syndrome (ARDS), as a result of pneumonitis, has been reported in patients following inhalation of chlorine following the mixing of sodium hypochlorite and other hydrochloric acid. Sodium hypochlorite is corrosive and may irritate the skin or cause burning pain, inflammation and blisters. Ocular exposure can cause irritation, pain, lacrimation and photophobia.	UK

Compound		**Sodium Hypochlorite**	
Occupational Inhalation Guidelines (mg/m3)	**TWA**	NA	
	Peak	3 for chlorine gas	S
Ranking - Occupational Risk Issues		On the basis of the chemical properties and acute toxicity of the compound - occupational hazard ranking determined as moderate to high where appropriate PPE is required for the use and this chemical	**3-4**
Chronic Effects		Limited data is available in relation to long-term exposures to low concentrations of Sodium Hypochlorite. There are no chronic toxicity reference values available for sodium hypochlorite. Chronic skin exposure may result in skin irritation, pain, inflammation and blisters. There are no data indicating that sodium hypochlorite, without severe maternal toxicity, is associated with adverse effects on reproductive function, pregnancy or lactation in humans (Bull, 2007).	H
Classifications		International Agency for Research on Cancer (IARC) has classified hypochlorite salts as Group 3: not classifiable as to human carcinogenicity.	
Guidelines	**Soil**	NA	
	Drinking water	0.3 mg/L for chlorite, 3 mg/L for monochloramine (and chloramines in general) and 250 mg/L aesthetic guideline for chloride.	NHMRC
Ranking - Chronic Health Impacts		The potential concentrations in hydraulic fluids are well in excess of the drinking water guidelines for chlorite and monochloramine. It is noted that from a chronic exposure perspective sodium hypochlorite will not remain in the environment for a long period of time reducing the potential for chronic exposures and risks.	**3**
Ecological			
General		Sodium hypochlorite is low in toxicity to avian wildlife but highly toxic to freshwater fish and invertebrates. A significant number of ecotoxicity studies (991 records) have been conducted on sodium hypochlorite have been conducted, that are summarised on the USEPA PAN Pesticide Database. These data support the high toxicity of sodium hypochlorite to aquatic species (which is consistent with its use as a microbiocide). Studies associated with chlorinated organic by-products did not identify measureable effects on aquatic species. In addition no bioaccumulative compounds were detected.	SDA
Aquatic toxicity data (mg/L)	**LC50**	33 freshwater species in 28 general have been exposed to sodium hypochlorite and the acute LC50 (as the sum of free and combined chlorine) range from 0.028 mg/L for Daphnia magna to 0.71 mg/L for three spine stickleback.	SDA, U
	Tox(eco)	0.028 – 0.71 mg/L	
Published Guidelines	**Fresh water**	NA	
	Marine water	NA	
Ranking - Ecological Impacts		Potential concentrations in hydraulic fracturing fluid are significantly higher than the available LC50s, hence where present in hydraulic fracturing fluids the ecological risk is considered to be high. It is noted that these potential impacts are considered to be acute as sodium hypochlorite readily breaks down in the environment.	**4**

SDA, 1997. Sodium Hypochlorite. Prepared by the Soap and Detergent Association
UK, 2007. Sodium Hypochlorite Toxicological Review. UK Health Protection Agency 2007
Bull S., 2007. Sodium Hypochlorite, Toxicological Overview. Prepared for the UK Health Protection Agency, CHAPD, HPA 2007, Version 1.
U = USEPA PAN Pesticides Database, accessed in April 2011 at http://www.pesticideinfo.org/Detail_Chemical.jsp?Rec_Id=PC34390
M = data available on MSDS (refer to Appendix B)
H = data available from HSDB (accessed in February 2012)
S = occupational guidelines available from Safework Australia (retrieved February 2012)

Compound		**Tetrakis(hydroxymethyl)phosphonium sulfate [THPS]**	
Proposed concentration in hydraulic fracturing fluid (mg/L)		110 (34pprox..)	AGL
MSDS Available		yes	
Listed on AICS		yes	
NICNAS		Not assessed	
CAS No.		55566-30-8	M
Molecular Formula		C8H24O12P2S	H
Colour/ Form		colourless or yellowish liquid	M
Odour/ Taste		extremely sharp, acrid pungent odour	M
Odour Threshold		0.98ppm	M
Corrosive		Considered corrosive	M
Irritation		Severe irritation to eyes and may cause skin irritation. May cause skin sensitisation (allergic reaction)	M
Stability		Stable under normal storage and handling conditions. Decomposes at temperatures above 160^{o}C	M
Incompatibility		Oxidizing agents, acids, bases and reducing agents	M
Solubility		Soluble in ethanol, ether, acetone; slightly soluble in chloroform, soluble in oxygenated solvents, miscible with lower alcohols, ketones, benzene, diethyl ether	
Solubility (mg/L in water (20-25^{o}C)		NA	
Molecular weight		406.28	H
pH		3-6	M
Vapour Pressure (mmHg at 20-25^{o}C)		26.7	C
Density		1.38 g/mL (75% product)	C
Vapour Density (air = 1)		1.94	H
Henry's Law (atm.m^{3}/mol at 20-25^{o}C)		1.76x10^{-14}	C
Volatility potential	**Soil**	very low	
	Water	very low	
Log Kow		<0	H
Koc		2.2	H
Soil Adsorption/ Mobility		Limited potential for sorbtion to soil, organic matter or sediments. If remaining in the environment this compound will be mobile	C
Potential for bioaccumulation (BCF)		No	M, C
Degradation potential	**Soil**	High	C
	Water	Data suggests the compound biodegrades under aerobic and anaerobic conditions. Rapidly mineralised to CO2 in aquatic environment. May produce low concentrations of degradation products	M, C
Ranking - Fate and Transport		Overall, of released into the environment, this compound does not sorb to solid particles in the water column and is mobile, is mineralised to carbon dioxide and is not bioaccumulative in aquatic species or the food chain, on this basis the potential for discharge of this compound to a receiving environment is considered to be low.	**2**

Compound		**Tetrakis(hydroxymethyl)phosphonium sulfate [THPS]**	
Human Health			
General		Health effects from exposure to this compound are principally associated with acute exposures in occupational environments.	H
Acute Effects		The product has been shown to be highly acutely toxic via the oral route, of low toxicity via the dermal route, and of moderate toxicity via the inhalation route. It is considered to be corrosive to the eye and has been shown to be a dermal sensitiser. The product was also considered to be irritating to the skin.	H
Occupational Inhalation Guidelines (mg/m3)	**TWA**	2	ACGIH
	STEL	3 times TWA for no more than 30 minutes and under no circumstances more than 5 times TWA	ACGIH
Ranking - Occupational Risk Issues		On the basis of the chemical properties and acute toxicity of the compound - occupational hazard ranking determined as moderate to high where appropriate PPE is required for the use of this chemical	**3-4**
Chronic Effects		In short- and long-term oral animal studies, the liver has been identified as the primary target organ of toxicity for exposure to tetrakis (hydroxymethyl) phosphonium sulphate. Other health effects associated with chronic exposures, derived from animal studies, include effects on the liver, lung, testes, uterus and bone marrow, as well as lymphoid depletion of spleen and thymus. Some animals died when high doses of tetrakis (hydroxymethyl) phosphonium sulphate were given, or when higher doses of tetrakis (hydroxymethyl) phosphonium sulphate was given for longer periods of time. There is no indication that tetrakis (hydroxymethyl) phosphonium sulphate caused damage to the nervous system. Developmental effects have been reported in animals, but only at doses that are also toxic to the mother, which suggests that the foetus is not more sensitive to tetrakis (hydroxymethyl) phosphonium sulphate than the adult animal.	W
		Review by Health Canada (2010) considered data from chronic rat and mouse sties that suggested that tetrakis (hydroxymethyl) phosphonium sulphate has carcinogenic potential. In relation to genotoxicity, the number and quality of the available studies is limited and provide mixed results. However the Health Canada (2010) review considered that there was sufficient weight of evidence to consider the product as potentially genotoxic	C
Classifications		IARC has classified tetrakis (hydroxymethyl) phosphonium sulphate as Group 3: not classifiable as to human carcinogenicity due to lack of epidemiological data and inadequate evidence in animals.	

	Compound	**Tetrakis(hydroxymethyl)phosphonium sulfate [THPS]**	
Guidelines	**Soil**	NA	
	Drinking water	NA	
	NOAEL	3.6 mg/kg/day based on bone marrow hypoplasia from a long term study in mice	W,C
	NOAEL	15 to 18 mg/kg bw/day based on maternal toxicity derived from a developmental study on rats and rabbits	C, M
	DWGp	0.126 mg/L based on lowest NOAEL and equation in report	
Ranking - Chronic Health Impacts		The potential for long term human health impacts, should exposure occur, is considered to be high due to the potential for carcinogenic and genotoxic effects and the potential for concentrations in hydraulic fracturing fluids to be higher than the DWGp	**4**
	Ecological		
	General	Limited data is available in relation to ecotoxicological data for THPS. Given that tetrakis (hydroxymethyl) phosphonium sulphate is an algaecide and slimicide, it is expected to adversely affect algae. Tetrakis (hydroxymethyl) phosphonium sulphate negatively affects biomass of the freshwater green algae at concentrations of 0.063 mg/L. LC50 ranges from 93 to 119 mg/L, EC50 ranges from 0.06 to 24 mg/L. Toxicity considered to be high.	M,H,C
Aquatic toxicity data (mg/L)	**NOEC**	0.67 to 10.4 mg/L based on studies conducted on juvenile Eastern oysters and water fleas, following USEPA guidelines	W
	NOEC	18.1 to 41 mg/L for studies conducted in accordance with USEPA guidance on rainbow trout, bluegill sunfish and marine sheepshead minnow	W
	NOEC	0.72 to 67.4 mg/L	C
	Tox(eco)	0.06 – 24 mg/L (based on range of EC50 and LC50)	
Published Guidelines	**Fresh water**	NA	
	Marine water	NA	
Ranking - Ecological Impacts		The most sensitive adverse effect associated with the release of tetrakis (hydroxymethyl) phosphonium sulphate into an aquatic environment is on algae. Other species are less sensitive to exposures to this compound, however the presence of algae in the aquatic ecosystem can be an important source of food for other species. Hence the protection of algae is of importance. On the basis of the available information the potential for adverse effects to aquatic ecosystems has been ranked as high	**4**

C = Health Canada, 2010. Tetrakis (Hydroxymethyl) Phosphonium Sulfate, Evaluation Report ERC2010-02. Health Canada, 17 February 2010
WHO 2000. Environmental Health Criteria 218, Flame Retardants: Tris(2-Butoxyethyl)phosphate, Tris(2-ethylhexyl)phosphate and Tetrakis(hydroxymethyl)phosphonium salts
M = data available on MSDS (refer to Appendix B)
H = data available from HSDB (accessed in February 2012)
S = occupational guidelines available from Safework Australia (retrieved February 2012)

Compound		**Sodium Hydroxide**	
Proposed concentration in hydraulic fracturing fluid (mg/L)		12 to 103 mg/L (approx.) for the proposed products	AGL
Listed on AICS		yes	
NICNAS		Not assessed however and Existing Chemical Information Sheet is available and the chemical has been assigned as a Priority Existing Chemical for assessment, classified by HOHSC	
CAS No.		1310-73-2	M
Molecular Formula		H-Na-O	H
Colour/ Form		clear liquid	M
Odour/ Taste		no distinct odour	M
Odour Threshold		NA	
Corrosive		Corrosive to tin, aluminium, zinc and alloys containing these metals.	M
Explosive		direct contact with water can cause violent exothermic reaction	M
Irritation		Can cause eye, skin and respiratory burns	M
Stability		Stable	M
Incompatibility		Avoid contact with water, leather, wood, acids, organic halogen compounds or organic nitro compounds. Carbon monoxide gas can form upon contact with reducing sugars, food and beverage products in enclosed spaces.	M
Solubility (mg/L in water (20-25oC)		1.11E+06	H
Molecular weight		40	H
pH		14	M
Vapour Pressure (mmHg at 20-25oC)		1	H
Vapour Density (air = 1)		NA	
Henry's Law (atm.m3/mol at 20-25oC)		NA	
Volatility potential	**Soil**	low	
	Water	low	
Soil Adsorption/ Mobility		highly mobile	OECD
Potential for bioaccumulation (BCF)		NA	
Degradation potential	**Soil**	Dissociates rapidly to sodium and hydroxyl ions.	OECD
	Water		
Comments		Dissociates rapidly to sodium and hydroxyl ions that do not sorb to particulates or accumulate in living tissues. Both sodium and hydroxyl ions have a wide natural occurrence.	OECD
Ranking - Fate and Transport		Overall, the potential for migration to a receiving environment is considered to be negligible to low.	**1-2**

Compound		**Sodium Hydroxide**	
Human Health			
General		Solid NaOH is corrosive and many of the adverse effects associated with exposure to this compound are associated with pH and irritation effects.	H
Acute Effects		Depending on the concentration, solutions of NaOH are non-irritating, irritating or corrosive and they cause direct local effects on the skin, eyes and gastrointestinal tracts. Based on human data concentrations of 0.5-4.0 % were irritating to the skin, while a concentration of 8.0 % was corrosive for the skin of animals. Eye irritation data are available for animals. The non-irritant level was 0.2-1.0 %, while the corrosive concentration was 1.2 % or higher. A study with human volunteers did not indicate a skin sensitisation potential of sodium hydroxide. The acute toxicity of sodium hydroxide depends on the physical form (solid or solution), the concentration and dose. Lethality has been reported for animals at oral doses of 240 and 400 mg/kg bw. Fatal ingestion and fatal dermal exposure has been reported for humans.	OECD
Occupational Inhalation Guidelines (mg/m3)	**TWA**	NA	
	Peak	2	S
Ranking - Occupational Risk Issues		On the basis of the chemical properties and acute toxicity of the compound - occupational hazard ranking determined as moderate to high where appropriate PPE is required for the use of this chemical	**3-4**
Chronic Effects		Limited data is available in relation to the repeated or long-term toxicity of sodium hydroxide. Under normal handling conditions (non-irritating) neither the concentration of sodium in the blood nor the pH of the blood will be increased and therefore NaOH is not expected to be systemically available in the body. There is no risk of developmental or reproductive toxicity. The compound has not demonstrated any evidence of genotoxicity. Effects associated with pH remain relevant for the assessment of human health effects and these may be of importance.	OECD
Guidelines	**Soil**	NA	
	Drinking water	NA	
	pDWG	NA – not calculated as there are no adverse effects identified other than those associated with pH	
Ranking - Chronic Health Impacts		Chronic effects considered to be low to moderate depending on the pH at the point of exposure, however it is noted that pH will be quickly neutralised once in the environment limiting the potential for effects	**2-3**

	Compound	**Sodium Hydroxide**	
	Ecological		
	General	The hazard of NaOH for the environment is caused by the hydroxyl ion (pH effect). For this reason the effect of NaOH on the organisms depends on the buffer capacity of the terrestrial or aquatic ecosystem. Also the variation in acute toxicity for aquatic organisms can be explained for a significant extent by the variation in buffer capacity of the test medium. For example, LC50 values of acute aquatic toxicity tests varied from 33 to 189 mg/L. It is not considered useful to calculate a guideline for NaOH because factors such as the buffer capacity, the natural pH and the fluctuation of the pH are very specific for a certain ecosystem. There is a possibility that the emission of NaOH product could locally increase the pH in the local aquatic environment.	OECD, M
	Tox(eco)	NA as effects relate to pH	
Published Guidelines	**Fresh water**	NA	
	Marine water	NA	
Ranking - Ecological Impacts			**3**

OECD 2002, OECD SIDS Sodium Hydroxide. UNEP Publications March 2002.
M = data available on MSDS (refer to Appendix B)
H = data available from HSDB (accessed in February 2012)
S = occupational guidelines available from Safework Australia (retrieved February 2012)

Appendix B MSDS for Proposed Hydraulic Fracturing Chemicals

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **ACETIC ACID**

Revision Date: 27-Aug-2013

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND OF THE COMPANY/UNDERTAKING

Statement of Hazardous Nature Hazardous according to the criteria of NOHSC, Dangerous Goods according to the criteria of ADG.

Manufacturer/Supplier

Halliburton Australia Pty. Ltd.
15 Marriott Road
Jandakot
WA 6164
Australia

ACN Number: 009 000 775
Telephone Number: 61 (08) 9455 8300
Fax Number: 61 (08) 9455 5300

Product Emergency Telephone
Australia: 08-64244950
Papua New Guinea: 05 1 281 575 5000
NewZealand: 06-7559274

Fire, Police & Ambulance - Emergency Telephone
Australia: 000
Papua New Guinea: 000
New Zealand: 111

Identification of Substances or Preparation

Product Trade Name:	ACETIC ACID
Synonyms:	None
Chemical Family:	Organic acid
UN Number:	, UN2790
Dangerous Goods Class:	8
Subsidiary Risk:	None
Hazchem Code:	2P
Poisons Schedule:	S6
Application:	Acid

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

Substances	CAS Number	PERCENT (w/w)	Australia NOHSC	New Zealand WES	ACGIH TLV-TWA

Acetic acid	64-19-7	30 - 60%	TWA: 10 ppm TWA: 25 mg/m^3 STEL: 15 ppm STEL: 37 mg/m^3	STEL: 15 ppm STEL: 37 mg/m^3 TWA: 10 ppm TWA: 25 mg/m^3	TWA: 10 ppm STEL: 15 ppm

Non-Hazardous Substance to Total of 100%

3. HAZARDS IDENTIFICATION

Hazard Overview	May cause eye, skin, and respiratory burns. May be harmful if swallowed. Combustible.
Risk Phrases	R10 Flammable. R34 Causes burns.
HSNO Classification	Not Determined

4. FIRST AID MEASURES

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Skin	In case of contact, immediately flush skin with plenty of soap and water for at least 15 minutes. Get medical attention. Remove contaminated clothing and launder before reuse.
Eyes	In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.
Ingestion	Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.
Notes to Physician	Not Applicable

5. FIRE FIGHTING MEASURES

Suitable Extinguishing Media
Water fog, carbon dioxide, foam, dry chemical.

Extinguishing media which must not be used for safety reasons
None known.

Special Exposure Hazards	Use water spray to cool fire exposed surfaces. Decomposition in fire may produce toxic gases. Do not allow runoff to enter waterways.
Special Protective Equipment for Fire-Fighters	Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment.
Environmental Precautionary Measures	Prevent from entering sewers, waterways, or low areas.

Procedure for Cleaning / Absorption	Isolate spill and stop leak where safe. Neutralize with lime slurry, limestone, or soda ash. Contain spill with sand or other inert materials. Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. Avoid breathing vapors. Wash hands after use. Launder contaminated clothing before reuse.
Storage Information	Store away from alkalis. Store away from oxidizers. Store in a cool well ventilated area. Keep container closed when not in use.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area. Local exhaust ventilation should be used in areas without good cross ventilation.
Respiratory Protection	Organic vapor/acid gas respirator.
Hand Protection	Impervious rubber gloves. Neoprene gloves. Nitrile gloves. Butyl rubber gloves.
Skin Protection	Full protective chemical resistant clothing.
Eye Protection	Chemical goggles; also wear a face shield if splashing hazard exists.
Other Precautions	Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Liquid
Color:	Clear
Odor:	Acrid
pH:	2.9
Specific Gravity @ 20 C (Water=1):	1.05
Density @ 20 C (kg/l):	1.048
Bulk Density @ 20 C (kg/M3):	Not Determined
Boiling Point/Range (C):	117
Freezing Point/Range (C):	16
Pour Point/Range (C):	Not Determined
Flash Point/Range (C):	42
Flash Point Method:	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (g/m^3):	Not Determined
Flammability Limits in Air - Lower (%):	5.4
Flammability Limits in Air - Upper (g/m^3):	Not Determined
Flammability Limits in Air - Upper (%):	16
Vapor Pressure @ 20 C (mmHg):	11.7
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	100
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Soluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (g/l):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	60.6
Decomposition Temperature (C):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	Keep away from heat, sparks and flame.
Incompatibility (Materials to Avoid)	Strong alkalis.
Hazardous Decomposition Products	Toxic fumes. Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.

Sympotoms related to exposure

Acute Toxicity

Inhalation	Causes severe respiratory irritation.
Eye Contact	May cause eye burns.
Skin Contact	Causes severe burns.
Ingestion	Causes burns of the mouth, throat and stomach.

Chronic Effects/Carcinogenicity	Prolonged, excessive exposure may cause erosion of the teeth.

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Acetic acid	64-19-7	3310 mg/kg (Rat) 600 mg/kg (Rabbit)	1060 mg/kg (Rabbit)	11.4 mg/L (Rat) 4 h

12. ECOLOGICAL INFORMATION

Ecotoxicological Information

Ecotoxicity Product

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined

Ecotoxicity Substance

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Daphnia Magna (Water Flea)
Acetic acid	64-19-7	EC50: 90 mg/L (Microcystis aeruginosa)	LC50: 79 mg/l (Pimephales promelas) LC50: 75 mg/l (Pimephales promelas)	No information available	EC50: 47 mg/l (Daphnia magna) LC50: 32 mg/L (Artemia salina)

Persistence and degradability

Readily biodegradable

Bioaccumulative potential

Does not bioaccumulate

Mobility in soil
No information available

Results of PBT and vPvB assessment
No information available.

Other adverse effects

13. DISPOSAL CONSIDERATIONS

Disposal Method	Disposal should be made in accordance with federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

ADR

UN2790, Acetic Acid Solution , 8 , III

Air Transportation

ICAO/IATA

UN2790, Acetic Acid Solution , 8 , III
RQ (Acetic Acid - 5683 kg.)

Sea Transportation

IMDG

UN2790, Acetic Acid Solution , 8 , III
RQ (Acetic Acid - 5683 kg.)
EmS F-A, S-B

Other Transportation Information

Labels:	Corrosive

15. REGULATORY INFORMATION

Chemical Inventories

Australian AICS Inventory	All components listed on inventory or are exempt.
New Zealand Inventory of Chemicals	All components listed on inventory or are exempt.
US TSCA Inventory	All components listed on inventory or are exempt.
EINECS Inventory	This product, and all its components, complies with EINECS

Classification	C - Corrosive.

Risk Phrases	R10 Flammable. R34 Causes burns.
Safety Phrases	S23 Do not breathe gas, fumes, vapour or spray. S26 In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. S45 In case of accident or if you feel unwell, seek medical advice immediately. S1/2 Keep locked up and out of reach of children.

16. OTHER INFORMATION

The following sections have been revised since the last issue of this SDS
Not applicable

Contact

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

New Zealand National Poisons Centre
0800 764 766

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **BC-140C**

Revision Date: 27-Aug-2013

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND OF THE COMPANY/UNDERTAKING

Statement of Hazardous Nature Non-Hazardous according to the criteria of NOHSC, Non-Dangerous Goods according to the criteria of ADG.

Manufacturer/Supplier

Halliburton Australia Pty. Ltd.
15 Marriott Road
Jandakot
WA 6164
Australia

ACN Number: 009 000 775
Telephone Number: 61 (08) 9455 8300
Fax Number: 61 (08) 9455 5300

Product Emergency Telephone
Australia: 08-64244950
Papua New Guinea: 05 1 281 575 5000
NewZealand: 06-7559274

Fire, Police & Ambulance - Emergency Telephone
Australia: 000
Papua New Guinea: 000
New Zealand: 111

Identification of Substances or Preparation

Product Trade Name:	BC-140C
Synonyms:	None
Chemical Family:	Blend
UN Number:	None
Dangerous Goods Class:	None
Subsidiary Risk:	None
Hazchem Code:	None Allocated
Poisons Schedule:	None Allocated
Application:	Crosslinker

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

Substances	CAS Number	PERCENT (w/w)	Australia NOHSC	New Zealand WES	ACGIH TLV-TWA
Monoethanolamine borate	26038-87-9	30 - 60%	Not applicable	Not applicable	Not applicable

Non-Hazardous Substance to Total of 100%

3. HAZARDS IDENTIFICATION

Hazard Overview	May cause eye, skin, and respiratory irritation. May be harmful if swallowed.
Risk Phrases	None
HSNO Classification	Not Determined

4. FIRST AID MEASURES

Inhalation	If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult give oxygen. Get medical attention.
Skin	In case of contact, immediately flush skin with plenty of soap and water for at least 15 minutes. Get medical attention. Remove contaminated clothing and launder before reuse.
Eyes	In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.
Ingestion	Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.
Notes to Physician	Not Applicable

5. FIRE FIGHTING MEASURES

Suitable Extinguishing Media
Water fog, carbon dioxide, foam, dry chemical.

Extinguishing media which must not be used for safety reasons
None known.

Special Exposure Hazards	Decomposition in fire may produce toxic gases.
Special Protective Equipment for Fire-Fighters	Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment.
Environmental Precautionary Measures	Prevent from entering sewers, waterways, or low areas.
Procedure for Cleaning / Absorption	Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. Avoid breathing vapors. Wash hands after use. Launder contaminated clothing before reuse.
Storage Information	Store away from oxidizers. Store in a cool well ventilated area. Keep container closed when not in use. Product has a shelf life of 36 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area. Local exhaust ventilation should be used in areas without good cross ventilation.
Respiratory Protection	Not normally needed. But if significant exposures are possible then the following respiratory is recommended: Organic vapor respirator.
Hand Protection	Impervious rubber gloves.
Skin Protection	Rubber apron.
Eye Protection	Safety glasses.
Other Precautions	Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Liquid
Color:	Blue
Odor:	Amine
pH:	7.9
Specific Gravity @ 20 C (Water=1):	1.16
Density @ 20 C (kg/l):	1.16
Bulk Density @ 20 C (kg/M3):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (C):	Not Determined
Pour Point/Range (C):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (g/m^3):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (g/m^3):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Soluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (g/l):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined
Decomposition Temperature (C):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated

Incompatibility (Materials to Avoid)	Strong oxidizers. Dehydrating agents.
Hazardous Decomposition Products	Toxic fumes. Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.

Sympotoms related to exposure

Acute Toxicity

Inhalation	May cause respiratory irritation.
Eye Contact	May cause eye irritation.
Skin Contact	May cause skin irritation.
Ingestion	May be harmful if swallowed.

Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Monoethanolamine borate	26038-87-9	>2000 mg/kg (Rat)	>2000 mg/kg (Rat)	No data available

12. ECOLOGICAL INFORMATION

Ecotoxicological Information

Ecotoxicity Product

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined

Ecotoxicity Substance

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Daphnia Magna (Water Flea)
Monoethanolamine borate	26038-87-9	No information available	No information available	No information available	No information available

Persistence and degradability

No information available

Bioaccumulative potential

No information available

Mobility in soil

No information available

Results of PBT and vPvB assessment

No information available.

Other adverse effects

13. DISPOSAL CONSIDERATIONS

Disposal Method	Disposal should be made in accordance with federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

ADR
Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Transportation Information

Labels:	None

15. REGULATORY INFORMATION

Chemical Inventories

Australian AICS Inventory	All components listed on inventory or are exempt.
New Zealand Inventory of Chemicals	All components listed on inventory or are exempt.
US TSCA Inventory	All components listed on inventory or are exempt.
EINECS Inventory	This product, and all its components, complies with EINECS
Classification	Not Classified
Risk Phrases	None
Safety Phrases	None

16. OTHER INFORMATION

The following sections have been revised since the last issue of this SDS
Not applicable

Contact

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

New Zealand National Poisons Centre
0800 764 766

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **BE-7™**

Revision Date: 04-Jan-2011

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND OF THE COMPANY/UNDERTAKING

Statement of Hazardous Nature Hazardous according to the criteria of NOHSC, Dangerous Goods according to the criteria of ADG.

Manufacturer/Supplier

Halliburton Australia Pty. Ltd.
53-55 Bannister Road
Canning Vale
WA 6155
Australia

ACN Number: 009 000 775
Telephone Number: 61 (08) 9455 8300
Fax Number: 61 (08) 9455 5300

Product Emergency Telephone
Australia: 08-64244950
Papua New Guinea: 05 1 281 575 5000
NewZealand: 06-7559274

Fire, Police & Ambulance - Emergency Telephone
Australia: 000
Papua New Guinea: 000
New Zealand: 111

Identification of Substances or Preparation

Product Trade Name:	BE-7™
Synonyms:	None
Chemical Family:	Inorganic
UN Number:	, UN1791
Dangerous Goods Class:	8
Subsidiary Risk:	None
Hazchem Code:	2X
Poisons Schedule:	S5
Application:	Biocide

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

Substances	CAS Number	PERCENT	Australia NOHSC	ACGIH TLV-TWA
Sodium hypochlorite	7681-52-9	10 - 30%	Not applicable	Not applicable
Sodium hydroxide	1310-73-2	0 - 2%	2 mg/m^3	2 mg/m^3

Total to 100%

3. HAZARDS IDENTIFICATION

Hazard Overview	May cause eye and skin burns. May cause respiratory irritation. May be harmful if swallowed.

Hazard Ratings

Flammability:	0
Toxicty:	1
Body Contact:	3
Reactivity:	2
Chronic:	1

Scale: Min/Nil=0 Low=1 Moderate=2 High=3 Extreme=4

4. FIRST AID MEASURES

Inhalation	If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult give oxygen. Get medical attention.
Skin	In case of contact, immediately flush skin with plenty of soap and water for at least 15 minutes. Get medical attention. Remove contaminated clothing and launder before reuse.
Eyes	Immediately flush eyes with large amounts of water for at least 20 minutes. Seek prompt medical attention.
Ingestion	Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.
Notes to Physician	Treatment based on sound judgment of physician and individual reactions of patient.

5. FIRE FIGHTING MEASURES

Suitable Extinguishing Media	Water fog, carbon dioxide, foam, dry chemical.
Extinguishing media which must not be used for safety reasons	None known.
Special Exposure Hazards	Decomposition in fire may produce toxic gases. Reacts with metals to generate flammable hydrogen gas.
Special Protective Equipment for Fire-Fighters	Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment.
Environmental Precautionary Measures	Prevent from entering sewers, waterways, or low areas.
Procedure for Cleaning / Absorption	Isolate spill and stop leak where safe. Remove ignition sources and work with non-sparking tools. Contain spill with sand or other inert materials. Scoop up and remove. Hypochlorite can be broken down by covering it with a reducing agent such as sodium sulfite or sodium thiosulfate.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. Avoid breathing vapors. Wash hands after use. Launder contaminated clothing before reuse.
Storage Information	Store away from acids. Store away from reducing agents. Store in a cool well ventilated area. Store away from direct sunlight. Keep container closed when not in use. Store between 59 F (15 C) and 84 F (29 C). Keep from freezing. Product has a shelf life of up to 6 months at 60F or lower.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area. Local exhaust ventilation should be used in areas without good cross ventilation.
Respiratory Protection	If engineering controls and work practices cannot keep exposure below occupational exposure limits or if exposure is unknown, wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product. Selection of and instruction on using all personal protective equipment, including respirators, should be performed by an Industrial Hygienist or other qualified professional. Acid gas respirator with a dust/mist filter. In high concentrations, supplied air respirator or a self-contained breathing apparatus.
Hand Protection	Impervious rubber gloves. Nitrile gloves. Neoprene gloves. Viton gloves Butyl rubber gloves.
Skin Protection	Wear impervious protective clothing, including boots, gloves, lab coat, apron, rain jacket, pants or coverall, as appropriate, to prevent skin contact.
Eye Protection	Splashproof chemical monogoggles or safety glasses with side shields in conjunction with a face shield.
Other Precautions	Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Liquid
Color:	Clear light yellow
Odor:	Pungent
pH:	11-13
Specific Gravity @ 20 C (Water=1):	1.21
Density @ 20 C (kg/l):	1.14
Bulk Density @ 20 C (kg/m^3):	Not Determined
Boiling Point/Range (C):	~110
Freezing Point/Range (C):	-13.6
Pour Point/Range (C):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (g/m^3):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (g/m^3):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined
Vapor Pressure @ 20 C (mmHg):	12
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	85
Evaporation Rate (Butyl Acetate=1):	Not Determined

9. PHYSICAL AND CHEMICAL PROPERTIES

Solubility in Water (g/100ml):	Soluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (g/l):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined
Decomposition Temperature (C):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	Avoid contact with hydrochloric acid. Can react to release chlorine gas. Contact with certain metals produces hydrogen gas. Hazards increase greatly if material is allowed to dry.
Incompatibility (Materials to Avoid)	Strong acids. Contact with metals. Ammonium compounds. Organic matter. Cyanides. Alcohols. Nitrogen compounds. Cellulose. Ethyleneimine.
Hazardous Decomposition Products	Hydrogen chloride. Chlorine. Hypochlorous acid. Flammable hydrogen gas. Sodium oxides. Oxygen. Chlorine dioxide. Sodium chlorate
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	Causes severe respiratory irritation.
Skin Contact	Causes severe skin irritation. May cause skin burns. May cause an allergic skin reaction.
Eye Contact	Causes severe eye irritation May cause eye burns.
Ingestion	Causes burns of the mouth, throat and stomach. May be fatal if swallowed.
Aggravated Medical Conditions	Skin disorders. Lung disorders.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.
Toxicity Tests	
Oral Toxicity:	LD50: 8910 mg/kg (Rat)
Dermal Toxicity:	LD50: > 10000 mg/kg (Rabbit)
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Sodium hypochlorite caused mutations in several short-term studies using bacteria and cultured mammalian cells. The significance of these tests is unclear. It was not mutagenic in tests (chromosome aberration and micronucleus) on live animals.

Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Not determined
Bio-accumulation	Not determined

Ecotoxicological Information

Acute Fish Toxicity:	TLM48: 0.07 mg/l (Oncorhynchus mykiss) TLM96: 5.9 mg/l (Pimephales promelas)
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined

Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Disposal should be made in accordance with federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

ADR

UN1791,Hypochlorite Solution, 8, III

Air Transportation

ICAO/IATA

UN1791,Hypochlorite Solution, 8, IIIRQ (Sodium Hypochlorite - 454 kg.)

Sea Transportation

IMDG

UN1791,Hypochlorite Solution, 8, IIIRQ (Sodium Hypochlorite - 454 kg.)
EmS F-A, S-B

Other Shipping Information

Labels:	Corrosive

15. REGULATORY INFORMATION

Chemical Inventories

Australian AICS Inventory	All components listed.
US TSCA Inventory	All components listed on inventory or are exempt.
EINECS Inventory	This product, and all its components, complies with EINECS

Classification

C - Corrosive.
N - Dangerous For The Environment.

Risk Phrases

R31 Contact with acids liberates toxic gas.
R34 Causes burns.
R50 Very toxic to aquatic organisms.

Safety Phrases

S28 After contact with skin, wash immediately with plenty of water
S45 In case of accident or if you feel unwell, seek medical advice immediately.
S50 Do not mix with acids
S61 Avoid release to the environment. Refer to special instructions/Safety data sheets.

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Contact

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

New Zealand National Poisons Centre
0800 764 766

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **CAUSTIC SODA LIQUID - 50%**

Revision Date: 27-Aug-2013

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND OF THE COMPANY/UNDERTAKING

Statement of Hazardous Nature Hazardous according to the criteria of NOHSC, Dangerous Goods according to the criteria of ADG.

Manufacturer/Supplier

Halliburton Australia Pty. Ltd.
15 Marriott Road
Jandakot
WA 6164
Australia

ACN Number: 009 000 775
Telephone Number: 61 (08) 9455 8300
Fax Number: 61 (08) 9455 5300

Product Emergency Telephone
Australia: 08-64244950
Papua New Guinea: 05 1 281 575 5000
NewZealand: 06-7559274

Fire, Police & Ambulance - Emergency Telephone
Australia: 000
Papua New Guinea: 000
New Zealand: 111

Identification of Substances or Preparation

Product Trade Name:	CAUSTIC SODA LIQUID - 50%
Synonyms:	None
Chemical Family:	Hydroxide
UN Number:	, UN1824
Dangerous Goods Class:	8
Subsidiary Risk:	None
Hazchem Code:	2R
Poisons Schedule:	S6
Application:	pH Control

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

Substances	CAS Number	PERCENT (w/w)	Australia NOHSC	New Zealand WES	ACGIH TLV-TWA
Sodium hydroxide	1310-73-2	30 - 60%	2 mg/m³	Not applicable	2 mg/m³

Non-Hazardous Substance to Total of 100%

3. HAZARDS IDENTIFICATION

Hazard Overview	May cause eye, skin, and respiratory burns. May be harmful if swallowed.
Risk Phrases	R35 Causes severe burns.
HSNO Classification	Not Determined

4. FIRST AID MEASURES

Inhalation	If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult give oxygen. Get medical attention.
Skin	In case of contact, immediately flush skin with plenty of soap and water for at least 15 minutes. Get medical attention. Remove contaminated clothing and launder before reuse. Destroy or properly dispose of contaminated shoes.
Eyes	In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.
Ingestion	Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.
Notes to Physician	Not Applicable

5. FIRE FIGHTING MEASURES

Suitable Extinguishing Media
All standard fire fighting media

Extinguishing media which must not be used for safety reasons
None known.

Special Exposure Hazards	May form explosive mixtures with strong acids. Reaction with steel and certain other metals generates flammable hydrogen gas.
Special Protective Equipment for Fire-Fighters	Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment.
Environmental Precautionary Measures	Prevent from entering sewers, waterways, or low areas.
Procedure for Cleaning / Absorption	Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Neutralize to pH of 6-8. Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. Avoid breathing vapors. Wash hands after use. Launder contaminated clothing before reuse.

Storage Information	Store away from acids. Store in a cool well ventilated area. Keep container closed when not in use. Product has a shelf life of 12 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area. Local exhaust ventilation should be used in areas without good cross ventilation.
Respiratory Protection	Dust/mist respirator. (N95, P2/P3)
Hand Protection	Impervious rubber gloves.
Skin Protection	Full protective chemical resistant clothing.
Eye Protection	Chemical goggles; also wear a face shield if splashing hazard exists.
Other Precautions	Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Liquid
Color:	Clear colorless
Odor:	Odorless
pH:	14
Specific Gravity @ 20 C (Water=1):	1.52
Density @ 20 C (kg/l):	1.52
Bulk Density @ 20 C (kg/M3):	Not Determined
Boiling Point/Range (C):	144
Freezing Point/Range (C):	12
Pour Point/Range (C):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (g/m³):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (g/m³):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined
Vapor Pressure @ 20 C (mmHg):	13 @ 60C
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	< 50
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Miscible
Solubility in Solvents (g/100ml):	Soluble in alcohols
VOCs (g/l):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	40
Decomposition Temperature (C):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated

Incompatibility (Materials to Avoid)	Strong acids. Peroxides. Halogenated compounds. Amphoteric metals such as aluminum, magnesium, lead, tin, or zinc.
Hazardous Decomposition Products	None known.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.

Sympotoms related to exposure

Acute Toxicity

Inhalation	Causes severe respiratory burns.
Eye Contact	Causes severe eye burns.
Skin Contact	Causes severe burns.
Ingestion	Causes burns of the mouth, throat and stomach.

Chronic Effects/Carcinogenicity	Prolonged, excessive exposure may cause erosion of the teeth.

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Sodium hydroxide	1310-73-2	No data available	1350 mg/kg (Rabbit)	No data available

12. ECOLOGICAL INFORMATION

Ecotoxicological Information

Ecotoxicity Product

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined

Ecotoxicity Substance

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Daphnia Magna (Water Flea)
Sodium hydroxide	1310-73-2	No information available	LC50: 45.4 mg/l (Oncorhynchus mykiss)	No information available	No information available

Persistence and degradability

The methods for determining biodegradability are not applicable to inorganic substances.

Bioaccumulative potential

Does not bioaccumulate

Mobility in soil

No information available

Results of PBT and vPvB assessment

No information available.

Other adverse effects

13. DISPOSAL CONSIDERATIONS

Disposal Method	Disposal should be made in accordance with federal, state, and local regulations.

Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

ADR

UN1824, Sodium Hydroxide Solution , 8 , II

Air Transportation

ICAO/IATA

UN1824, Sodium Hydroxide Solution , 8 , II
RQ (Sodium Hydroxide - 908 kg.)

Sea Transportation

IMDG

UN1824, Sodium Hydroxide Solution , 8 , II
RQ (Sodium Hydroxide - 908 kg.)
EmS F-A, S-B

Other Transportation Information

Labels:	Corrosive

15. REGULATORY INFORMATION

Chemical Inventories

Australian AICS Inventory	All components listed on inventory or are exempt.
New Zealand Inventory of Chemicals	All components listed on inventory or are exempt.
US TSCA Inventory	All components listed on inventory or are exempt.
EINECS Inventory	This product, and all its components, complies with EINECS
Classification	C - Corrosive.
Risk Phrases	R35 Causes severe burns.
Safety Phrases	S26 In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. S45 In case of accident or if you feel unwell, seek medical advice immediately. S1/2 Keep locked up and out of reach of children. S37/39 Wear suitable gloves and eye/face protection.

16. OTHER INFORMATION

The following sections have been revised since the last issue of this SDS
Not applicable

Contact

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

New Zealand National Poisons Centre
0800 764 766

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name:	**CHOLINE CHLORIDE**
Revision Date:	03-Jan-2013

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name:	CHOLINE CHLORIDE
Synonyms:	None
Chemical Family:	Salt
Application:	Clay Stabilization Agent
Manufacturer/Supplier	Halliburton Energy Services, Inc. P.O. Box 1431 Duncan, Oklahoma 73536-0431 Emergency Telephone: (281) 575-5000
Prepared By	Chemical Compliance Telephone: 1-580-251-4335 e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

Substances	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Choline chloride	67-48-1	60 - 100%	Not applicable	Not applicable

3. HAZARDS IDENTIFICATION

Hazard Overview	May cause mild eye, skin, and respiratory irritation. May be harmful if swallowed.

4. FIRST AID MEASURES

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Eyes	In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.
Ingestion	Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.
Notes to Physician	Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	Water fog, carbon dioxide, foam, dry chemical.
Special Exposure Hazards	Not applicable.
Special Protective Equipment for Fire-Fighters	Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.
NFPA Ratings:	Health 2, Flammability 0, Reactivity 0
HMIS Ratings:	Health 2, Flammability 0, Physical Hazard 0 , PPE: B

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment.
Environmental Precautionary Measures	None known.
Procedure for Cleaning / Absorption	Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing.
Storage Information	Store in a cool, dry location. Keep container closed when not in use.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area.
Respiratory Protection	Not normally necessary.
Hand Protection	Impervious rubber gloves.
Skin Protection	Normal work coveralls.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Liquid
Color:	White
Odor:	Mild amine
pH:	7-9
Specific Gravity @ 20 C (Water=1):	1.07 - 1.091
Density @ 20 C (lbs./gallon):	Not Determined

9. PHYSICAL AND CHEMICAL PROPERTIES

Bulk Density @ 20 C (lbs/ft3):	Not Determined
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Soluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	Avoid contact with metals such as aluminum, tin, lead, brass, bronze, copper, and zinc.
Incompatibility (Materials to Avoid)	Strong oxidizers.
Hazardous Decomposition Products	Oxides of nitrogen. Hydrogen chloride. Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	None known
Inhalation	May cause mild respiratory irritation.
Skin Contact	May cause mild skin irritation.
Eye Contact	May cause mild eye irritation.
Ingestion	May be harmful if swallowed.
Aggravated Medical Conditions	None known.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.
Toxicity Tests	
Oral Toxicity:	Not determined
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined

Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Readily biodegradable
Bio-accumulation	Not determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined

Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Disposal should be made in accordance with federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR
Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Transportation Information

Labels:	None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory or are exempt.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Not determined
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	Does not apply.
NJ Right-to-Know Law	Does not apply.
PA Right-to-Know Law	Does not apply.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory or are exempt.
WHMIS Hazard Class	Un-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

MATERIAL SAFETY DATA SHEET

Product Trade Name: **FE-2**

Revision Date: 27-Aug-2013

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND OF THE COMPANY/UNDERTAKING

Statement of Hazardous Nature Hazardous according to the criteria of NOHSC, Non-Dangerous Goods according to the criteria of ADG.

Manufacturer/Supplier

Halliburton Australia Pty. Ltd.
15 Marriott Road
Jandakot
WA 6164
Australia

ACN Number: 009 000 775
Telephone Number: 61 (08) 9455 8300
Fax Number: 61 (08) 9455 5300

Product Emergency Telephone
Australia: 08-64244950
Papua New Guinea: 05 1 281 575 5000
NewZealand: 06-7559274

Fire, Police & Ambulance - Emergency Telephone
Australia: 000
Papua New Guinea: 000
New Zealand: 111

Identification of Substances or Preparation

Product Trade Name:	FE-2
Synonyms:	None
Chemical Family:	Organic acid
UN Number:	None
Dangerous Goods Class:	None
Subsidiary Risk:	None
Hazchem Code:	None Allocated
Poisons Schedule:	None Allocated
Application:	Iron Control Agent

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

Substances	CAS Number	PERCENT (w/w)	Australia NOHSC	New Zealand WES	ACGIH TLV-TWA
Citric acid	77-92-9	60 - 100%	Not applicable	Not applicable	Not applicable

Non-Hazardous Substance to Total of 100%

3. HAZARDS IDENTIFICATION

Hazard Overview	May cause eye, skin, and respiratory irritation. Airborne dust may be explosive.
Risk Phrases	R36 Irritating to eyes.
HSNO Classification	6.1E (Inhalation) Acutely Toxic Substances 6.3B Mildly irritating to the skin 8.3A Corrosive to ocular tissue

4. FIRST AID MEASURES

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Eyes	In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.
Ingestion	Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.
Notes to Physician	Not Applicable

5. FIRE FIGHTING MEASURES

Suitable Extinguishing Media
Water fog, carbon dioxide, foam, dry chemical.

Extinguishing media which must not be used for safety reasons
None known.

Special Exposure Hazards	Decomposition in fire may produce toxic gases. Organic dust in the presence of an ignition source can be explosive in high concentrations. Good housekeeping practices are required to minimize this potential.
Special Protective Equipment for Fire-Fighters	Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	Prevent from entering sewers, waterways, or low areas.
Procedure for Cleaning / Absorption	Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust.

Storage Information	Store away from alkalis. Store away from oxidizers. Store in a cool, dry location. Product has a shelf life of 60 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area.
Respiratory Protection	Dust/mist respirator. (N95, P2/P3)
Hand Protection	Impervious rubber gloves. Nitrile gloves. Neoprene gloves. Polyvinyl alcohol gloves. Polyvinylchloride gloves.
Skin Protection	Normal work coveralls.
Eye Protection	Chemical goggles; also wear a face shield if splashing hazard exists.
Other Precautions	Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	White
Odor:	Odorless
pH:	2 - 2.2
Specific Gravity @ 20 C (Water=1):	1.665
Density @ 20 C (kg/l):	Not Determined
Bulk Density @ 20 C (kg/M3):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (C):	Not Determined
Pour Point/Range (C):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (C):	1000
Flammability Limits in Air - Lower (g/m^3):	Not Determined
Flammability Limits in Air - Lower (%):	8
Flammability Limits in Air - Upper (g/m^3):	Not Determined
Flammability Limits in Air - Upper (%):	65
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	0
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Soluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (g/l):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	192.13
Decomposition Temperature (C):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated

Incompatibility (Materials to Avoid)	Strong alkalis. Strong oxidizers.
Hazardous Decomposition Products	Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.

Sympotoms related to exposure

Acute Toxicity

Inhalation	May cause respiratory irritation.
Eye Contact	May cause severe eye irritation.
Skin Contact	May cause skin irritation.
Ingestion	Irritation of the mouth, throat, and stomach. May cause abdominal pain, vomiting, nausea, and diarrhea.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
LD50 Oral:	11700 mg/kg; (rat)

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Citric acid	77-92-9	3000 mg/kg (Rat)	No data available	No data available

Test species: Rat

12. ECOLOGICAL INFORMATION

Ecotoxicological Information

Ecotoxicity Product

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	TLM96: 100-330 ppm (Crangon crangon)
Acute Algae Toxicity:	Not determined

Ecotoxicity Substance

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Daphnia Magna (Water Flea)
Citric acid	77-92-9	No information available	LC50: 1516 mg/L (Lepomis macrochirus)	No information available	TLM96: 100-330 ppm (Crangon crangon)

Persistence and degradability

Biodegradable.

Bioaccumulative potential

Does not bioaccumulate

Mobility in soil

No information available

Results of PBT and vPvB assessment

No information available.

Other adverse effects

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations. Contaminated packaging may be disposed of by: rendering packaging incapable of containing any substance, or treating packaging to remove residual contents, or treating packaging to make sure the residual contents are no longer hazardous, or by disposing of packaging into commercial waste collection.

14. TRANSPORT INFORMATION

Land Transportation

ADR
Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Transportation Information

Labels: None

15. REGULATORY INFORMATION

Chemical Inventories

Australian AICS Inventory	All components listed on inventory or are exempt.
New Zealand Inventory of Chemicals	All components listed on inventory or are exempt.
US TSCA Inventory	All components listed on inventory or are exempt.
EINECS Inventory	This product, and all its components, complies with EINECS

Classification	Xi - Irritant.
Risk Phrases	R36 Irritating to eyes.
Safety Phrases	S24/25 Avoid contact with skin and eyes.

16. OTHER INFORMATION

The following sections have been revised since the last issue of this SDS
Not applicable

Contact

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

New Zealand National Poisons Centre
0800 764 766

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

MATERIAL SAFETY DATA SHEET

Product Trade Name: **GBW-30 BREAKER**

Revision Date: 05-Jan-2009

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND OF THE COMPANY/UNDERTAKING

Statement of Hazardous Nature Hazardous according to criteria of WorkSafe

Manufacturer/Supplier

Halliburton Australia Pty. Ltd.
53-55 Bannister Road
Canning Vale
WA 6155
Australia

ACN Number: 009 000 775
Telephone Number: 61 (08) 9455 8300
Fax Number: 61 (08) 9455 5300

Product Emergency Telephone
Australia: 08-64244950
Papua New Guinea: 05 1 281 575 5000
NewZealand: 06-7559274

Fire, Police & Ambulance - Emergency Telephone
Australia: 000
Papua New Guinea: 000
New Zealand: 111

Identification of Substances or Preparation

Product Trade Name: GBW-30 BREAKER
Synonyms: None
Chemical Family: Polysaccharide
UN Number: None
Dangerous Goods Class: None
Subsidiary Risk: None
Hazchem Code: None
Poisons Schedule: None
Application: Breaker

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	Australia NOHSC	ACGIH TLV-TWA
Hemicellulase enzyme	9012-54-8	5-15	Not applicable	Not applicable
Carbohydrates		85-85	Not applicable	Not applicable

Total to 100%

3. HAZARDS IDENTIFICATION

Hazard Overview	May cause eye and respiratory irritation. May cause allergic respiratory reaction. Airborne dust may be explosive.

Hazard Ratings

Flammability:	1
Toxicity:	0
Body Contact:	1
Reactivity:	0
Chronic:	0

Scale: Min/Nil=0 Low=1 Moderate=2 High=3 Extreme=4

4. FIRST AID MEASURES

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Eyes	In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.
Ingestion	Under normal conditions, first aid procedures are not required.
Notes to Physician	Not Applicable

5. FIRE FIGHTING MEASURES

Suitable Extinguishing Media	All standard fire fighting media
Unsuitable Extinguishing Media	None known.
Special Exposure Hazards	Organic dust in the presence of an ignition source can be explosive in high concentrations. Good housekeeping practices are required to minimize this potential.
Special Protective Equipment for Fire-Fighters	Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	Prevent from entering sewers, waterways, or low areas.
Procedure for Cleaning / Absorption	Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions	Avoid creating or inhaling dust.

Storage Information	Store away from oxidizers. Store in a cool, dry location. Product has a shelf life of 12 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area.
Respiratory Protection	Not normally needed. But if significant exposures are possible then the following respirator is recommended: Dust/mist respirator. (95%)
Hand Protection	Normal work gloves.
Skin Protection	Normal work coveralls.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Powder
Color:	White
Odor:	Odorless
pH:	7
Specific Gravity @ 20 C (Water=1):	1.5
Density @ 20 C (kg/l):	Not Determined
Bulk Density @ 20 C (kg/m^3):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (C):	Not Determined
Pour Point/Range (C):	Not Determined
Flash Point/Range (C):	Not Determined**Min:** > 93
Flash Point Method:	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (g/m^3):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (g/m^3):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Soluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (g/l):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined
Decomposition Temperature (C):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated

Incompatibility (Materials to Avoid)	Strong oxidizers.
Hazardous Decomposition Products	Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause mild respiratory irritation. May cause allergic respiratory reaction.
Skin Contact	None known.
Eye Contact	May cause mild eye irritation.
Ingestion	None known
Aggravated Medical Conditions	None known.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.

Toxicity Tests

Oral Toxicity:	LD50: 29700 mg/kg (Rat)
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Readily biodegradable
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	TLM96: > 3300 ppm (Crangon crangon)
Acute Algae Toxicity:	Not determined

Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

EPG:	None
IERG:	None
Labels:	None

15. REGULATORY INFORMATION

Chemical Inventories

Australian AICS Inventory	Not Determined
US TSCA Inventory	All components listed on inventory or are exempt.
EINECS Inventory	This product, and all its components, complies with EINECS
Classification	Xn - Harmful.
Risk Phrases	R42 May cause sensitization by inhalation.
Safety Phrases	S2 Keep out of reach of children. S22 Do not breathe dust. S24 Avoid contact with skin. S36/37 Wear suitable protective clothing and gloves.

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Contact

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

New Zealand Poisons Information System
Deunedin: -(03) 479 1200 (Normal Hours)
-(03) 474 0999 (Emergency)

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **HAI-150E**

Revision Date: 27-Aug-2013

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND OF THE COMPANY/UNDERTAKING

Statement of Hazardous Nature Non-Hazardous according to the criteria of NOHSC, Non-Dangerous Goods according to the criteria of ADG.

Manufacturer/Supplier

Halliburton Australia Pty. Ltd.
15 Marriott Road
Jandakot
WA 6164
Australia

ACN Number: 009 000 775
Telephone Number: 61 (08) 9455 8300
Fax Number: 61 (08) 9455 5300

Product Emergency Telephone
Australia: 08-64244950
Papua New Guinea: 05 1 281 575 5000
NewZealand: 06-7559274

Fire, Police & Ambulance - Emergency Telephone
Australia: 000
Papua New Guinea: 000
New Zealand: 111

Identification of Substances or Preparation

Product Trade Name:	HAI-150E
Synonyms:	None
Chemical Family:	Blend
UN Number:	None
Dangerous Goods Class:	None
Subsidiary Risk:	None
Hazchem Code:	None Allocated
Poisons Schedule:	None Allocated
Application:	Corrosion Inhibitor

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

Substances	CAS Number	PERCENT (w/w)	Australia NOHSC	New Zealand WES	ACGIH TLV-TWA
Contains no hazardous substances	Mixture	60 - 100%	Not applicable	Not applicable	Not applicable

Non-Hazardous Substance to Total of 100%

3. HAZARDS IDENTIFICATION

Hazard Overview	May cause eye, skin, and respiratory irritation.
Risk Phrases	None
HSNO Classification	Non-hazardous

4. FIRST AID MEASURES

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Skin	Get medical attention if irritation persists. Wash with soap and water.
Eyes	In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.
Ingestion	Under normal conditions, first aid procedures are not required.
Notes to Physician	Not Applicable

5. FIRE FIGHTING MEASURES

Suitable Extinguishing Media
All standard fire fighting media

Extinguishing media which must not be used for safety reasons
None known.

Special Exposure Hazards	Organic dust in the presence of an ignition source can be explosive in high concentrations. Good housekeeping practices are required to minimize this potential.
Special Protective Equipment for Fire-Fighters	Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment.
Environmental Precautionary Measures	None known.
Procedure for Cleaning / Absorption	Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions	Avoid creating or inhaling dust.
Storage Information	Store away from oxidizers. Store in a dry location.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	A well ventilated area to control dust levels.
Respiratory Protection	Not normally needed. But if significant exposures are possible then the following respirator is recommended: Dust/mist respirator. (N95, P2/P3)
Hand Protection	Normal work gloves.
Skin Protection	Normal work coveralls.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	Brown
Odor:	Coffee bean
pH:	Not Determined
Specific Gravity @ 20 C (Water=1):	Not Determined
Density @ 20 C (kg/l):	Not Determined
Bulk Density @ 20 C (kg/M3):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (C):	Not Determined
Pour Point/Range (C):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (g/m^3):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (g/m^3):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Soluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (g/l):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined
Decomposition Temperature (C):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None known.
Incompatibility (Materials to Avoid)	Strong oxidizers.

Hazardous Decomposition Products	Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.

Sympotoms related to exposure

Acute Toxicity

Inhalation	May cause mild respiratory irritation.
Eye Contact	May cause mild eye irritation.
Skin Contact	May cause mild skin irritation.
Ingestion	None known

Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards. Generally Recognized As Safe (GRAS)

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Contains no hazardous substances	Mixture	No data available	No data available	No data available

12. ECOLOGICAL INFORMATION

Ecotoxicological Information

Ecotoxicity Product

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined

Ecotoxicity Substance

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Daphnia Magna (Water Flea)
Contains no hazardous substances	Mixture	No information available	No information available	No information available	No information available

Persistence and degradability

Product is biodegradable

Bioaccumulative potential

Does not bioaccumulate

Mobility in soil

No information available

Results of PBT and vPvB assessment

No information available.

Other adverse effects

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.

Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

ADR
Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Transportation Information

Labels:	None

15. REGULATORY INFORMATION

Chemical Inventories

Australian AICS Inventory	All components listed on inventory or are exempt.
New Zealand Inventory of Chemicals	All components listed on inventory or are exempt.
US TSCA Inventory	All components listed on inventory or are exempt.
EINECS Inventory	This product, and all its components, complies with EINECS

Classification	Not Classified
Risk Phrases	None
Safety Phrases	None

16. OTHER INFORMATION

The following sections have been revised since the last issue of this SDS
Not applicable

Contact

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

New Zealand National Poisons Centre
0800 764 766

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: HYDROCHLORIC ACID

Revision Date: 27-Aug-2013

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND OF THE COMPANY/UNDERTAKING

Statement of Hazardous Nature Hazardous according to the criteria of NOHSC, Dangerous Goods according to the criteria of ADG.

Manufacturer/Supplier

Halliburton Australia Pty. Ltd.
15 Marriott Road
Jandakot
WA 6164
Australia

ACN Number: 009 000 775
Telephone Number: 61 (08) 9455 8300
Fax Number: 61 (08) 9455 5300

Product Emergency Telephone
Australia: 08-64244950
Papua New Guinea: 05 1 281 575 5000
NewZealand: 06-7559274

Fire, Police & Ambulance - Emergency Telephone
Australia: 000
Papua New Guinea: 000
New Zealand: 111

Identification of Substances or Preparation

Product Trade Name:	HYDROCHLORIC ACID
Synonyms:	None
Chemical Family:	Inorganic acid
UN Number:	, UN1789
Dangerous Goods Class:	8
Subsidiary Risk:	None
Hazchem Code:	2R
Poisons Schedule:	S6
Application:	Solvent

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

Substances	CAS Number	PERCENT (w/w)	Australia NOHSC	New Zealand WES	ACGIH TLV-TWA
Hydrochloric acid	7647-01-0	30 - 60%	5 ppm	Not applicable	2 ppm

Non-Hazardous Substance to Total of 100%

3. HAZARDS IDENTIFICATION

Hazard Overview	May cause eye, skin, and respiratory burns. May be harmful if swallowed.
Risk Phrases	R34 Causes burns. R37 Irritating to respiratory system.
HSNO Classification	6.1B (Inhalation) Acutely Toxic Substances 6.1D (Oral) Acutely Toxic Substances 6.1D (Dermal) Acutely Toxic Substances 8.1A Corrosive to metals 8.2B Corrosive to dermal tissue if exposed for greater than 3 mins 8.3A Corrosive to ocular tissue 9.1D Slightly harmful in the aquatic environment 9.3C Harmful to terrestrial vertebrates

4. FIRST AID MEASURES

Inhalation	If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult give oxygen. Get medical attention.
Skin	In case of contact, immediately flush skin with plenty of soap and water for at least 15 minutes. Get medical attention. Remove contaminated clothing and launder before reuse.
Eyes	In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.
Ingestion	Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.
Notes to Physician	Not Applicable

5. FIRE FIGHTING MEASURES

Suitable Extinguishing Media
Water fog, carbon dioxide, foam, dry chemical.

Extinguishing media which must not be used for safety reasons
None known.

Special Exposure Hazards	May form explosive mixtures with strong alkalis. Decomposition in fire may produce toxic gases. Reaction with steel and certain other metals generates flammable hydrogen gas. Do not allow runoff to enter waterways.
Special Protective Equipment for Fire-Fighters	Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment.

Environmental Precautionary Measures	Prevent from entering sewers, waterways, or low areas.
Procedure for Cleaning / Absorption	Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Neutralize to pH of 6-8. Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. Avoid breathing vapors. Wash hands after use. Launder contaminated clothing before reuse.
Storage Information	Store away from alkalis. Store in a cool well ventilated area. Keep container closed when not in use. Store locked up. Product has a shelf life of 24 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area. Local exhaust ventilation should be used in areas without good cross ventilation.
Respiratory Protection	Acid gas respirator.
Hand Protection	Impervious rubber gloves.
Skin Protection	Full protective chemical resistant clothing. Rubber boots.
Eye Protection	Chemical goggles; also wear a face shield if splashing hazard exists.
Other Precautions	Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Liquid
Color:	Clear colorless
Odor:	Pungent acrid
pH:	0.8
Specific Gravity @ 20 C (Water=1):	1.18
Density @ 20 C (kg/l):	1.16
Bulk Density @ 20 C (kg/M3):	Not Determined
Boiling Point/Range (C):	110
Freezing Point/Range (C):	-46
Pour Point/Range (C):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (g/m^3):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (g/m^3):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined
Vapor Pressure @ 20 C (mmHg):	26
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	35
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Soluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (g/l):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistokes):	Not Determined

Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	36.5
Decomposition Temperature (C):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Strong alkalis.
Hazardous Decomposition Products	Flammable hydrogen gas. Chlorine. Hydrogen sulfide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.

Sympotoms related to exposure

Acute Toxicity

Product Information	Under certain conditions of use, some of the product ingredients may cause the following:
Inhalation	Causes severe respiratory irritation.
Eye Contact	May cause eye burns.
Skin Contact	May cause skin burns.
Ingestion	Causes burns of the mouth, throat and stomach.

Chronic Effects/Carcinogenicity	Prolonged, excessive exposure may cause erosion of the teeth.

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Hydrochloric acid	7647-01-0	700 mg/kg (Rat)	5010 mg/kg (Rabbit) 1449 mg/kg (Mouse)	3124 ppm (Rat) 1 h 3.2 mg/L (Mouse)

12. ECOLOGICAL INFORMATION

Ecotoxicological Information

Ecotoxicity Product

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined

Ecotoxicity Substance

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Daphnia Magna (Water Flea)
Hydrochloric acid	7647-01-0	No information available	LC50: 282 mg/L (Gambusia affinis) LC50: 20.5 mg/L (Lepomis macrochirus)	No information available	No information available

Persistence and degradability

The methods for determining biodegradability are not applicable to inorganic substances.

Bioaccumulative potential
Does not bioaccumulate

Mobility in soil
No information available

Results of PBT and vPvB assessment
No information available.

Other adverse effects

13. DISPOSAL CONSIDERATIONS

Disposal Method	Disposal should be made in accordance with federal, state, and local regulations. Substance should NOT be deposited into a sewage facility.
Contaminated Packaging	Follow all applicable national or local regulations. Contaminated packaging may be disposed of by: rendering packaging incapable of containing any substance, or treating packaging to remove residual contents, or treating packaging to make sure the residual contents are no longer hazardous, or by disposing of packaging into commercial waste collection.

14. TRANSPORT INFORMATION

Land Transportation

ADR

UN1789, Hydrochloric Acid Solution , 8 , II

Air Transportation

ICAO/IATA

UN1789, Hydrochloric Acid Solution , 8 , II
RQ (Hydrochloric Acid - 2273 kg.)

Sea Transportation

IMDG

UN1789, Hydrochloric Acid Solution , 8 , II
RQ (Hydrochloric Acid - 2273 kg.)
EmS F-A, S-B

Other Transportation Information

Labels:	Corrosive

15. REGULATORY INFORMATION

Chemical Inventories

Australian AICS Inventory	All components listed on inventory or are exempt.

New Zealand Inventory of Chemicals	All components listed on inventory or are exempt.
US TSCA Inventory	All components listed on inventory or are exempt.
EINECS Inventory	This product, and all its components, complies with EINECS
Classification	C - Corrosive.
Risk Phrases	R34 Causes burns. R37 Irritating to respiratory system.
Safety Phrases	S9 Keep container in a well ventilated place. S26 In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. S45 In case of accident or if you feel unwell, seek medical advice immediately. S1/2 Keep locked up and out of reach of children. S36/37/39 Wear suitable protective clothing, gloves and eye/face protection.

16. OTHER INFORMATION

The following sections have been revised since the last issue of this SDS
Not applicable

Contact

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

New Zealand National Poisons Centre
0800 764 766

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

TOLCIDE® PS75

1. IDENTIFICATION OF THE MATERIAL AND SUPPLIER

Product Name: TOLCIDE® PS75

Other Names: None

Recommended Use: Biocides.

Intended for industrial use only.
For further information, refer to the product technical data sheet.

MANUFACTURER / SUPPLIER:
RHODIA CHEMICALS PTY. LTD.
ACN 004 449 870
ABN 80 004 449 870
44 Real Avenue,
Norman Park, QLD. 4170
PO Box 1452 Coorparoo QLD. 4151 Australia
TEL: +61 7 38752888 FAX: +61 7 38752156

RHODIA NEW ZEALAND LIMITED
1 Bush Street, Levin New Zealand
TEL: +64 6 368 9372 FAX: +64 6 368 2071

EMERGENCY CONTACT NUMBER:
FOR EMERGENCY INVOLVING A SPILL, LEAK, FIRE, EXPOSURE OR ACCIDENT, CONTACT:
TEL: 1 800 033 111 [Australia] / 0800 734 607 [New Zealand] / +61 3 9663 2130 [International Callers] / +65 3103 1074 [Singapore/Asia Pacific]

2. HAZARDS IDENTIFICATION

AUSTRALIAN CLASSIFICATION

Classified as hazardous according to the criteria of Safe Work Australia Council (SWAC).
Hazard Category: - TOXIC (T)
- DANGEROUS FOR THE ENVIRONMENT (N)

Hazard Classification: HAZARDOUS SUBSTANCE, DANGEROUS GOODS.

Risk Phrases:

R23	Toxic by inhalation
R22	Harmful if swallowed.
R41	Risk of serious damage to eyes.
R43	May cause sensitisation by skin contact.
R61	May cause harm to the unborn child.
R50	Very toxic to aquatic organisms.

Safety Phrases:
S24 Avoid contact with skin.
S26 In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
S36/37/39 Wear suitable protective clothing, gloves and eye/face protection.
S45 Avoid contact with skin.
S53 Avoid exposure - obtain special instructions before use.
S61 Avoid release to the environment. Refer to special instruction/Safety Data Sheet.

Poison Schedule (Australia): Not scheduled.
NOTE: The SUSDP No. 24 June 2009 Appendix A provides a General Exemption from scheduling for "ALGICIDES, BACTERIOCIDES OR SLIMICIDES for industrial use that do not fit the definition of an agvet chemical product."

Signal Word: None allocated.

Further data:
Possible damage to liver following repeated or prolonged exposure by ingestion. Very toxic to aquatic organisms. NO particular fire or explosion hazard.

Specific hazards:
According to EC regulations, this product is classified as:
- TOXIC.
- TOXIC TO REPRODUCTION, Category 2.
- SENSITIZING.
- IRRITANT.
- DANGEROUS FOR THE ENVIRONMENT.

NEW ZEALAND CLASSIFICATION

Classified as Dangerous Goods according to NZS 5433:2007 Transport of Dangerous Goods on Land.
Classified as hazardous according to criteria in the HS (Minimum Degrees of Hazard) Regulations 2001.

HSNO Classification:
6.1C(oral), 6.5B(contact), 8.2C, 8.3A, 9.1A(fish), 9.1A(crustacean), 9.1A(algal), 9.3B

Signal Word: DANGER

Hazard Statements:
H301 Toxic if swallowed.
H317 May cause an allergic skin reaction.
H314 Causes severe skin burns and eye damage.
H400 Very toxic to aquatic life.

Precautionary Statements:
Prevention:
P104 Read Safety Data Sheet before use.
P264 Wash hands thoroughly after handling.
P260 Do not breath vapours
P261 Avoid breathing dust/fume/gas/mist/vapours/spray.
P270 Do not eat, drink or smoke when using this product.
P272 Contaminated work clothing *should* not be allowed out of the workplace.
P280 Wear protective gloves/protective clothing/eye protection/face protection.
P273 Avoid release to the environment.

Response:
P301+P310 IF SWALLOWED immediately call a POISON CENTRE or doctor/physician.
P301+P330+P331 IF SWALLOWED, rinse mouth, do NOT induce vomiting
P303+P361+P353 IF ON SKIN (or hair) Remove/Take off immediately all contaminated clothing and rinse skin with water/shower
P302+P352 IF ON SKIN, wash with plenty of soap and water.
P333+P313 If skin irritation or rash occurs, get medical advice/attention.

P305+P351+P338 IF IN EYES, rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do so. Continue rinsing.
P304+P340 IF INHALED remove to fresh air and keep at rest in a position comfortable for breathing.
P310 Immediately call a POISON CENTRE or doctor/physician.
P363 Wash contaminated clothing before re-use.
P391 Collect spillage.

Storage:
P405 Store locked up.

Disposal:
P501 Dispose of waste material through a licensed contractor.

3. COMPOSITION / INFORMATION ON INGREDIENTS

SUBSTANCE NAME	Proportion	CAS Number
TETRAKIS(HYDROXYMETHYL)PHOSPHONIUM SULPHATE	> 60%	55566-30-8
WATER	10 - 30%	7732-18-5

4. FIRST AID MEASURES

Ingested:
NEVER attempt to induce vomiting. Do not give anything to drink. Always obtain medical attention immediately. Show this sheet to the doctor.

Eye:
If contact with the eye(s) occurs, flush the eye with copious amounts of water for at least 15 minutes holding eyelid(s) open. Take care not to rinse contaminated water into the non-affected eye. Remove contact lenses, if present and easy to do so. Continue rinsing. Always obtain medical advice immediately, even if there are no symptoms. Show this sheet to the doctor.

Skin:
Remove all contaminated clothing and footwear. Wash with soap and water. Wash immediately and thoroughly for a prolonged period (at least 15 minutes). In case of inflammation (redness, irritation, ...) obtain medical attention.

Inhaled: Move the person away from the contaminated area. Make the affected person rest. Obtain medical attention. Show this sheet to the doctor.

Aggravated Medical Conditions Caused by Exposure.
Skin contact may aggravate existing skin disease.

First Aid Facilities:
Emergency equipment and first-aid box with instructions should be readily available. Safety shower and eye fountain as collective emergency equipment.

Advice to Doctor:
Treat symptomatically. No specific antidote available.
All treatment should be based on observed signs and symptoms of distress in the patient. Consideration should be given to the possibility that overexposure to materials other than this product may have occurred.

Further information:
Establish a first aid action plan before using this product. Use appropriate protective equipment when treating a contaminated person. Use first aid techniques to restore vital functions. Place contaminated clothing in a sealed bag for disposal.

Poisons Information:
For advice, contact a Poisons Information Centre (e.g. phone Australia 13 1126; New Zealand 0800 764 766) or a doctor (at once).

5. FIRE-FIGHTING MEASURES

Extinguishing Media
- **Suitable:** All extinguishing agents can be used (water, foam, powders, carbon dioxide, sand ...).
- **Not suitable:** None. If there is a fire close by, use suitable extinguishing agents.

Hazards from Combustion Products:
Under fire conditions, toxic gases or vapours are released. Decomposes at temperatures above 160 ^{0}C. On combustion or on thermal decomposition (pyrolysis) releases toxic gases or vapours of (Sulphur oxides).(Phosphorus oxides).(Carbon oxides ($CO + CO_2$)).(Phosphine)(Hydrogen).

Precautions for Fire Fighters and Special Protective Equipment:
Toxic gases or vapours are released. Do not breathe fumes. If safe to do so, move undamaged containers from fire area. Stay upwind. Evacuate the personnel away from the fumes. If possible to do so safely, shut off fuel to fire. In case of fire close by, cool down the containers/equipment exposed to heat with a water spray.

Fire fighters to wear self-contained breathing apparatus (SCBA) and full protective clothing.

Hazchem Code: 2X

Flammability:
This product is not a flammable or combustible liquid. Decomposes at temperatures above 160 ^{0}C.

6. ACCIDENTAL RELEASE MEASURES

Emergency Procedures
Personal Precautions:
Do not breathe spray. Avoid contact with eyes, skin and respiratory system. If spillage occurs on the public highway, indicate the danger and notify the authorities (police, fire brigade). Use full protective clothing and equipment. For further information refer to section 8 "Exposure-controls/personal protection".

Environmental Precautions: Prevent the product from spreading into the environment. Contain the spilled material by bunding.

Methods and Materials for Containment and Clean Up Procedures:
- **Recovery:** Recover as much of the product as possible. Absorb the product
onto porous material. Transfer the product into a spare container:
- suitably labelled. Then take the emergency containers to an
area reserved for subsequent recycling or disposal.
- **Neutralisation:** Absorb spillage with diatomaceous earth, sand or inert absorbent.
- **Cleaning/Decontamination:** Wash non-recoverable remainder with large amounts of water.
Recover the cleaning water for subsequent disposal.
- **Disposal:** Place in an appropriate container and dispose of the contaminated material at a licensed site.
(Refer to Section 13 "Disposal Considerations").

Dangerous Goods - Initial Emergency Response Guide (IERG) (SAA/SNZ HB76)
Guide 36: TOXIC LIQUID, ORGANIC, N.O.S.

7. HANDLING AND STORAGE

Precautions for Safe Handling
Technical measures: Ventilation
Measures: This product must only be handled by skilled operators.
Avoid exposure: Work in a well-ventilated area. Avoid forming aerosols. Avoid the formation of mists in the atmosphere. Do NOT handle without gloves. For further information refer to section 8 "Exposure-controls/personal protection".

Safe handling advice: Obtain special instructions before use. Handle and use in accordance with good occupational hygiene and safety practice. Do not mix with incompatible materials (See list in Section 10). When mixed with additives (for example surfactants, dispersants, antifoams), the toxicity by inhalation may be increased. Please contact Rhodia Product Stewardship for advice.

Conditions for Safe Storage
Take all necessary measures to avoid accidental discharge of products into drains and waterways due to the rupture of containers or transfer systems.
Store in a cool, dry area away from incompatible products.
Incompatible products: Strong reducing agents. Strong oxidizing agents. Strong acids. Strong bases.
Packaging: Polyethylene or polypropylene drums. (high density)
Packaging materials: Recommended: Plastic materials (polyethylene, polypropylene). (high density)

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

National Exposure Standards:
No exposure standards assigned to this specific material by the Safe Work Australia Council (SWAC), or the New Zealand Occupational Safety & Health Service (OSH).

Biological Limit Values:
Not established.

Engineering Controls:
Avoid splashes (appropriate clothing, protective screens on machines etc.)
Ensure good ventilation of the work station. Reduce exposure time to the minimum necessary.

Personal Protection Equipment:

Eye/Face Protection:
Safety glasses with side shields, or splash-proof chemical goggles, and a full-face shield. Final choice of appropriate eye/face protection will vary according to individual circumstances i.e. methods of handling or engineering controls and according to risk assessments undertaken. Eye protection should conform with Australian/New Zealand Standard AS/NZS 1337 - Eye Protectors for Industrial Applications.

Hand Protection:
Wear chemical-resistant protective gloves of impervious material. Protective gloves must be chosen according to the function of the work station: other chemicals which may be handled, physical protection necessary (resistance to cutting, puncture, heat), dexterity required. The selection of gloves must take into account the extent and duration of use at the workstation.

Glove material : Protective gloves made of PVC.

Thickness : 1.23 mm
Breakthrough time : >480 minutes
Protection class : 6
Glove material: Nitrile protective gloves
Thickness: 1.23 mm
Breakthrough time: >480 minutes
Protection class: 6
(Unpublished internal reports)

Final choice of appropriate gloves will vary according to individual circumstances i.e. methods of handling or according to risk assessments undertaken. Reference should be made to AS/NZS 2161.1: Occupational protective gloves - Selection, use and maintenance.

Skin and Body Protection: Wear suitable protective clothing, gloves and eye/face protection.

Respiratory Protection: Avoid breathing of vapours/mists. If mist is formed: Respiratory protective device with a particle filter. If engineering controls are not effective in controlling airborne exposure then respiratory protective equipment should be used suitable for protecting against airborne contaminants. Correct fit is essential to obtain adequate protection. If entering spaces where the airborne concentration of a contaminant is unknown then the use of a self-contained breathing apparatus (SCBA) with positive pressure air supply complying with AS/NZS 1715 / 1716, or any other acceptable International Standard is recommended. Final choice of appropriate respiratory protection will vary according to individual circumstances i.e. methods of handling or engineering controls and according to risk assessments undertaken. Reference should be made to Australian/New Zealand Standards AS/NZS 1715, Selection, Use and maintenance of Respiratory Protective Devices; and AS/NZS 1716, Respiratory Protective Devices.

Selection Criteria: Protective equipment must be chosen according to current AS/NZS standards and in cooperation with the supplier of protective equipment. Personal protective equipment must be defined after risk assessment for the workstation.

Collective emergency equipment: Personal protective equipment available close by in case of emergency. Safety shower and eye fountain.

Workplace Hygiene Measures:
Use clean and correctly maintained personal protective equipment. Keep personal protective equipment in a clean place, away from the work area.
Personal hygiene is an important work practice exposure control measure and the following general measures should be taken when working with or handling this material:
Always wash your hands immediately after handling this product, and once again before leaving the workplace.
Do NOT eat or drink in the workplace.

Further information: The user is responsible for monitoring the working environment in accordance with local laws and regulations.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance:	Colourless to pale yellow liquid with characteristic odour.
pH:	3 - 6
Freezing Point:	< -20 ^{0}C
Boiling Point:	108.5 ^{0}C (Normal pressure: 1013 hPa).
Flash Point:	Not applicable.
Oxidizing properties:	Not applicable.

Vapour Pressure: <0.0000026 hPa @ 25 ^{0}C (Dry product).
Specific Gravity: 1370 - 1410 kg/m³ @ 20 ^{0}C
Solubility in Water: Miscible (in all proportions).
Solubility in organic solvents: Soluble in: methanol, n-methyl pyrrolidone, ispropanol.
Insoluble in: acteone, tetrahydrofuran.
Octanol/water partition coefficient: - 9.8 (log POW) (evaluation by structure-activity relationship)

10. STABILITY AND REACTIVITY

Chemical Stability:
Stable under normal storage and handling conditions. Decomposes at temperatures above 160 ^{0}C.

Hazardous Decomposition Products:
Under fire conditions, toxic gases or vapours are released. Decomposes at temperatures above 160 ^{0}C. On combustion or on thermal decomposition (pyrolysis) releases toxic gases or vapours of (Sulphur oxides).(Phosphorus oxides).(Carbon oxides (CO + CO_2)).(Phosphine)(Hydrogen).

Hazardous Reactions:
Hazardous Polymerization will not occur.

Incompatible Materials:
Strong bases.
Strong reducing agents.
Strong acids.
Strong oxidising agents.

Conditions to Avoid:
Decomposes above 160 ^{0}C.

11. TOXICOLOGICAL INFORMATION

Acute Health Effects:
Ingested:
Harmful if swallowed. Swallowing can result in nausea and vomiting. May cause irritation to mouth, throat and stomach. Possible damage to liver following repeated or prolonged exposure by ingestion.

Eye:
Risk of serious damage to eyes. Will cause severe irritation to the eyes with effects including watering of the eyes (tearing), pain, corneal opacity and blurred vision. If prompt action is not taken permanent eye damage may occur. Risk of serious damage to eyes.

Skin:
May cause sensitisation by skin contact. May cause irritation to the skin, with effects including redness, itchiness and drying/defatting.

Inhaled:
Toxic by inhalation. NOT considered to be irritating to the respiratory system.

Main Symptoms: Lachrymatory effect (watering of the eyes).

Acute Toxicity:
LC 50 inhalation (Rat) / 4 h : 0.591 mg/l. for males and females
Toxic by inhalation. (Published data).

LD 50 skin (Rat) : > 2000 mg/kg. for males and females
Not classified as harmful by contact with skin
(Unpublished internal reports)

LD 50 oral (Rat): 575 mg/kg. for males and females
Harmful if swallowed.
(Unpublished internal reports)

Irritation - Skin:
According to OECD method 404:
Not irritating to rabbits on cutaneous application. (Unpublished internal reports)

Irritation - Eyes:
Acute Symptoms: Watering of the eyes.

According to OECD method 405 :
Extremely irritating to rabbits on ocular application.
Risk of serious damage to eyes. (Unpublished internal reports)

Sensitisation - Skin:
May cause sensitisation on contact with skin. (Unpublished internal reports)

Repeated Dose Toxicity:
on ingestion
Repeated dose toxicity (90 days)(Rat)
for males and females
Hepatotoxic effects.
No observed effect level (NOEL) : 1 mg/kg/day (Unpublished internal reports)

Carcinogenicity:
Oral toxicity tests on rats and mice did not reveal any carcinogenic potential. (Published data).

Mutagenicity:
Ames test.
(S. typhimurium) (with or without metabolic activation). Negative. (Unpublished internal reports)

Chromosomal aberrations :
Mammalian cells (CHO) In vitro (with or without metabolic activation). Positive. (Unpublished internal reports)

In vitro
UDS test (Rat) Negative. (Unpublished internal reports)

Mouse lymphoma test/TK. (with or without metabolic activation). Positive. (Unpublished internal reports)

Rodent dominant Lethal test (Rat) In vivo Negative. (Unpublished internal reports)
In vivo micronucleus test (Mouse) Negative. (Unpublished internal reports)

Product is not considered to be genotoxic.

Reproductive Toxicity:
Fertility study (2 generations)(Rat) no impairment of fertility has been observed on ingestion (Unpublished internal reports)
Developmental toxicity study: on ingestion (Rat) NOEL, maternal toxicity : 15 mg/kg/day NOEL, foetal Toxicity : 30 mg/kg/day (Unpublished internal reports)

Developmental toxicity study: on ingestion(Rabbit) NOEL, maternal toxicity : 18 mg/kg/day NOEL, foetal toxicity : 18 mg/kg/day Effects on development were observed
May cause harm to the unborn child. (Unpublished internal reports)

Neurotoxicity:
Screening biochemistry test kit for cholinesterase activity inhibition.
The product does not induce inhibition.

12. ECOLOGICAL INFORMATION

Ecotoxicity:
LC 50 (Fish: Oncorhynchus mykiss) / 96h: 119 mg/l.
LC 50 (Fish: Lepomis macrochirus) / 96h: 93 mg/l.
EC 50 (Daphnia: Daphnia magna)/48 h: 19.4 mg/l.
EC 50 (Fresh water algae: Pseudokirchneriella subcapitata) / 96h : 0.20 mg/l.
EC 50 (Bacteria : Activated sludge) / 3 hr(s) : 24 mg/l
Very toxic to aquatic organisms tested. (Unpublished internal reports)

Persistence / Degradability
Persistence
Product is not persistent.

Degradability:
Abiotic degradation
- Other physico-chemical reactions: Product is easily oxidisable in aqueous media in dilute solutions.

Biodegradability:
- Ultimate aerobic biodegradability: Simulation study:
70% biodegradation after 21days (US EPA FIFRA, Subdivision N, § 162-4)
Readily biodegradable.

- Anaerobic biodegradation. Simulation study: 60% biodegradation after 30 days (US EPA FIFRA, Subdivision N, § 162-3)

Mobility:
Adsorption/Desorption: Log Koc = 2.2
Moderately mobile in soils.
Ultimate destination of the product: WATER

Bio-accumulation:
Octanol/water partition coefficient: - 9.8 (log POW) (evaluation by structure-activity relationship). Not potentially bioaccumulable.

Further Information: M factor = 1 [according to the Globally Harmonized System (GHS) and the 2nd Adaptation to Technical Progress of Directive 1999/45/EC]

Avoid contaminating waterways, drains or sewers

13. DISPOSAL CONSIDERATIONS

RESIDUES FROM PRODUCT

Prohibition: Do NOT discharge waste into drains.
Destruction/Disposal: Dispose of in accordance with relevant local regulations. Dispose of this product as hazardous waste. Incinerate at a licensed installation.

CONTAMINATED PACKAGING

Decontamination/cleaning: Take preliminary precautions based on the dangerous properties of the product. Empty the packaging completely prior to disposal.

Destruction/Disposal: Depending on local facilities, recycle or incinerate the packaging at an authorised site.

NOTE: The user's attention is drawn to the possible existence of local regulations regarding disposal.

14. TRANSPORT INFORMATION

UN Number: 2810
Proper Shipping Name: TOXIC LIQUID, ORGANIC, N.O.S. (Aqueous Solution of Tetrakis(hydroxymethyl)phosphonium sulphate)
Dangerous Goods Class: 6.1
Subsidiary risk: None allocated
Packing Group: III
Hazchem Code: 2X

AUSTRALIA

Road and Rail Transport: (Australia)

Australian Code for the Transport of Dangerous Goods by Road and Rail. Dangerous Goods of Class 6 (Toxic and Infectious Substances) are incompatible in a placard load with any of the following:
- Class 1, Explosives
- Class 3, Flammable Liquids, if the Class 3 dangerous goods are nitromethane
- Class 8, Corrosives, if the Class 6 dangerous goods are cyanides and the Class 8 dangerous goods are acids

And are incompatible with food and food packaging in any quantity.

Class 6 materials that are fire-risk substances are incompatible with Class 5 materials.

NEW ZEALAND

Land Transport: (New Zealand)

Classified as Dangerous Goods Class 6.1 (Toxic and Infectious Substances) according to NZS 5433:2007 Transport of Dangerous Goods on Land.
Dangerous Goods of Class 6 must not be loaded in the same freight container or on the same vehicle with the following:
- Class 1, Explosives
- Foodstuffs or Food Containers

Dangerous Goods of Class 6 must not be loaded in the same freight container with the following; and on the same vehicle must be separated horizontally by at least 3 metres unless all but one are packed in separate freight containers:
- Class 5.1, Oxidising Substances
- Class 5.2, Organic Peroxides

Dangerous Goods of Class 6 must not be loaded in the same freight container or on the same vehicle with the following if transported in segregation devices:

- Class 5.1, Oxidising Substances
- Class 5.2, Organic Peroxides
- Foodstuffs or Food Containers

Note: Cyanides (Class 6.1) of Packing Group II or III may be loaded in the same freight container or on the same vehicle with acids (Class 8).

INTERNATIONAL REGULATIONS
Land
- Rail/road (RID/ADR)
UN number: 2810
Proper Shipping Name (Technical Name) : TOXIC LIQUID, ORGANIC, N.O.S. (Aqueous Solution of Tetrakis(hydroxymethyl)phosphonium sulphate)
Labelling: 6.1.
Packing group: III.
ADR tunnel category : (E)
Class/Division : 6.1
Environmentally hazardous mark : YES
Hazard identification number: 60

Sea (IMO/IMDG)
UN Number: 2810
Proper Shipping Name (Technical Name) : TOXIC LIQUID, ORGANIC, N.O.S. (Aqueous Solution of Tetrakis(hydroxymethyl)phosphonium sulphate)
Labelling: 6.1.
Packing group: III.
Class/Division : 6.1
Marine pollutant (environmentally hazardous mark) : YES
Emergency schedule (EmS): F-A, S-A.

Air (ICAO-IATA)
UN number: 2810
Proper Shipping Name (Technical Name) : TOXIC LIQUID, ORGANIC, N.O.S. (Aqueous Solution of Tetrakis(hydroxymethyl)phosphonium sulphate)
Labelling: 6.1.
Packing group: III.
Class/Division : 6.1
Environmentally hazardous mark : NO
Passenger aircraft : Packing instruction: 611 - Maximum net quantity per package: 60 L
Cargo aircraft : Packing instruction: 618 - Maximum net quantity per package: 220 L

Further information: Empty containers which have not been cleaned are subject to the same transport regulations as those which are full.

NOTE: The above regulatory prescriptions are those valid on the date of publication of this sheet. However, given the possible evolution of transport regulations for hazardous materials and in the event of the SDS in your possession dating back more than 12 months, it is advisable to check their validity with your sales office.

15. REGULATORY INFORMATION

Poison Schedule (Australia): Not scheduled.
NOTE: The SUSDP No. 24 June 2009 Appendix A provides a General Exemption from scheduling for "ALGICIDES, BACTERIOCIDES OR SLIMICIDES for industrial use that do not fit the definition of an agvet chemical product."

HSNO Group: This substance falls under the HSNO Additives, Process Chemicals and Raw Materials (Toxic [6.1], Corrosive) Group Standard 2006.

HSNO Approval Number: The HSNO Approval Number for this Group Standard is HSR002510.

Approved handler requirements
Substances covered under this Group Standard **will** require an approved handler.

INVENTORY STATUS:

Inventory	*Status*
Australia (AICS)	Y
United States (TSCA)	Y
Europe (EINECS/ELINCS)	Y

Y = all ingredients are on the inventory.
P = One or more ingredients fall under the polymer exemption or are on the no longer polymer list. All other ingredients are on the inventory or exempt from listing.
N = Not determined or one or more ingredients are not on the inventory and are not exempt from listing.

Market limitation: Restrict to professional users. Intended for industrial use only.

16. OTHER INFORMATION

Reason For Revision:
1) Review against current SWAC / NOHSC and ERMA / HSNO criteria and latest information from manufacturer.
2) Changes and / or additions made to all Sections.

TThe customer is advised to consult the product Technical Data Sheets for further information including advice on suitable equipment.

SDSs are updated frequently. Please ensure that you have a current copy.

Key Legend Information:
ACGIH - American Conference of Governmental Industrial Hygienists
AICS - Australian Inventory of Chemical Substances
ASCC - Australian Safety and Compensation Council
CAS - Chemical Abstracts Service
EPA - Environmental Protection Agency [Int]
ERMA - Environmental Risk Management Authority [NZ]
EU - European Union
GHS - United Nations - Globally Harmonized System of Classification and Labelling of Chemicals[Int]
HSNO - Hazardous Substances and New Organisms [NZ]
IACR - International Agency for Research on Cancer
IATA - International Aviation Transport Authority [Int]
ICAO - International Civil Aviation Organization [Int]

IMDG - International Maritime Dangerous Goods [Int]
IMO - International Maritime Organisation. [Int]
NTP - National Toxicology Program
NIOSH - National Institute for Occupational Safety and Health [US]
NOHSC - National Occupational Health & Safety Commission
NZIoC - New Zealand Inventory of Chemicals [NZ]
OSHA - Occupational Safety and Health Administration [US]
SUSDP - Standard for the Uniform Scheduling of Drugs and Poisons [Aust]
STEL - Short Term Exposure Limit [Int]
SWAC - Safe Work Australia Council [Formerly ASCC]
TWA - Time Weighted Average [Int]
WES - Workplace Exposure Standard [NZ]
[Aust/NZ] = Australia/New Zealand
[Int] = International
[US] = United States of America

Principal References: Safety Data Sheet (SDS) - TOLCIDE®PS75, Issued by Rhodia UK Limited, UK, Date Prepared: 07-04-2010 Version: 7.

Date Prepared:	**04 – 07 – 2010**	**Prepared By: Rhodia Chemicals Pty. Ltd.**
Date Superseded:	**22 – 07 – 2007**	**The information herein is given in good faith but no warranty is expressed nor implied.**

END OF SAFETY DATA SHEET

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **WG-36 GELLING AGENT**

Revision Date: 27-Aug-2013

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND OF THE COMPANY/UNDERTAKING

Statement of Hazardous Nature Non-Hazardous according to the criteria of NOHSC, Non-Dangerous Goods according to the criteria of ADG.

Manufacturer/Supplier

Halliburton Australia Pty. Ltd.
15 Marriott Road
Jandakot
WA 6164
Australia

ACN Number: 009 000 775
Telephone Number: 61 (08) 9455 8300
Fax Number: 61 (08) 9455 5300

Product Emergency Telephone
Australia: 08-64244950
Papua New Guinea: 05 1 281 575 5000
NewZealand: 06-7559274

Fire, Police & Ambulance - Emergency Telephone
Australia: 000
Papua New Guinea: 000
New Zealand: 111

Identification of Substances or Preparation

Product Trade Name:	WG-36 GELLING AGENT
Synonyms:	None
Chemical Family:	Polysaccharide
UN Number:	None
Dangerous Goods Class:	None
Subsidiary Risk:	None
Hazchem Code:	None Allocated
Poisons Schedule:	None Allocated
Application:	Gelling Agent

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

Substances	CAS Number	PERCENT (w/w)	Australia NOHSC	New Zealand WES	ACGIH TLV-TWA
Guar gum	9000-30-0	60 - 100%	Not applicable	Not applicable	10 mg/m³

Non-Hazardous Substance to Total of 100%

3. HAZARDS IDENTIFICATION

Hazard Overview	May cause eye and respiratory irritation. May cause allergic respiratory reaction. Airborne dust may be explosive.
Risk Phrases	None
HSNO Classification	Not Determined

4. FIRST AID MEASURES

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Eyes	In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.
Ingestion	Under normal conditions, first aid procedures are not required.
Notes to Physician	Not Applicable

5. FIRE FIGHTING MEASURES

Suitable Extinguishing Media
Water fog, carbon dioxide, foam, dry chemical.

Extinguishing media which must not be used for safety reasons
None known.

Special Exposure Hazards	Decomposition in fire may produce toxic gases. Organic dust in the presence of an ignition source can be explosive in high concentrations. Good housekeeping practices are required to minimize this potential.
Special Protective Equipment for Fire-Fighters	Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	Prevent from entering sewers, waterways, or low areas.
Procedure for Cleaning / Absorption	Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust.
Storage Information	Store away from oxidizers. Store in a cool, dry location. Product has a shelf life of 24 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area.
Respiratory Protection	Not normally needed. But if significant exposures are possible then the following respirator is recommended: Dust/mist respirator. (N95, P2/P3)
Hand Protection	Normal work gloves.
Skin Protection	Normal work coveralls.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	Off white
Odor:	Bean
pH:	6.5-7.5
Specific Gravity @ 20 C (Water=1):	1.42 -1.47
Density @ 20 C (kg/l):	Not Determined
Bulk Density @ 20 C (kg/M3):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (C):	Not Determined
Pour Point/Range (C):	Not Determined
Flash Point/Range (C):	Not Determined **Min:** > 93
Flash Point Method:	COC
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (g/m^3):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (g/m^3):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Soluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (g/l):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined
Decomposition Temperature (C):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Strong oxidizers.

Hazardous Decomposition Products	Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.

Sympotoms related to exposure

Acute Toxicity

Inhalation	May cause respiratory irritation. May cause allergic respiratory reaction.
Eye Contact	May cause eye irritation.
Skin Contact	None known.
Ingestion	None known

Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.

Toxicology data for the components

Substances	CAS Number	**LD50 Oral**	**LD50 Dermal**	**LC50 Inhalation**
Guar gum	9000-30-0	6770 mg/kg (Rat)	No data available	No data available

12. ECOLOGICAL INFORMATION

Ecotoxicological Information

Ecotoxicity Product

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined

Ecotoxicity Substance

Substances	CAS Number	**Toxicity to Algae**	**Toxicity to Fish**	**Toxicity to Microorganisms**	**Daphnia Magna (Water Flea)**
Guar gum	9000-30-0	No information available	No information available	No information available	No information available

Persistence and degradability

Readily biodegradable

Bioaccumulative potential

Does not bioaccumulate

Mobility in soil

No information available

Results of PBT and vPvB assessment

No information available.

Other adverse effects

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

ADR
Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Transportation Information

Labels:	None

15. REGULATORY INFORMATION

Chemical Inventories

Australian AICS Inventory	All components listed on inventory or are exempt.
New Zealand Inventory of Chemicals	All components listed on inventory or are exempt.
US TSCA Inventory	All components listed on inventory or are exempt.
EINECS Inventory	This product, and all its components, complies with EINECS

Classification	Not Classified
Risk Phrases	None
Safety Phrases	None

16. OTHER INFORMATION

The following sections have been revised since the last issue of this SDS
Not applicable

Contact

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

New Zealand National Poisons Centre
0800 764 766

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****