30 November 2016

QGC - ADDENDUM TO HYDRAULIC STIMULATION CHEMICAL ASSESSMENT

Hazard Assessment of Additional Stimulation Chemicals

Some parts of this report have been redacted to maintain the confidentiality of commercially sensitive information

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ADDENDUM

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Golder Associates

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Document Number	Issue Date	Revisions
127635006-016-R-Rev0-05300	9 September 2014	-
127635006-016-R-Rev1-05300	22 September 2014	Clarification of the Human Health ranking for ethane-1,2-diol, ethylene glycol and sodium bicarbonate. Minor formatting amendments.
127635006-016-R-Rev2-05300	19 July 2016	Removal of Fluid Disclosure Sheets from Appendix A and Appendix D – Mass Balance Table. Documents removed to maintain the confidentiality of commercially sensitive information.
127635006-016-R-Rev3-05300	30 November 2016	Some information redacted to maintain confidentiality.

1.0 INTRODUCTION

QGC has requested that Golder Associates Pty Ltd (Golder) undertake a hazard assessment of stimulation chemicals proposed for use in hydraulic stimulation operations in south-west Queensland. The assessment is in regards to their potential toxicity to human health and ecotoxicity in aquatic and terrestrial environments.

This Technical Memorandum presents the hazard assessment of four (4) chemicals proposed for inclusion in two stimulation fluids[1]. In addition, QGC requested an assessment of three (3) additional chemicals: nitrogen, carbon dioxide and sodium bicarbonate.

1.1 Background

Golder has previously assessed a number of hydraulic stimulation chemicals for human health and ecological hazards for QGC. The chemical assessments are documented in the report*: Human Health and Ecological Chemical Assessment – Hydraulic Stimulation Chemical Assessment – QGC Surat and Bowen Basin Operation* (Golder Ref. 127635006-004-R) hereafter referred to as 'HSCA report'. This assessment is provided as an addendum to that Report.

1.2 Chemicals to be Assessed

QGC provided Golder with the following information relevant to this assessment:

- Fluid Disclosure Sheet (FDS) for two stimulation fluids.
- Material Safety Data Sheets (MSDS) for nitrogen, carbon dioxide and sodium bicarbonate.

The MSDSs provided by QGC is included in Appendix A. The FDSs have not been included in this report to maintain the confidentiality of commercially sensitive information.

A review of the chemicals identified in the two FDSs found that hazard assessments have already been undertaken for the majority of chemicals listed (as a part of the initial assessment works, identified in Section 1.1). Four chemicals were identified as not yet assessed. These chemicals are provided in Table 1.

In addition to the stimulation chemicals identified in the fluid disclosure sheets, QGC also requested an assessment of the stimulation chemicals identified in Table 2.

Table 1: Additional Stimulation Chemicals

CAS RN	Chemical Name
11138-66-2	Xanthan gum
50-70-4	Sorbitol
107-21-1	Ethane-1,2-diol
1330-43-4	Sodium tetraborate, anhydrous

Note: CAS RN - Chemical Abstracts Service Registry Number

Table 2: Additional Stimulation Chemicals

CAS RN	Chemical Name	Physical State[1]
7727-37-9	Nitrogen	Gas
124-38-9	Carbon dioxide	Gas
144-55-8	Sodium bicarbonate	Solid

Note: 1. Physical state identified on the MSDS supplied

1.3 Scope of Work

The approach applied for chemical hazard assessment is documented in the report*: Human Health and Ecological Chemical Assessment – Hydraulic Stimulation Chemical Assessment – QGC Surat and Bowen*

[1] Fluid names have been redacted to maintain the confidentiality of commercially sensitive information.

Basin Operation (Golder Ref. 127635006-004-R-Rev3). This approach was applied to the chemicals identified in Table 1 and to sodium bicarbonate, listed in Table 2. The standard approach could not be applied to the gases (listed in Table 2), as Golder was unable to complete full human health and ecological hazard assessment due to the limited information available on the required parameters (e.g., ecotoxicity) for these gases[2]. Therefore, an overall summary of the available information has been provided in Section 7.0.

As a part of this assessment, the following scope of work was completed:

- Preparation of human health toxicological profiles for each of the chemicals in Table 1 and Table 2 (where possible) (results presented in Appendix B).
- A review of environmental hazards of each of the chemicals in Table 1 and Table 2 (where possible) using measures of persistence (P), bioaccumulation (B) and toxicity (T) (PBT) and preparation of chemical information sheets and hazard summaries (results presented in Appendix C).
- General assessment of the chemicals identified as gases in Table 2.
- Mass fraction calculations for each of the two fluids.
- Preparation of this technical memorandum.

A summary of the information collated for each chemical is provided in the following sections:

- Xanthan gum – Section 2.0
- Sorbitol – Section 3.0
- Ethane 1,2-diol – Section 4.0
- Sodium tetraborate – Section 5.0
- Sodium bicarbonate – Section 6.0
- Assessment of Gases (nitrogen and carbon dioxide) – Section 7.0.

Mass balance calculations for each of the fluids are presented in Section 8.0.

2.0 XANTHAN GUM

2.1 General

Xanthan gum is a natural polysaccharide polymer produced by the bacterium *Xanthomonas campestris*. It is a heteropolysaccharide with a primary structure consisting of repeated pentasaccharide units formed by two glucose units, two mannose units, and one glucuronic acid unit (Garcia-Ochoa et al., 2000). The chemical structure of the main chain is identical to that of cellulose. Xanthan gum is widely used in food for a number of reasons including emulsion, stabilization, temperature stability and compatibility with food ingredients (US FDA, 2012). It is also used in pharmaceutical formations, cosmetics, agricultural products and in petroleum production and enhanced oil recovery. In oil recovery it reduces water mobility by increasing viscosity and decreasing permeability (Garcia-Ochoa et al., 2000).

[2] The chemical assessment parameters are based on the chemical being in a liquid or solid form, rather than a gas.

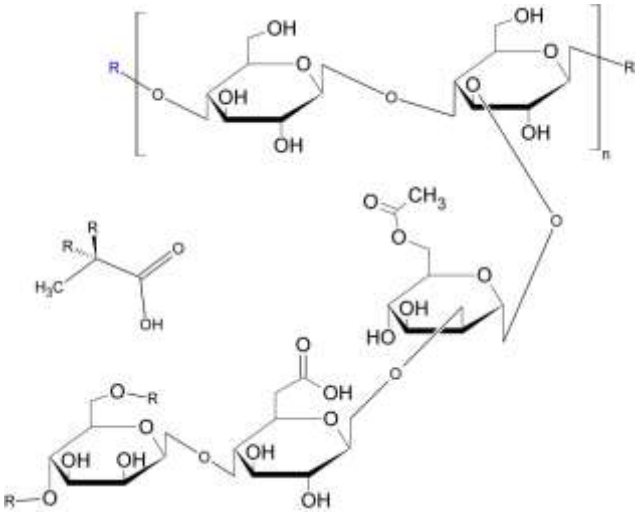

Figure 1: Molecular Structure of Xanthan Gum

2.2 Human Health Toxicity

The Human Health Toxicity Profile for xanthan gum is included in Appendix B, with the results of the review summarised below.

Xanthan gum is a widely used food additive that is used primarily as a thickening agent. It has been used for this purpose for many years and is listed as *Generally Recognised as Safe*" (GRAS[3]) by the U.S. Food and Drug Administration's (FDA) Select Committee on GRAS Substances (SCOGS) (US FDA, 2012). Xanthan gum is not considered inherently toxic to humans, with dietary studies showing no adverse effects in humans at levels up to 10 – 13 grams daily (although it is noted no information was provided on the weight of the humans studied) (JECFA, 1998). Published animal studies report a low order of acute oral toxicity. It is readily metabolised in the liver (Environment Canada, 1994). Based on this information xanthan gum was assigned to the Group 0 Band (0 = lowest, 4 = highest). The major concerns relate to the generation of xanthan gum dusts which have not been evaluated in human or animal studies. As an organic dust, xanthan gum may present some irritancy based on generic information on organic dusts and the physical effects of dusts or respirable particles in particular. As an organic dust it has the capacity to combust (Safe Work Australia, 2012), with the major hazard for occupational settings being the potential for organic dust explosions in confined environments. The latter would require suitable management measures if large amounts of xanthan gum dust is transported or stored.

2.3 Ecotoxicology

An environmental hazard assessment for aquatic ecosystems was undertaken for xanthan gum, based on PBT. For terrestrial hazards, the physical-chemical properties of xanthan gum plus any terrestrial toxicity data were assessed to assign the hazard rank. The Chemical Information Sheet in Appendix C presents the available physical and chemical information for xanthan gum in addition to available ecotoxicological data for aquatic and terrestrial organisms.

2.3.1 Aquatic toxicity assessment

There were limited physical-chemical and eco-toxicological (both aquatic and terrestrial) data available for xanthan gum.

Due to the compound being variable in structure and size, and there being limited physical and chemical information, the environmental hazard assessment was undertaken using toxicological potential only (i.e.,

[3] GRAS indicates general recognition of safety through experience, based on common use in foods and with a substantial history of consumption in food by a significant number of consumers (US Food and Drug Administration 2014).

not including persistence and bioaccumulation). The environmental hazard assessment categorises a chemical as having potential to pose a high (score = 3), moderate (2) or low (1) hazard to the environment.

Table 3 below summarises the overall hazard score for xanthan gum.

Table 3: Aquatic toxicity score for xanthan gum

Chemical	Bioaccumulation Score	Persistence Score	Toxicity Score	Overall Hazard Score
Xanthan gum	NA	NA	1	1

Note: For further detail see Table A in Appendix C

Based on the PBT assessment, xanthan gum has been given an overall hazard score of 1, indicating that is poses a low hazard to the aquatic environment. The low hazard classification was based on acute toxicological effects (mortality) in a freshwater fish (Rainbow trout – *Oncorhynchus mykiss*).

2.3.2 Terrestrial toxicity assessment

The Chemical Information Sheet on xanthan gum presents the available ecotoxicological data for terrestrial organisms.

For xanthan gum the only terrestrial toxicity data available was for mammals, with the lowest mammalian LD_{50} being greater than 1 000 mg/kg for rats (Table 4). As xanthan gum is an organic compound, the use of quantitative structure activity relationships (QSARs) to predict toxicity to plants and invertebrates was considered. However, a search of the xanthan gum CAS registry number provided no or limited results in the databases required to complete this analysis, therefore, this information could not be used.

Table 4: Terrestrial toxicity data for xanthan gum

	Mammalian LD_{50}
	mg/kg
Xanthan gum	>1 000

Note: LD_{50} – Lethal Dose for 50% of the test population.

Based on the toxicological results for the rainbow trout (low risk), the toxicity data for the rat, and the fact that xanthan gum is used in human food, pharmaceutical and cosmetics, the low hazard classification for ecological effects of xanthan gum is considered to be appropriate.

3.0 SORBITOL

3.1 General

Sorbitol is a sugar alcohol obtained by the reduction of glucose. Sorbitol can be produced from corn syrup but it is also occurs naturally in some fruits (e.g. apples, pears, peaches and prunes). Sorbitol is widely used in cosmetics, food products and pharmaceuticals for various reasons including its ability to act as a viscosity control agent (HSDB, 2010).

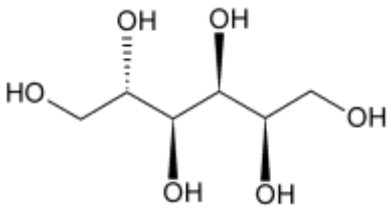

Figure 2: Molecular Structure of Sorbitol

3.2 Human Health Toxicity

The Human Health Toxicity Profile for sorbitol is included in Appendix B, with the results of the review summarised below.

Sorbitol is listed as GRAS by the US FDA's SCOGS (US FDA, 1972). The committee reviewed available animal toxicology data and concluded that there were no short-term or long-term toxicological adverse effects observed at concentrations of sorbitol currently consumed in the normal diet of the U.S. population. A laxative effect has been observed following human consumption at certain dose levels (US FDA, 2013). The US FDA's Code of Federal Register (CFR) (2013) requires an associated warning be placed on any food item containing more than 50 g of sorbitol. There is also the potential for sorbitol to result in respiratory irritation if inhalable sorbitol dusts are generated (IPCS, 2002). As organic dusts may be explosive, suitable occupational management measures are generally required. On the basis of the respiratory irritation, sorbitol in powder form has been assigned a Hazard Band of 1 (0 = lowest, 4 = highest).

3.3 Ecotoxicology

An environmental hazard assessment for aquatic ecosystems was undertaken based on PBT for sorbitol. For terrestrial ecosystems, both physical-chemical data and available terrestrial toxicity data were used to assess the potential hazard of sorbitol. The Chemical Information Sheet in Appendix C presents the available physical and chemical information for sorbitol in addition to available ecotoxicological data for aquatic and terrestrial organisms.

3.3.1 Aquatic toxicity assessment

An overall score (the environmental hazard score) for sorbitol (organic chemical) in aquatic environments was calculated based on PBT potential. Table 7 below summarises the overall hazard score for sorbitol.

Table 5: Aquatic toxicity score for sorbitol

Chemical	Bioaccumulation Score	Persistence Score	Toxicity Score	Overall Hazard Score
Sorbitol	1.3	1.0	1.0	1.1

Note: For further detail see Table A in Appendix C

Based on the PBT classification, sorbitol has been given an overall hazard score of 1.1 (1 = lowest, 3 = highest), indicating that it poses a low potential hazard to the aquatic environment. The low hazard classification for toxicity was based on high solubility, low persistence and low potential to bioaccumulate in aquatic organisms in addition to modelled acute toxicological effects in fish, invertebrates and plants.

3.3.2 Terrestrial toxicity assessment

The Chemical Information Sheet presents the available physical and chemical information for sorbitol in addition to available ecotoxicological data for terrestrial organisms. Terrestrial toxicity data were available for mammals and earthworms, with the earthworm data based on predictive modelling. Additionally due to sorbitol being organic, QSARs can be used to predict toxicity to plants[4] and invertebrates[5].

Table 6: Terrestrial toxicity data for sorbitol

	Mammalian LD_{50}	Ecosar Earthworm LD_{50}	QSAR earthworm LC_{50}	QSAR lettuce EC_{50}
	mg/kg	mg/L	mg/kg	mg/L
Sorbitol	15 900	1 048	2 310	0.903

Notes: LD_{50} – Lethal Dose for 50% of the test population. LC/EC50 – concentration that is lethal (or effective) on 50% of the test population. QSAR – quantitative structure activity relationship. QSAR data presented in Table B in Appendix C.

[4] The QSAR of Huzelbos et al. (1991) may be used to predict the toxicity of chemicals to lettuce is used to predict the toxicity of chemicals to plants.

[5] The QSAR of van Gestel (1992) may be used to predict the toxicity of organic chemicals to earthworms.

Based on the water solubility, sorbitol is expected to have high mobility if released to soil, indicating that extended exposure for terrestrial organisms is unlikely. Additionally, the chemical rapidly degrades, does not bioaccumulate and has low potential to biomagnify in organisms. Based on this information and the toxicity data, sorbitol is expected to pose a low hazard to the terrestrial environment.

4.0 ETHANE-1,2-DIOL

4.1 General

Ethane-1,2-diol is a synthetic liquid that absorbs water. It has high mobility, with a low binding capacity to soil and degradation in soil (ATSDR, 2010a; WHO, 2000). Ethane-1,2-diol has wide spread applications in the chemical, cosmetic, pharmaceutical and food industries. It is a component of antifreeze, hydraulic brake fluids, de-icing solutions, paints and plastics, inks and adhesives, skin lotions, food extracts and flavouring essences (ATSDR, 2010a; HSDB, 2012).

Ethane-1,2-diol is not flammable or explosive and burns with difficulty (ATSDR, 2010a). These properties warrant management for the occupational setting. However, should large scale emergency spills result, local population exposure is likely to be minimal as rapid degradation of ethane-1,2-diol is expected following dilution. For example, in a river die-away test, degradation was complete within 3 days at 20 deg C and 5-14 days at 8 deg C (HSDB, 2012).

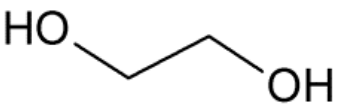

Figure 3: Structure of Ethane-1,2-diol

4.2 Human Health Toxicity

The Human Health Toxicity Profile for ethane-1, 2-diol is included in Appendix B, with the results of the review summarised below.

Ethane-1, 2-diol exhibits a diverse range of adverse toxicological outcomes in animal studies including reproductive, developmental and teratogenic effects, and renal effects after chronic exposure, although it is not considered highly acutely toxic via the oral, dermal and inhalation pathways (ATSDR, 2010a). In humans it is considered to be acutely toxic. While ECHA consider the data to not allow classification as a reproductive toxicant (which under the GHS system also includes developmental effects) the ATSDR (2010) information reports developmental effects in animal studies. On this basis, and subject to further evaluations of the animal data by regulatory agencies, a GHS Category 2 classification for reproductive toxicity has been included. The latter results in a rank as Hazard Band 3 (0 = lowest, 4 = highest) due to it having "*suspected human developmental toxicity*"[6] on the basis of "..some evidence from humans or experimental animals, …".(UN, 2011, p174.

4.3 Ecotoxicology

An environmental hazard assessment for aquatic ecosystems was undertaken based on PBT for ethane-1,2-diol. For terrestrial ecosystems, both physical-chemical data and available terrestrial toxicity data were used to assess the potential hazard of ethane-1,2-diol. The Chemical Information Sheet in Appendix C presents the available physical and chemical information for ethane-1,2-diol in addition to available ecotoxicological data for aquatic and terrestrial organisms.

4.3.1 Aquatic toxicity assessment

An overall score (the environmental hazard score) for ethane-1,2-diol (organic chemical) was calculated based on PBT. Table 7 summarises the overall hazard score for ethane-1,2-diol.

[6] Ethane-1,2-diol was not ranked as Hazard Band 4 as it does not have *presumed or known* human developmental toxicity

Table 7: Aquatic toxicity score for ethane-1,2-diol

Chemical	Bioaccumulation Score	Persistence Score	Toxicity Score	Overall Hazard Score
Ethane-1,2-diol	1.1	1.0	1.0	1.0

Note: For further detail see Table A in Appendix C

Based on the PBT assessment, ethane-1,2-diol has been given an overall hazard score of 1 (1= lowest, 3 = highest), indicating that it has a low potential to pose a hazard to the aquatic environment. The low hazard classification for toxicity was based on bioaccumulation (low potential) and persistence (rapidly degrades) data in addition to acute and chronic toxicological effects in fish and invertebrates. If released into water, ethane-1,2-diol is readily biodegradable , which may reduce its bioavailability to aquatic organisms.

4.3.2 Terrestrial toxicity assessment

For ethane-1,2-diol terrestrial toxicity data were available for mammals and earthworms. Additionally, due to ethane-1,2-diol being organic, QSAR can be used to predict toxicity to plants and invertebrates.

Table 8: Terrestrial toxicity data for ethane-1,2-diol

	Mammalian LD_{50}	Ecosar Earthworm LD_{50}	QSAR earthworm LC_{50}	QSAR lettuce EC_{50}
	mg/kg	mg/L	mg/kg	mg/L
Ethane-1,2-diol	4 700	232	8.6	0.27

Notes: LD_{50} – Lethal Dose for 50% of the test population. QSAR data presented in Table B in Appendix C.

Ethane-1,2-diol has low volatility, a “fast” half-life (NEPC 1999) and low potential to biomagnify. Based on this information and the toxicity data, ethane-1,2-diol is expected to pose a low hazard to the terrestrial environment .

5.0 SODIUM TETRABORATE, ANHYDROUS

5.1 General

Sodium tetraborate is a naturally occurring mineral distributed widely in the environment. It is a white crystalline solid with no odour and an alkaline taste (ATSDR, 2010b). Commonly known as borax, it occurs in arid regions as a result of evaporative deposition in salt lakes during the Tertiary Period. The compound can occur as decahydrate ($10H_2O$), pentahydrate ($5H_2O$) or anhydrous ($0H_2O$). The focus of this review is on the anhydrous form. However, in the absence of data specific to the anhydrous form, available information on the decahydrate and pentahydrate form has been used to complete the assessment.

The primary uses of sodium tetraborate are in industrial processes such as the manufacture of glass, as a fire retardant, in laundry additives, in fertilisers and in pesticides (herbicides, insecticides and fungicides) (ATSDR, 2010b).

In the environment, sodium tetraborate readily dissolves in water to form boric acid (H_3BO_3) and the borate anion ($B(OH)^-_4$). The relative proportions of these dissociation products depend on pH (Soucek et al., 2011). At alkaline pHs, such as that expected in hydraulic stimulation flowback and production waters, the borate anion is expected to dominate. The structure of sodium tetraborate, anhydrous is shown in Figure 4.

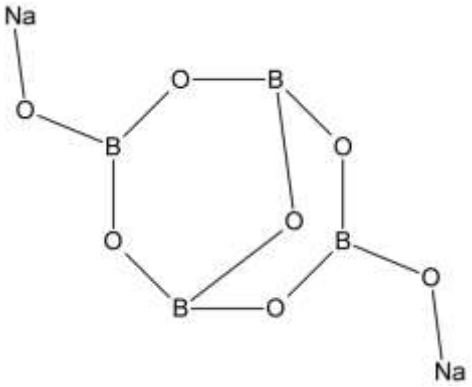

Figure 4: Structure of Sodium Tetraborate, anhydrous

5.2 Human Health Toxicity

The Human Health Toxicity Profile for sodium tetraborate is included in Appendix B, with the results of the review summarised below.

Low concentrations of simple inorganic borates (e.g. boric acid, disodium tetraborate pentahydrate, boric oxide and disodium octaborate tetrahydrate) will predominately exist as un-dissociated boric acid in aqueous solutions at physiological and acidic pH (ATSDR, 2010b). Sodium tetraborate exhibits a Hazard Band Ranking of 4 (0 = lowest, 4 = highest) based on its reproductive toxicity potential in animal studies and *presumed* reproductive toxicity in humans (ECHA, 2014a). In addition, anhydrous boric acid and aqueous solutions have been reported as being irritating to the eye (ECHA, 2014a). There appears a greater potential for irritancy associated with the less hydrated forms. Sodium tetraborate is not flammable and explosive but as a powder it may result in contact and inhalation exposures in occupational settings which can lead to adverse respiratory, dermal and ocular effects.

5.3 Ecotoxicology

An environmental hazard assessment was undertaken based on PBT for sodium tetraborate. The Chemical Information Sheet in Appendix C presents the available physical and chemical information for sodium tetraborate in addition to available ecotoxicological data for aquatic organisms.

It should be noted that due to sodium tetraborate being an inorganic chemical some of the physico-chemical parameters collated for use in hazard assessment in the HSCA report (Golder, 2016) were not available or applicable because the predominance of international guidance for chemical assessment centres on hazard assessment of organic chemicals.

5.3.1 Aquatic toxicity assessment

An overall score (the environmental hazard score) for sodium tetraborate (inorganic chemical) was calculated based on persistence and toxic potential (data was not available to assess bioaccumulation). Table 9 below summarises the overall hazard score for sodium tetraborate.

Table 9: Aquatic toxicity score for sodium tetraborate

Chemical	Bioaccumulation Score	Persistence Score	Toxicity Score	Overall Hazard Score
Sodium tetraborate	NA	3	2	2.5

Note: For further detail see Table A in Appendix C

Based on the available information for sodium tetraborate the hazard ranking for aquatic toxicity is assessed to be high. However, toxicity values provided by the USEPA (2006) indicate low toxicity range for some fish, crustaceans, molluscs and amphibians based on acute exposure. Effect concentrations of sodium tetraborate can be influenced by water hardness and pH consistent with effects on metal bioavailability.

As sodium tetraborate is ranked as a 'high hazard' it is therefore considered to be a chemical of potential concern (COPC) to the aquatic environment.

5.3.2 Terrestrial toxicity assessment

The Chemical Information Sheet on sodium tetraborate presents the available physical and chemical information in addition to available ecotoxicological data for terrestrial organisms. For sodium tetraborate terrestrial toxicity data were available for mammals only (Table 10).

Table 10: Terrestrial toxicity data for sodium tetraborate

	Mammalian LD_{50}
	mg/kg bw/d
Sodium tetraborate	2 660

Notes: LD_{50} – Lethal Dose for 50% of the test population.

For chemicals with few or no data, Golders' approach has been to use QSARs to predict toxicity to plants and invertebrates. As sodium tetraborate is an inorganic chemical and is not appropriate for QSAR modelling, plant and invertebrate toxicity could not be predicted.

Persistence and bioaccumulation in terrestrial ecosystems are generally determined using three physico-chemical parameters; soil half-life, Henry's Law Constant and Log K_{ow}. Sodium tetraborate is an inorganic solid of moderate to high solubility and based on the chemical information is expected to have negligible volatility. Soil persistence and bioaccumulation data provided by the USEPA (2005) indicate that sodium tetraborate may have some potential to adhere to soils and has low potential to bioaccumulate in organisms (log K_{ow} of 0.175).

It is noted that sodium tetraborate decahydrate and sodium tetraborate pentahydrate are used as terrestrial insecticides and fungicides. The toxic (pesticide properties) of these sodium borates is attributable to the boron content (Thurston County Health Department, 2009).

Based on the available physico-chemical data for sodium tetraborate and review of the toxicological data the potential hazard to the terrestrial environment posed by sodium tetraborate was assessed to be moderate.

6.0 SODIUM BICARBONATE

6.1 General

Sodium bicarbonate is a white, odourless, crystalline solid, with a water solubility of 93.4 g/L and a pH of 8.4 at 20°C (ECHA, 2014b). Sodium bicarbonate has numerous uses including in the production of pulp and paper, in the formulation of cleaning products, in non-industrial spraying, as a laboratory reagent, and in cosmetics and personal care products. Sodium bicarbonate is commonly used as a pH buffering agent, an electrolyte replenisher, systemic alkaliser and in topical cleansing solutions (ECHA, 2014b; US EPA, 2014). Sodium bicarbonate has a long history of use in foodstuffs, feed and industrial processes. The bicarbonate ion is a normal constituent in vertebrates, as the principal extracellular buffer in the blood and interstitial fluid is the bicarbonate buffer system. Excess sodium and bicarbonate ions are readily excreted in the urine. It is therefore assumed that normal handling and use of sodium bicarbonate will not have any adverse effects on people (OECD, 2002). Sodium bicarbonate is listed as GRAS as a food ingredient by the US FDA's SCOGS (US FDA, 1975).

Sodium bicarbonate has a high solubility in water and will dissociate to sodium and bicarbonate ions in water, the latter of which will always act to buffer the water to a pH of around 8.34 if in sufficient quantity. The addition of sodium bicarbonate to water will, therefore, only result in an increase in the concentration of sodium, an ion which is abundant in the environment.

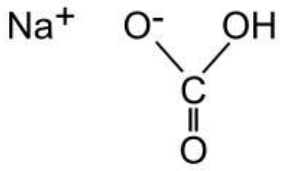

Figure 5: Structure of Sodium Bicarbonate

6.2 Human Health Toxicity

The Human Health Toxicity profile for sodium bicarbonate is included in Appendix B, with the results of the review summarised below.

Sodium bicarbonate has been assigned to Hazard Band 1 (0 = lowest, 4 = highest) because of its classification as a slight/mild irritant to the eyes and skin.

6.3 Ecotoxicology

An environmental hazard assessment was undertaken based on PBT for sodium bicarbonate. The Chemical Information Sheet in Appendix C presents the available physical and chemical information for sodium bicarbonate in addition to available ecotoxicological data for freshwater organisms.

It should be noted that due to sodium bicarbonate being an inorganic chemical some of the physico-chemical parameters collated for use in hazard assessment in the HSCA report (Golder, 2016) were not available or applicable because the predominance of international guidance for chemical assessment centres on hazard assessment of organic chemicals.

6.3.1 Aquatic toxicity assessment

An overall score (the environmental hazard score) for sodium bicarbonate (inorganic chemical) was calculated based on persistence and toxic potential (data was not available to assess bioaccumulation). Table 11 below summarises the overall hazard score for sodium bicarbonate.

Table 11: Aquatic toxicity score for Sodium bicarbonate

Chemical	Bioaccumulation Score	Persistence Score	Toxicity Score	Overall Hazard Score
Sodium bicarbonate	NA	3	1	2

Note: For further detail see Table A in Appendix C

Based on the available information for sodium bicarbonate the hazard ranking for aquatic toxicity is assessed to be moderate.

6.3.2 Terrestrial toxicity assessment

For sodium bicarbonate, terrestrial toxicity data were available for mammals only (Table 12).

Table 12: Terrestrial toxicity data for Sodium bicarbonate

	Mammalian LD_{50}
	mg/kg bw/d
Sodium bicarbonate	3 360

Notes: LD_{50} – Lethal Dose for 50% of the test population.

As sodium bicarbonate is an inorganic chemical and is not appropriate for QSAR modelling, plant and invertebrate toxicity could not be predicted.

Persistence and bioaccumulation in terrestrial ecosystems is generally determined using three physico-chemical parameters; soil half-life, Henry's Law Constant and Log K_{ow}. Sodium bicarbonate is an inorganic solid of high solubility and based on the chemical information is expected to have negligible volatility.

Based on the available physico-chemical data for sodium bicarbonate and review of the toxicological data the potential hazard to the terrestrial environment posed by sodium bicarbonate was assessed to be low.

7.0 ASSESSMENT OF GASES

7.1 Nitrogen

Nitrogen is an inert, odourless, colourless gas, under standard temperature and pressure (ECHA, 2008). At extremely low temperatures (-195.8°C), nitrogen gas condenses to form liquid nitrogen (ECHA, 2008). However, the focus of this assessment is the gaseous form of nitrogen. Nitrogen forms 78.1% v/v of the earth's atmosphere. The majority of Earth's organisms are exposed to this concentration of atmospheric nitrogen for their entire life cycle. Therefore, under standard temperature and pressure nitrogen does not exhibit any adverse toxicological, metabolic or environmental effects (ECHA, 2008). However, when the concentration of atmospheric nitrogen increases (e.g. in confined spaces) it can become asphyxiating (through displacement of ambient oxygen) (ECHA, 2008).

Nitrogen is widely used and is employed for uses such as an insecticide, medical aid and food additive (ECHA, 2008). As a broad-spectrum insecticide it is used to eradicate wood destroying insects, stored product pests, textile pests and other arthropods. Nitrogen acts as a biocide through inhalation by depleting oxygen which the target insects require for respiration and does not directly affect the insect's physiology.

Upon release in the environment, the gaseous form of nitrogen will likely be lost to the atmosphere, with no residual effects likely apart from the acute effects described above. The primary asphyxiation hazard associated with nitrogen gas is limited to the occupational setting (i.e. confined space).

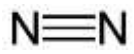

Figure 6: Structure of Nitrogen

7.2 Carbon dioxide

Carbon dioxide is a stable, colourless, odourless gas under standard temperature and pressure (CCOHS, 2013). It is a non-flammable and non-combustible gas, although storage of carbon dioxide as a compressed gas results in an explosive hazard. Carbon dioxide has numerous uses including in the manufacturing of other chemicals and food processing (CCOHS, 2013).

The concentration of carbon dioxide in the earth's atmosphere varies, but is approximately 0.04% (Baird and Cann, 2005). At low concentrations carbon dioxide is non-hazardous (CCOHS, 2013). However, at high concentrations carbon dioxide can displace oxygen in the air, creating an asphyxiation hazard (CCOHS, 2013). Carbon dioxide is not irrigating to the skin but may cause mild irritation to the eyes (CCOHS, 2013). Carbon dioxide has not been evaluated by IARC as to its potential carcinogenicity. It is also not known to be a teratogenic, reproductive or mutagenic hazard (CCOHS, 2013).

Upon release to the environment, like nitrogen, the carbon dioxide gas is expect to be lost to the atmosphere, with no residual effects likely apart from the acute effects described above.

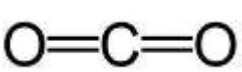

Figure 7: Structure of Carbon Dioxide

8.0 MASS BALANCE CALCULATIONS

Two stimulation fluid disclosure sheets were provided for the fluids. In the fluid disclosures, [redacted] provided the total volume of each fluid, a list of individual chemical names/CAS numbers and mass fractions (%) of each component. These fluid components were divided into chemical additives, proppants and water, and the estimated mass of each fluid is summarised in Table 13. To estimate the mass of proppant, any chemical which was assumed to be a solid at depth (e.g. ceramic material and silica) was considered to be a

proppant. Due to the preparation method and injection protocols, it is assumed that concentrations of substances will vary during the hydraulic stimulation process and estimating concentrations for chemical components would be problematic.

The fluid disclosure sheets indicate that stimulations use 2.4 megalitres (ML) to 2.7 ML. However, each stimulation treatment at an individual well is specifically designed for that well and therefore, exact volumes of fluids will vary to suit the site-specific conditions.

Table 13: Indicative Component Mass per Stimulation Stage

Fluid System	Fluid 1	Fluid 2
Typical fluid Volume[1]	~ 2 649 500 L	~ 2 384 550 L
Additives	~ 105 108 kg (~4%)	~ 152 926 kg (~6%)
Proppant	~ 397 693 kg (~15%)	~ 644 096 kg (~26%)
Water*	~ 2 225 580 kg (~84%)	~ 1 693 031 kg (~68%)

Notes: Fluid volume for stimulation, as indicated in the service provider's FDS (not provided to maintain the confidentiality of commercially sensitive information). *Assuming that density of total typical fluid volume is 1 kg/L. [1]Mass of components are related to typical fluid volume density.

The hydraulic stimulation fluids comprise predominantly water (68 to 84%), with a secondary component consisting of proppant (15 to 26%) and a minor fraction which consists of additives (4 to 6%).

Following completion of the hydraulic stimulation process, a percentage fraction of the injected hydraulic stimulation fluids are recovered upon flowback and production of the well. However, it should be noted that most of the additives would have undergone chemical transformations in the sub-surface. In addition, the formation also contributes a certain amount of water and dissolved salts to the flowback and production of the well. If it is conservatively assumed that 20% of the hydraulic stimulation fluid volume remains in the formation (reasonable "worst case") this would correspond to approximately 21 000 kg to 31 000 kg of chemical additives per well, excluding proppant, depending on the fluid system used.

9.0 UNCERTAINTY ANALYSIS

The evaluation of the human health and ecological hazards is limited to the quantity and quality of information available in the information sources reviewed and the literature received by Golder from the provider. A measure of the data completeness across the toxicological and hazard parameters used has been estimated expressed as a percentage of the parameters for which data were available. These are presented in each summary in Appendix B and Appendix C.

An assessment of the quality of the available data is beyond the scope of this report. In the absence of such a review Golder has relied on primary literature sources from established, robust and reputable sources such as WHO, OECD and US EPA where available. As new toxicological data are generated and become available in the published literature, the information presented in this hazard evaluation and the associated conclusions may be subject to change. On this basis the hazard profiles are dated to enable future review as may be appropriate. This is particularly pertinent across human health parameters within the highest Hazard Band category (4) which includes such areas as endocrine disruption potential and carcinogenicity.

10.0 EXCLUSIONS

This document provides a hazard assessment which reflects the potential concerns associated with the intrinsic toxicity of the substances reviewed. This does not include exposure assessment considerations that may realise the expression of this toxicity, however, comment is made to place exposures into perspective associated with fate and transport properties and specific physico-chemical properties, e.g. the residual nature of metals.

11.0 CONCLUSIONS

Table 14 and Table 15 summarise the outcomes of the human health and ecological toxicity reviews, respectively.

Table 14: Summary of Human Health Toxicity Hazard Band Ranking

Compound	Human Health Hazard Band[1]	Comment
Xanthan gum	0	Xanthan gum is considered not inherently toxic to humans and has been ranked as 0. The major potential concerns relate to the generation of xanthan gum dusts which have not been evaluated in human or animal studies.
Sorbitol	1	This ranking has been based on the potential for sorbitol to result in respiratory irritation if inhalable sorbitol dusts are generated. Similar to xanthan gum, in addition to irritancy, organic dusts may be explosive which reflects a need for suitable occupational management measures.
Sodium bicarbonate	1	Sodium bicarbonate was classified as a slight/mild irritant to the eyes and skin.
Ethane 1,2-diol	3	Ethylene glycol exhibits a diverse range of adverse toxicological outcomes in animals including reproductive, developmental and teratogenic effects and renal effects after chronic exposure, although it is not considered highly acutely toxic via the oral, dermal and inhalation pathways. It is considered acutely toxic to humans.
Sodium tetraborate, anhydrous	4	This high hazard band is based on sodium tetraborate's reproductive toxicity potential which has been shown in animal studies. In addition, anhydrous boric acid and aqueous solutions have been reported as being irritating to the eye. There appears a greater potential for irritancy associated with the less hydrated forms.

Note: 1. A ranking of 0 represents the lowest toxicity and 4 represents the highest toxicity.

Table 15: Summary of Ecotoxicology Ranking

Compound	Aquatic Toxicity	Comment	Terrestrial Toxicity	Comment
Xanthan gum	Low hazard	Based on acute toxicity data for fish	Low hazard	Based on toxicity data for rats
Sorbitol	Low hazard	Based on bioaccumulation, persistence and acute toxicity data	Low hazard	Based on bioaccumulation, persistence and acute toxicity data
Ethane 1,2-diol	Low hazard	Based on bioaccumulation, persistence and acute and chronic toxicity data	Low hazard	Based on fast half-life and low potential to biomagnify
Sodium bicarbonate	Moderate hazard	Based on persistence and acute and chronic toxicity data	Low hazard	Based on toxicity data for mice
Sodium tetraborate, anhydrous	High hazard	Based on bioaccumulation potential and acute toxicity data for fish and plants	Moderate hazard	Based on limited mobility if released to soil and low potential for bioaccumulation in organisms

Nitrogen and Carbon dioxide were not assigned human health or ecotoxicity rankings like those presented in Table 14 and Table 15. However, overall they are considered to be of low toxicity, with the exception of an asphyxiation hazard (through displacement of ambient oxygen).

The overall conclusions of the *Human Health and Ecological Chemical Assessment – Hydraulic Stimulation Chemical Assessment – QGC Surat and Bowen Basin Operation* report (Golder, 2016) are not changed by the outcomes of this assessment, although it must be noted that sodium tetraborate, anhydrous was identified as a high human health and ecological aquatic hazard.

12.0 IMPORTANT INFORMATION

Your attention is drawn to the document - "Important Information Relating to this Report", which is included in Appendix D of this report. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be. The document is not intended to reduce the level of responsibility accepted by Golder, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

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Report Signature Page

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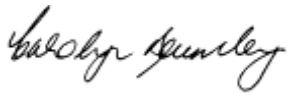

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APPENDIX A

Product Information

Label 2.2 : Non flammable, non toxic gas.

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

Trade name : Nitrogen
MSDS Nr : AL188
Use : Analytical chemistry. Industrial applications.
Chemical formula : N2
Company identification : Air Liquide
Level 9, 380 St.Kilda Road
3004 Melbourne AUSTRALIA
Emergency phone nr : 1800 812 588

2 HAZARDS IDENTIFICATION

Hazard classification : Not classified as hazardous according to NOHSC criteria.
Classified as a dangerous good by the criteria of the ADG code.
Hazards identification : Compressed gas.
In high concentrations may cause asphyxiation.

3 COMPOSITION/INFORMATION ON INGREDIENTS

Substance / Preparation : Substance.

Substance name		Contents	CAS No	EC No	Annex No	Classification
Nitrogen	:	100 %	7727-37-9	231-783-9	-----	

Contains no other components or impurities which will influence the classification of the product.

4 FIRST AID MEASURES

First aid measures
- Inhalation : In high concentrations may cause asphyxiation. Symptoms may include loss of mobility/consciousness. Victim may not be aware of asphyxiation.
Remove victim to uncontaminated area wearing self contained breathing apparatus. Keep victim warm and rested. Call a doctor. Apply artificial respiration if breathing stopped.

5 FIRE-FIGHTING MEASURES

Specific hazards : Exposure to fire may cause containers to rupture/explode.
Hazardous combustion products : None.
Extinguishing media
- Suitable extinguishing media : All known extinguishants can be used.
Specific methods : If possible, stop flow of product.
Move away from the container and cool with water from a protected position.
Special protective equipment for fire fighters : In confined space use self-contained breathing apparatus.

6 ACCIDENTAL RELEASE MEASURES

Personal precautions : Evacuate area.
Wear self-contained breathing apparatus when entering area unless atmosphere is proved to be safe.
Ensure adequate air ventilation.

Environmental precautions : Try to stop release.

Clean up methods : Ventilate area.

7 HANDLING AND STORAGE

Storage : Keep container below 50°C in a well ventilated place.

Handling : Suck back of water into the container must be prevented.
Do not allow backfeed into the container.
Use only properly specified equipment which is suitable for this product, its supply pressure and temperature. Contact your gas supplier if in doubt.
Refer to supplier's container handling instructions.

8 EXPOSURE CONTROLS/PERSONAL PROTECTION

Personal protection : Ensure adequate ventilation.

9 PHYSICAL AND CHEMICAL PROPERTIES

Physical state at 20 °C : Gas.
Colour : Colourless gas.
Odour : No odour warning properties.
Molecular weight : 28
Melting point [°C] : -210
Boiling point [°C] : -196
Critical temperature [°C] : -147
Vapour pressure [20°C] : Not applicable.
Relative density, gas (air=1) : 0.97
Relative density, liquid (water=1) : Not applicable.
Solubility in water [mg/l] : 20

10 STABILITY AND REACTIVITY

Stability and reactivity : Stable under normal conditions.

11 TOXICOLOGICAL INFORMATION

Toxicity information : No known toxicological effects from this product.

12 ECOLOGICAL INFORMATION

Ecological effects information : No known ecological damage caused by this product.

13 DISPOSAL CONSIDERATIONS

General : Do not discharge into any place where its accumulation could be dangerous.
To atmosphere in a well ventilated place.
Contact supplier if guidance is required.

14 TRANSPORT INFORMATION

UN No. : 1066
Labelling ADG : Label 2.2 : Non flammable, non toxic gas.
H.I. nr : 20
Proper shipping name : NITROGEN, COMPRESSED
HAZCHEM - Emergency Action Code : 2T
: *2 = Fine water spray.*
T = Recommended personal protective equipment : Full fire kit and breathing apparatus.
Appropriate measures : dilute.
- ADG Class : 2
- ADG Classification code : 1 A
Other transport information : Avoid transport on vehicles where the load space is not separated from the driver's compartment.
Ensure vehicle driver is aware of the potential hazards of the load and knows what to do in the event of an accident or an emergency.
Before transporting product containers :
- Ensure that containers are firmly secured.
- Ensure cylinder valve is closed and not leaking.
- Ensure valve outlet cap nut or plug (where provided) is correctly fitted.
- Ensure valve protection device (where provided) is correctly fitted.
- Ensure there is adequate ventilation.
- Compliance with applicable regulations.

15 REGULATORY INFORMATION

EC Classification : Not included in Annex I.
Not classified as dangerous preparation/substance.
EC Labelling : No EC labelling required.
Symbol(s) : None.
R Phrase(s) : None.
S Phrase(s) : None.

16 OTHER INFORMATION

Asphyxiant in high concentrations.
Keep container in a well-ventilated place.
Do not breathe the gas.
Ensure all national/local regulations are observed.
The hazard of asphyxiation is often overlooked and must be stressed during operator training.

This Safety Data Sheet has been established in accordance with the applicable European Directives and applies to all countries that have translated the Directives in their national laws.

DISCLAIMER OF LIABILITY : Before using this product in any new process or experiment, a thorough material compatibility and safety study should be carried out.
Details given in this document are believed to be correct at the time of going to press. Whilst proper care has been taken in the preparation of this document, no liability for injury or damage resulting from its use can be accepted.

End of document

CARBON DIOXIDE, Compressed & Liquefied Gas (CO2)

AL062

Label 2.2 : Non flammable, non toxic gas.

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

Trade name : CARBON DIOXIDE, Compressed & Liquefied Gas (CO2)

MSDS Nr : AL062

Use : Beverage product dispensing. Freezing applications. Refrigerant. Shielding gas.

Chemical formula : CO2

Company identification : Air Liquide Australia Limited
Level 9 / 380 St. Kilda Road
Melbourne VIC 3004 Australia
Tel: + 61 3 9697 9888
Fax: + 61 3 9690 7107
ALAEnquiries@AirLiquide.com

Emergency phone nr : 1800 812 588

2 HAZARDS IDENTIFICATION

Hazard classification : Not classified as hazardous according to NOHSC criteria.
Classified as a dangerous good by the criteria of the ADG code.

Hazards identification : Liquefied gas. Contact with liquid may cause cold burns/frostbite.
In high concentrations may cause asphyxiation.

3 COMPOSITION/INFORMATION ON INGREDIENTS

Substance / Preparation : Substance.

Substance name		Contents	CAS No	EC No	Annex No	Classification
Carbon dioxide	:	100 %	124-38-9	204-696-9	-----	

Contains no other components or impurities which will influence the classification of the product.

4 FIRST AID MEASURES

First aid measures

- Inhalation : In high concentrations may cause asphyxiation. Symptoms may include loss of mobility/consciousness. Victim may not be aware of asphyxiation.
Low concentrations of CO2 cause increased respiration and headache.
Remove victim to uncontaminated area wearing self contained breathing apparatus. Keep victim warm and rested. Call a doctor. Apply artificial respiration if breathing stopped.

- Skin/eye contact : Immediately flush eyes thoroughly with water for at least 15 minutes.
In case of frostbite spray with water for at least 15 minutes. Apply a sterile dressing.
Obtain medical assistance.

- Ingestion : Not expected to present a significant ingestion hazard under anticipated conditions of normal use.

5 FIRE-FIGHTING MEASURES

Flammable class : Non flammable.

Specific hazards : Exposure to fire may cause containers to rupture/explode.

Hazardous combustion products : None.

Extinguishing media

- Suitable extinguishing media : All known extinguishants can be used.

Specific methods : If possible, stop flow of product.
Move away from the container and cool with water from a protected position.
If leaking do not spray water onto container. Water surrounding area (from protected position) to contain fire.

Special protective equipment for fire fighters : In confined space use self-contained breathing apparatus.

6 ACCIDENTAL RELEASE MEASURES

Personal precautions : Evacuate area.
Use protective clothing.
Wear self-contained breathing apparatus when entering area unless atmosphere is proved to be safe.
Ensure adequate air ventilation.

Environmental precautions : Try to stop release.
Prevent from entering sewers, basements and workpits, or any place where its accumulation can be dangerous.

Clean up methods : Ventilate area.

7 HANDLING AND STORAGE

General : Containers, which contain or have contained flammable or explosive substances, must not be inerted with liquid carbon dioxide. Potential production of solid CO2 particles must be ruled out. In order to rule out potential electrostatic discharge production, the system must be adequately grounded.

Storage : Keep container below 50℃ in a well ventilated plac e.

Handling : Suck back of water into the container must be prevented.
Do not allow backfeed into the container.
Use only properly specified equipment which is suitable for this product, its supply pressure and temperature. Contact your gas supplier if in doubt.
Refer to supplier's container handling instructions.

8 EXPOSURE CONTROLS/PERSONAL PROTECTION

Personal protection : Ensure adequate ventilation.
Protect eyes, face and skin from liquid splashes.

Occupational Exposure Limits : Carbon dioxide : ILV (EU) - 8 H - [mg/m³] : 9000
Carbon dioxide : ILV (EU) - 8 H - [ppm] : 5000
Carbon dioxide : TLV© -TWA [ppm] : 5000
Carbon dioxide : TLV© -STEL [ppm] : 30000

9 PHYSICAL AND CHEMICAL PROPERTIES

Physical state at 20 ℃ : Liquefied gas.

Colour : Colourless.

Odour : No odour warning properties.

Molecular weight : 44

9 PHYSICAL AND CHEMICAL PROPERTIES (continued)

Melting point [℃]	: -56.6
Boiling point [℃]	: -78.5 (s)
Critical temperature [℃]	: 30
Vapour pressure [20℃]	: 57.3 bar
Relative density, gas (air=1)	: 1.52
Relative density, liquid (water=1)	: 1.03
Solubility in water [mg/l]	: 2000
Flammability range [vol% in air]	: Non flammable.
Other data	: Gas/vapour heavier than air. May accumulate in confined spaces, particularly at or below ground level.

10 STABILITY AND REACTIVITY

Stability and reactivity : Stable under normal conditions.
Liquid spillages can cause embrittlement of structural materials.

11 TOXICOLOGICAL INFORMATION

Toxicity information : In high concentrations cause rapid circulatory insufficiency. Symptoms are headache, nausea and vomiting, which may lead to unconsciousness.

12 ECOLOGICAL INFORMATION

Ecological effects information : When discharged in large quantities may contribute to the greenhouse effect.
Can cause frost damage to vegetation.

Global warming potential [CO2=1] : 1

13 DISPOSAL CONSIDERATIONS

General : Do not discharge into any place where its accumulation could be dangerous.
Discharge to atmosphere in large quantities should be avoided.
Contact supplier if guidance is required.

14 TRANSPORT INFORMATION

UN No.	: 1013
Labelling ADG	: Label 2.2 : Non flammable, non toxic gas.
H.I. nr	: 20
Proper shipping name	: CARBON DIOXIDE
HAZCHEM - Emergency Action Code	: HAZCHEM
	: *HAZCHEM_C*
- ADG Class	: 2
- ADG Classification code	: 2 A
Other transport information	: Avoid transport on vehicles where the load space is not separated from the driver's compartment. Ensure vehicle driver is aware of the potential hazards of the load and knows what to do in the event of an accident or an emergency. Before transporting product containers : - Ensure that containers are firmly secured. - Ensure there is adequate ventilation. - Compliance with applicable regulations.

15 REGULATORY INFORMATION

EC Classification : Not included in Annex I.
Not classified as dangerous preparation/substance.

EC Labelling : No EC labelling required.

Symbol(s) : None.

R Phrase(s) : None.

S Phrase(s) : None.

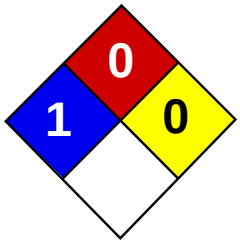
16 OTHER INFORMATION

Asphyxiant in high concentrations.
May cause frostbite.
Keep container in a well-ventilated place.
Do not breathe the gas.
Ensure all national/local regulations are observed.
The hazard of asphyxiation is often overlooked and must be stressed during operator training.

This Safety Data Sheet has been established in accordance with the applicable European Directives and applies to all countries that have translated the Directives in their national laws.

DISCLAIMER OF LIABILITY : Before using this product in any new process or experiment, a thorough material compatibility and safety study should be carried out.
Details given in this document are believed to be correct at the time of going to press. Whilst proper care has been taken in the preparation of this document, no liability for injury or damage resulting from its use can be accepted.

End of document



Health	1
Fire	0
Reactivity	0
Personal Protection	E

Material Safety Data Sheet
Sodium bicarbonate MSDS

Section 1: Chemical Product and Company Identification

Product Name: Sodium bicarbonate

Catalog Codes: SLS3241, SLS2446, SLS3868

CAS#: 144-55-8

RTECS: VZ0950000

TSCA: TSCA 8(b) inventory: Sodium bicarbonate

CI#: Not available.

Synonym: Baking Soda; Bicarbonate of soda; Sodium acid carbonate; Monosodium carbonate; Sodium hydrogen carbonate; Carbonic acid monosodium salt

Chemical Name: Sodium Bicarbonate

Chemical Formula: NaHCO3

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call: 1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Sodium bicarbonate	144-55-8	100

Toxicological Data on Ingredients: Not applicable.

Section 3: Hazards Identification

Potential Acute Health Effects: Slightly hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation.

Potential Chronic Health Effects:
CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. Repeated or prolonged exposure is not known to aggravate medical condition.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Cold water may be used. Get medical attention if irritation occurs.

Skin Contact:
Wash with soap and water. Cover the irritated skin with an emollient. Get medical attention if irritation develops. Cold water may be used.

Serious Skin Contact: Not available.

Inhalation:
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

Serious Inhalation: Not available.

Ingestion:
Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention if symptoms appear.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: Non-flammable.

Auto-Ignition Temperature: Not applicable.

Flash Points: Not applicable.

Flammable Limits: Not applicable.

Products of Combustion: Not available.

Fire Hazards in Presence of Various Substances: Not applicable.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions: Not applicable.

Special Remarks on Fire Hazards: When heated to decomposition it emits acrid smoke and irritating fumes.

Special Remarks on Explosion Hazards: Not available.

Section 6: Accidental Release Measures

Small Spill:
Use appropriate tools to put the spilled solid in a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and dispose of according to local and regional authority requirements.

Large Spill:
Use a shovel to put the material into a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and allow to evacuate through the sanitary system.

Section 7: Handling and Storage

Precautions:
Do not ingest. Do not breathe dust. If ingested, seek medical advice immediately and show the container or the label. Keep away from incompatibles such as acids.

Storage: Keep container tightly closed. Keep container in a cool, well-ventilated area.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection: Safety glasses. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits: Not available.

Section 9: Physical and Chemical Properties

Physical state and appearance: Solid.

Odor: Odorless.

Taste: Saline. Alkaline.

Molecular Weight: 84.01g/mole

Color: White.

pH (1% soln/water): Not available.

Boiling Point: Not available.

Melting Point: Not available.

Critical Temperature: Not available.

Specific Gravity: Density: 2.159 (Water = 1)

Vapor Pressure: Not applicable.

Vapor Density: Not available.

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water.

Solubility:
Soluble in cold water. Slightly soluble in alcohol. Solubility in Water: 6.4, 7.6, 8.7, 10.0, 11.3, 12.7, 14.2, 16.5, 19.1 g/100 solution at 0, 10, 20, 30, 40, 50, 60, 80, adn 100 deg. C, respectively. Solubility in Water: 6.9, 8,2, 9.6, 11.1, 12.7, 14.5, 16.5, 19.7, and 23.6 g/100g water at 0, 10, 20, 30, 40, 50, 60, 80, 100 deg. C, respectively.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Incompatible materials, Moisture. Stable in dry air, but slowly decomposes in moist air.

Incompatibility with various substances: Reactive with acids.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity:
Reacts with acids to form carbon dioxide. Dangerous reaction with monoammonium phosphate or a sodium-potassium alloy.

Special Remarks on Corrosivity: Not available.

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Inhalation. Ingestion.

Toxicity to Animals: Acute oral toxicity (LD50): 3360 mg/kg [Mouse].

Chronic Effects on Humans: Not available.

Other Toxic Effects on Humans: Slightly hazardous in case of skin contact (irritant), of ingestion, of inhalation.

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans:
Sodium Bicarbonate as produced genetic effects in rats (unscheduled DNA synthesis). However, no affects have been found in humans.

Special Remarks on other Toxic Effects on Humans:
Acute Potential Health Effects: Skin: May cause mild skin irritation. Eyes: May cause mild eye irritation. Inhalation: May cause respiratory tract irritation. Symptoms may include coughing and sneezing. Ingestion: Symptoms of overexposure to Sodium Bicarbonate include thirst, abdominal pain, gastroenteritis, and inflammation of the digestive tract. Chronic Potential Health Effects: Skin: Repeated or prolonged skin contact may cause irritation, drying or cracking of the skin. Ingestion and Inhalation: Chronic toxicity usually occurs within 4 to 10 days following ingestion of very large amounts. Repeated or prolonged ingestion or inhalation of large amounts may cause metabolic abnormalities, and sodium retention. Metabolic abnormalities such as acidosis, hypernatremia, hypochloremia, alkalosis, hypocalcemia, or sodium retention may affect the blood, kidneys, respiration (cyanosis, apnea secondary to metabolic acidosis or pulmonary edema), and cardiovascular system (tachycardia, hypotension). Severe toxicity may also affect behavior/central nervous system/nervous system. Neurological changes may result from metabolic abnormalities. These may include fatigue, irritability, dizziness, mental confusion, paresthesia, seizures, tetany, cerebral edema Medical Conditions Aggravated by Exposure: Persons with pre-existing skin conditions might have increased sensitivity. Predisposing conditions that contribute to a mild alkali syndrome include, renal disease, dehydration, adn electrolyte imbalance, hypertension, sarcoidosis, congestive heart failure, edema, or other sodium retaining conditions.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The product itself and its products of degradation are not toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:
Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

DOT Classification: Not a DOT controlled material (United States).

Identification: Not applicable.

Special Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

Federal and State Regulations: TSCA 8(b) inventory: Sodium bicarbonate

Other Regulations: Not available.

Other Classifications:

WHMIS (Canada): Not controlled under WHMIS (Canada).

DSCL (EEC):
This product is not classified according to the EU regulations. Not applicable.

HMIS (U.S.A.):

Health Hazard: 1

Fire Hazard: 0

Reactivity: 0

Personal Protection: E

National Fire Protection Association (U.S.A.):

Health: 1

Flammability: 0

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Safety glasses.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

Created: 10/10/2005 08:26 PM

Last Updated: 11/01/2010 12:00 PM

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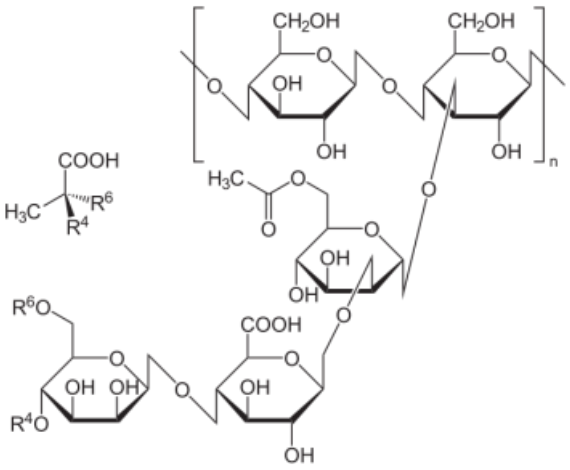
APPENDIX B

Human Health Chemical Profiles

Project number: 127635006
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: QGC

Name	Xanthan Gum
Synonyms	Corn sugar gum, Xanthan
CAS number	11138-66-2
Molecular formula	$C_{35}H_{49}O_{29}$ (monomer)
Molecular Structure	

Overview	References
A polysaccharide gum derived from the bacteria, Xanthomonas campestris. It is used as a thickening agent in food and personal care products. It is a hetero-polysaccharide with a primary structure consisting of repeated penta-saccharide units formed by two glucose units, two mannose units, and one glucuronic acid unit.	ChemIDPlus 2014; Garcia-Ochoa et al 2000
Xantham gum is listed as *Generally Recognised As Safe* (GRAS) by the US Food and Drug Administration (US FDA) for use as a thickening or a stabilizing agent in a diverse range of foods such as dairy products, breads, cookies, breakfast bars, noodles, whole wheat cereals, meatless lasagne , fruit juices, and cereal beverages. It is also used in medical food supplements	FDA 2012; Garcia-Ochoa et al. 2000
An early US Department of Agriculture toxicity study (1964) was a consideration in the JECFA review in 1986; which reported that the no-adverse-effect-level was considered to be 0.25 g/kg b.w./day (USDA, 1964). The study involved groups of 3 male and 3 female beagle dogs being fed containing 0, 0.25, or 0.5 g/kg bw/day xanthan gum for 12 weeks. More recently the USDA (2012) relisted xanthan gum as an approved product in organic foods (USDA, 2012).	USDA 1964(cited in JECFA 1998), USDA 2012
The Canadian Environmental Protection Act (CEPA) Environmental Registry lists xanthan gum on its Domestic Substances list as “does not” have great potential for human exposure, “is not” persistent and/or bioaccumulative and inherently toxic to humans and “low” for designation as a human health priority because it does not have potential for human exposure and/or is not inherently toxic to humans.	Environment Canada, 1994

Human Health Toxicity Summary	Reference
Carcinogenicity Xanthan gum has not been evaluated by the International Agency for Research on Cancer (IARC) as to its carcinogenicity.	IARC 2014
Mutagenicity/Genotoxicity Not expected to be genotoxic nor mutagenic.	WHO 1998
Reproductive Toxicity A three-generation reproductive study in rats reported no adverse effects attributable to xanthan gum. The study was carried out on 10 male and 20 female rats in the first generation and 20 male and 20 female rats in subsequent generations, with dose levels of 0, 0.25 and 0.5 g/kg/day. The study evaluated survival, body weight, general appearance, behaviour, the number of litters produced, number of live births and still births, physical condition of the young, weight at birth and weaning, and survival of the young.	Woodard et al., 1973 (cited in WHO 1998)
Developmental Toxicity/Teratogenicity NDF	
Endocrine Disruption Xanthan gum is not listed as a priority Endocrine Disrupting Substance by the European Commission.	EC 2000
Acute Toxicity (oral, dermal, inhalation) Xanthan gum has a low order of acute toxicity. An inhalation study involving five Albino rats receiving a single dose of xanthan gum, administered for one hour using a stainless steel inhalation chamber, reported no signs of toxicity during the following 14 day observation period. The exposure concentration was approximately 21 mg/L.	WHO 1998
Chronic/repeat dose toxicity (oral, dermal, inhalation) Xanthan gum toxicity studies (lifetime feeding studies and three generation reproductive toxicity study) have been reviewed by the US FDA and the World Health Organisation (WHO) and both expert bodies have concluded that the substance has very low toxicity and is generally recognised as safe (GRAS).	FDA 2012; WHO 1998
Sensitisation of the skin or respiratory system Xanthan gum is an inert polysaccharide and is unlikely to cause skin or respiratory sensitisation. WHO (1998) reports an intra-dermal test in guinea-pigs, which did not produced evidence of sensitisation.	WHO 1998
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye Xanthan gum is an inert polysaccharide and is unlikely to cause skin or eye irritation. Daily application of 1% solution for 15 days to rat skin produced no signs of irritation. Daily application of 1% solution for five days to rabbit conjunctiva produced no signs of irritation. However, potential irritation from xanthan gum dust has not been studied.	WHO 1998

Physical Hazards	Reference
Flammable Potential It is considered that based on its organic nature, xanthan gum dust could be flammable.	RMT, 2007; Lotioncrafter, 2009
Explosive Potential As an organic dust xanthan gum dust could pose an explosive hazard if ignited.	Safe Work Australia, 2012; RMT, 2007: Lotioncrafter, 2009

Toxicity Values	Value	Reference
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	> 45 000 mg/kg bw	WHO 1998
Mouse, oral	> 1 000 mg/kw bw	WHO 1998
Dog, oral	> 20 000 mg/ kg bw	WHO 1998

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NDF - No data found within the limits of the search strategy

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	NDF	
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	NDF	
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	No	Reproductive study in rats reported no adverse effects, WHO 1998
Endocrine Disruption[1]	No	
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	NDF	
Mutagenicity/Genotoxicity (GHS Category 2)	NDF	
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	No	WHO 1998
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg [2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L [3] (or mg/m^3) (vapour)	No	Oral LD_{50} in rats of > 45, 000 mg/kg bw, WHO 1998
High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d [2]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes [3]	No	FDA 2012; WHO 1998
Corrosive (irreversible effect)	No	WHO 1998
Respiratory sensitiser	No	WHO 1998
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [3]	No	FDA 2012; WHO 1998
Skin Sensitiser	No	WHO 1998
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours) [3]	No	Oral LD_{50} in rats of > 45, 000 mg/kg bw, WHO 1998
Irritant (reversible effect)	No	Assessed at 1% solution, WHO 1998
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**	Yes	
Physical Hazards		
Flammable potential	Yes	RMT, 2007: Lotioncrafter, 2009
Explosive potential	Yes	RMT, 2007: Lotioncrafter, 2009
Hazard Evaluation (highest band) not including physical hazards	0	

Uncertainty analysis /data confidence (out of 12 parameters)	10/ 12 = 83%	Data on carcinogenicity, mutagenicity or physical hazards

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]*Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.*

[2] *milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)*

[3] *Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed)". (p 18, NICNAS 2013).*

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)	NDF	
8-h TWA	NDF	
STEL	NDF	
Peak Limitation		
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	NDF	
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

Qualifying Summary Comments

Xanthan gum is a widely used food additive that is used primarily as a thickening agent. It has been used for this purpose for many years and is *listed as Generally Recognised As Safe* (GRAS). It is not considered inherently toxic to humans, with dietary studies showing no adverse effects in humans at levels up to 10 – 13 grams daily (although it is noted no information was provided on the weight of the humans studied) (JECFA, 1998). Published animal studies report a low order of acute toxicity. It is not expected to be persistent or bioaccumulative as it is readily degradable and metabolised in the liver. Based on this information xanthan gum was assigned to the Group 0 Band. The major concerns relate to the generation of xanthan gum dusts which have not been evaluated in human or animal studies. As an organic dust xanthan gum may present some irritancy based on generic information on organic dusts and the physical effects of dusts or respirable particles in particular. As an organic dust it has the capacity to burn with the major hazard for occupational settings being the potential for organic dust explosions in confined

environments. The latter would require suitable management measures if large amounts of xanthan gum dust is transported or stored.

References

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Environment Canada, 1994. *Domestic Substances List (DSL) listing for Xanthan Gum* (included in Part II of the *Canada Gazette*. Canadian Environmental Protection Act (CEPA) Environmental Registry. Available at http://www.ec.gc.ca/lcpe-cepa/eng/substance/chemicals_polymers.cfm, Accessed July 2014

EC (2000). European Commission Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000). Available at http://ec.europa.eu/environment/chemicals/endocrine/strategy/substances_en.htm#priority_list [Accessed July 2014]

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Garcia-Ochoa, F., Santos, V.E., Casas, J.A. and E. Gomez. 2000. Research review paper – Xanthan gum: production, recovery and properties. Biotechnology Advances 18: 549-579.

IARC (International Agency for Research on Cancer) 2014. *International Agency for Research on Cancer Agents classified by IARC Monographs*, Volumes 1- 109. Last updated: 31 March 2014, Available at http://monographs.iarc.fr/ENG/Classification/index.php., Accessed July 2014

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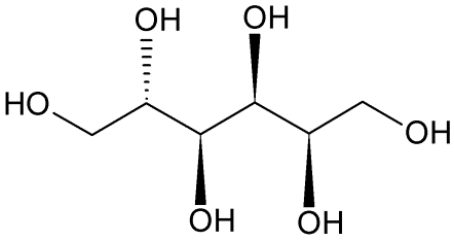
Project number: 127635006
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: QGC

Created by:	MGT	10/07/2014
Reviewed by:	LT	18/07/2014 Rev 0

Project number: 127635006
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: QGC

Name	Sorbitol
Synonyms	1,2,3,4,5,6-hexanehexol
CAS number	50-70-4
Molecular formula	$C_6H_{14}O_6$
Molecular Structure	

Overview	References
Sorbitol is a hexa-hydric alcohol, which is an isomer of mannitol. It is an odourless, white powder, which has a sweet taste. It has a melting point of approximately 111°C and is soluble in water. The production of sorbitol involves electrolytic reduction or transitional metal catalytic hydrogenation of sugar solutions containing glucose or fructose. Sorbitol also occurs naturally in many edible fruits and berries.	HSDB 2010; FDA 2013
Sorbitol is used in pharmaceutical and cosmetics products, primarily as an excipient, and in a variety of food products. The various uses of sorbitol in food products include as an anti-caking agent and free-flow agent, curing and pickling agent, drying agent, emulsifier and emulsifier salt, firming agent, flavouring agent, formulation aid, humectant, lubricant and release agent, nutritive sweetener, additive, stabiliser, thickener surface-finishing agent and texturiser. Sorbitol can comprise up to 99% of hard candy and cough drops, 98% of soft candy and up to 75% of chewing gum.	HSDB 2010; FDA 2013
Sorbitol is listed as "*Generally Recognised as Safe*" (GRAS) by the U.S. Food and Drug Administration's (FDA) Select Committee on GRAS Substances (SCOGS). The committee reviewed available information and concluded that there were no short-term toxicological adverse effects in rats, mice, monkeys or man and no long-term toxicological adverse effects in rats from consuming sorbitol in amounts exceeding those currently consumed in the normal diet of the U.S. population. The study also found that human consumption of sorbitol in food (in 1972) had not resulted in adverse effects in humans after many years of use, with the exception of a laxative effect at levels which were observed to be twice the estimated average adult intake level. The FDA's Code of Federal Register (CFR) states that any food with reasonable foreseeable consumption which would lead to a sorbitol intake of greater than 50 grams must indicate on its label that this consumption may lead to laxative effects.	FDA 1972; FDA 2013
Health effects of exposure to the substance have been investigated extensively but none have been found.	IPCS 2002

Human Health Toxicity Summary	Reference
Carcinogenicity Sorbitol has not been evaluated by the International Agency for Research on Cancer (IARC) as to its carcinogenicity.	IARC 2014

Mutagenicity/Genotoxicity NDF.	
Reproductive Toxicity NDF.	
Developmental Toxicity/Teratogenicity NDF.	
Endocrine Disruption Sorbitol is not listed as a priority endocrine disrupting substance by the European Commission.	EC 2000
Acute Toxicity (oral, dermal, inhalation) A study reported that consumption of sorbitol in food (1972) had not resulted in adverse effects in humans after many years of use, with the exception of a laxative effect at levels which were observed to be twice the estimated average adult intake level. The FDA's Code of Federal Register (CFR) states that any food with reasonable foreseeable consumption which would lead to a sorbitol intake of greater than 50 grams must indicate on its label that this consumption may lead to laxative effects.	FDA 1972; FDA 2013
Chronic/repeat dose toxicity (oral, dermal, inhalation) Sorbitol accumulation plays an important role in diabetic complications involving the kidney, nerves, retina, lens and cardiac muscle..	Shinohara R et al. 1998 (cited by HSDB 2010)
Sensitisation of the skin or respiratory system NDF.	
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye A nuisance-causing concentration of airborne particles can be reached quickly when dispersed.	IPCS 2002

Physical Hazards	Reference
Flammable Potential Combustible.	IPCS 2002
Explosive Potential Finely dispersed particles form explosive mixtures in air	IPCS 2002

Toxicity Values	Value	Reference
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	15 900 mg/kg	HSDB 2010
Mouse, oral	17 800 mg/kg	HSDB 2010
LC_{50}		
	NDF	
High Chronic/Repeat Dose Toxicity		
	NDF	

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NDF - No data found within the limits of the search strategy

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	NDF	
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	NDF	
Reproductive toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	NDF	
Endocrine Disruption[1]	No	EC 2000
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	NDF	
Mutagenicity/Genotoxicity (GHS Category 2)	NDF	
Reproductive toxicity/Developmental toxicity (GHS Category 2)	NDF	
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg [2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L [3] (or mg/m^3) (vapour)	No	Oral LD_{50} for Rat of 15 900 mg/kg (HSDB 2010)
High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d [2]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes [3]	No	Component of various common food products for decades (FDA 1972, FDA 2013)
Corrosive (irreversible effect)	NDF	
Respiratory sensitiser	NDF	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [3]	No	Component of various common food products for decades (FDA 1972; FDA 2013)
Skin Sensitiser	NDF	
Hazard Band 1		
Acute Toxicity • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours) [3]	No	Oral LD_{50} for Rat of 15 900 mg/kg (HSDB 2010)
Irritant (reversible effect)	Yes	Respiratory irritation(IPCS 2002)
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	Yes	
Explosive potential	Yes	
Hazard Evaluation (highest band) not including physical hazards	1	Respiratory irritation
Uncertainty analysis /data confidence (out of 12 parameters)	6/12 = 50%	Data lacking for carcinogenicity, mutagenicity, reproductive toxicity,

		sensitisation and corrosivity

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.

[2] milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)

[3] Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed)". (p 18, NICNAS 2013).

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	NDF	
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	NDF	
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

Qualifying Summary Comments

Sorbitol is a naturally occurring alcohol, which is sweet to the taste. It is used in several pharmaceutical and cosmetic products, primarily as an excipient, and also in a variety of food products. Sorbitol is listed as GRAS by the FDA's SCOGS. The committee reviewed available animal toxicology data and concluded that there were no short-term or long-term toxicological adverse effects observed at concentration of sorbitol currently consumed in the normal diet of the U.S. population. A laxative effect has been observed following human consumption at certain dose levels. The FDA's CFR requires an associated warning be placed on any food item containing more than 50 g of sorbitol. There is also the potential for sorbitol to result in respiratory irritation if inhalable sorbitol dusts are generated. In addition such organic dusts may be explosive which reflects a need for suitable occupational management measures. On the basis of the respiratory irritation, sorbitol in powder form has been assigned a Hazard Band of 1.

References and Notes

EC (European Commission) 2000. *European Commission Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000)*. BKH Consulting Engineers, Delft, The Netherlands in association with TNO Nutrition and Food Research, Zeist, The Netherlands Available at http://ec.europa.eu/environment/chemicals/endocrine/strategy/substances_en.htm#priority_list, Accessed July 2014

FDA (U.S. Food and Drug Administration) 1972. *Select Committee on GRAS Substances (SCOGS) Opinion: Sorbitol, Report Number 9*. Generally Recognised as Safe (GRAS) Substance Database. U.S. Food and Drug Administration. Available at http://www.fda.gov/Food/IngredientsPackagingLabeling/GRAS/SCOGS/ucm260079.htm, Accessed July 2014

FDA (U.S. Food and Drug Administration) 2013. *Code of Federal Regulations: Title 21, Volume 3 listing for Sorbitol* (Section 184.1835). Revised 1 April 2013. U.S. Food and Drug Administration. Available at http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?fr=184.1835, Accessed July 2014

HSDB (Hazardous Substances Data Bank) 2010. *Dossier for D-Sorbitol*.HSDB. Available at http://toxnet.nlm.nih.gov/, Accessed July 2014

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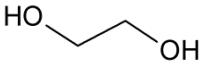
IPCS (International Program on Chemical Safety) 2002. *International Chemical Safety Card on D-Sorbitol*. IPCS, Commission of the European Communities. Available at http://www.inchem.org/documents/icsc/icsc/eics0892.htm, Accessed July 2014

Created by:	MGT	11/07/2014
Reviewed by:	LT	21/07/2014 Rev0

Project number: 127635006
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: QGC

Name	Ethane-1,2-diol
Synonyms	Ethylene Glycol, 1,2-ethanediol, glycol, ethylene alcohol, hypo-dicarbonous acid, mono-ethylene glycol, 1,2-dihydroxyethane, ethylene dehydrate, MEG, Lutrol-9, Dowtherm Sr 1, Fridex, Norkool, Ramp, Tescol; Ucar 17
CAS number	107-21-1
Molecular formula	$C_2H_6O_2$
Molecular Structure	

Overview	References
Ethylene glycol is a colourless, odourless, sweet tasting, relatively non-volatile liquid with high water solubility. It is a small molecular-weight alcohol which readily passes through biological membranes and is absorbed from the gastro-intestinal tract (GI) tract and in the lung. Ethylene glycol has numerous commercial and industrial applications such as in chemical manufacturing, natural gas processing and as an engine coolant. It is commonly used in antifreeze and hydraulic break fluids in both the automotive and aviation industry. It is also present in inks used in stamp pads, ballpoint pens and print shops. Ethylene glycol is considered highly toxic with multiple metabolites contributing to the toxic effects. The metabolites of ethylene glycol that have been typically detected are carbon dioxide, glycolic acid, and oxalic acid. Oxalic acid is converted to harmful calcium oxalate crystals, which are deposited in various tissues. Target organ cellular damage is seen in the kidney, brain, myocardium, pancreas, and blood vessel walls. Numerous human case studies and controlled experiments on animals are available to provide data on the toxic effects of ethylene glycol. Ethylene glycol is quickly and extensively absorbed through the GI tract of many species, but dermal absorption is slow in rodents and is slow and poorly absorbed through the skin in humans.	ATSDR 2010

Human Health Toxicity Summary	Reference
Carcinogenicity Ethylene glycol has not been evaluated by the International Agency for Research on Cancer.. Ethylene glycol exhibited no evidence of carcinogenicity based on a two year bioassay with rats and mice. In several animal studies, there was no evidence of carcinogenicity in animals.	IARC 2014;ATSDR 2010
Mutagenicity/Genotoxicity Ethylene glycol is not classified as a mutagen by the European Chemicals Agency (ECHA). An ATSDR study reported that available *in vivo* and *in vitro* laboratory studies provided consistently negative genotoxicity results. No significant mutagenic activity was observed using the Ames test. *In vitro* mutagenicity studies in bacterial cells have consistently reported negative	ECHA 2014; ATSDR 2010

results.	
Reproductive Toxicity Ethylene glycol is not classified as reproductively toxic by ECHA on the basis that the data are sufficient and do not support classification under the GHS (Rev4)) thresholds. This fact contrasts with the ATSDR (2010) animal data on developmental toxicity (see section below). While the GHS classification includes both reproductive and developmental toxicity these data have been presented separately in this profile to differentiate the nature of the toxicological response. There have been equivocal studies of reproductive toxicity. There has been no evidence of an adverse impact on reproductive organs observed in repeated dose toxicity studies in animals while other contradictory reports suggest reproductive effects such as decreased number of litters per pair, number of live pups per pair, and live pup weight, pup facial deformities and abnormal skeletons following long-term exposure to high doses. While the latter was observed in mice the effect was not observed in rats or rabbits under the same conditions. A further study in rats reported embryotoxicity following administration of ethylene glycol.	ECHA 2014 ATSDR 2010
Developmental Toxicity/Teratogenicity While there are insufficient human data on developmental toxicity / teratogenicity of ethyl glycol, There are animal data as presented in ATSDR (2010) and summarized below. Several acute-durational studies have been undertaken to assess developmental toxicity of ethylene glycol in mice, rats and rabbits. The studies indicate that malformations occur in both mice and rats exposure during gestations. Skeletal malformations were most apparent and mice appeared more sensitive than the other animals. Reduction in foetal body weight was also observed in laboratory animals exposed to ethylene glycol. ATSDR (2010) consider ethylene glycol to be teratogenic, more so in mice than in rats, rabbits and chickens. It induces primarily skeletal and external malformations. Teratogenic effects in mice were seen at all dose levels (750-3000 mg/kg/day) and in rats at 2500 and 5000 mg/kg/day. Animals given less than the limit dose (1000 mg/kg/day) only by the oral route and only when rapidly ingested (bolus) exhibited developmental toxicity.	ATSDR 2010
Endocrine Disruption Ethylene glycol is listed on the European Commission Priority List for endocrine disruptors as Category 3C. A classification of 3 indicates that the review found no scientific basis for inclusion in the priority list. The classification of C indicates that data were available on wildlife/relevant and/or mammal relevant endocrine effects for assessment.	EC 2000
Acute Toxicity (oral, dermal, inhalation) Ethyl glycol is classified as acutely toxic via the oral route by ECHA based on its classification thresholds. ATSDR reports that in humans, the lethal dose of ethylene glycol is estimated to be in the range of 1,400–1,600 mg/kg. However, there are difficulties in quantifying the amounts consumed by persons who have succumbed to the toxic effects, which has led to uncertainty in the human lethal dose estimates. In laboratory animals (rats, mice, monkeys), oral doses of ≥4,000 mg/kg were required to cause death. Available information on the effects of acute accidental or intentional ingestion of ethylene glycol in humans suggests that acute oral toxicity in humans occurs in three stages within 72 hours of ingestion. Initially central nervous system depression, metabolic changes (hyper-osmolality) and gastrointestinal upset occurs and lasts from 30 minutes to 12 hours. These effects are followed by a second stage of symptoms which includes metabolic acidosis and associated cardio-	ECHA 2014; ATSDR 2010

pulmonary symptoms (tachypnea, hyperpnea, tachycardia, cyanosis, pulmonary oedema, and/or cardiac failure). The second stage of effects has been observed to last 12 – 24 hours after ingestion. The third stage (24 – 72 hours after ingestion) is characterized by renal involvement (flank pain and oliguria/anuria). There is also limited information suggesting a fourth stage, where cranial nerves (evident through deafness, facial paralysis, and other sequelae) may occur 6 or more days after exposure. Renal effects in orally exposed animals are consistent with those observed in humans. In acute-duration studies, effects occurred in the kidneys of rats exposed to 1,250–2,500 mg/kg/day by gavage or 2, 615– 5,270 mg/kg/day in drinking water for 9–29 days, and rabbits exposed to 2,000 mg/kg/day by gavage for 13 days. A human inhalation study of short-term, high-exposure periods found that ethylene glycol was tolerated for only 15 minutes at 188 mg/m^3; 2 minutes at 244 mg/m^3; and one or two breaths at 308 mg/m^3. The study reports that irritation of the respiratory tract became common at an ethylene glycol concentration of approximately 140 mg/m^3 (further data not provided), with concentration of ≥ 200 mg/m^3 being intolerable due to strong irritation of the upper respiratory tract. Reported effects included a burning sensation in the trachea and a burning cough.	
Chronic/repeat dose toxicity (oral, dermal, inhalation) Ethylene glycol is classified as chronically toxic via the oral route by ECHA. Prolonged or repeat exposure may cause damage to the kidney (GHS Category 2). A 90-day study of rats exposed to ethylene glycol in drinking water found that renal effects were observed in males at > 947 mg/kg/day and females at 3, 087 mg/kg/day. The effects included renal tubular oxalate crystal deposition, dilation and degeneration of the kidney. Renal effects in rats and mice exposed to ethylene glycol in the diet for up to 2 years have also been studied. The studies showed males were more sensitive than females and rats were more sensitive than mice. At concentrations of ≥ 300 mg/kg/day, renal effects, including oxalate nephrosis, were observed in male rats. Oxalate crystal deposition and apparent tubular degenerative changes in male rats was observed at ≥ 375 mg/kg/day and in female rats at ≥ 750 mg/kg/day. A 30-day human study reported that inhalation exposure to ethylene glycol vapour was well tolerated at an average concentration of 30 mg/m^3 for 20-22 hours/day. The effects reported were essentially limited to the occasional complaint about mild irritation of the upper respiratory tract.	ECHA 2014; ATSDR 2010
Sensitisation of the skin or respiratory system Ethylene glycol is not classified as a skin or respiratory system sensitiser by ECHA (considered conclusive data for not classifying the substance by ECHA).	ECHA 2014
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye Ethylene glycol is not reported as causing corrosion or irritation effects on the skin or eyes by ECHA.	ECHA 2014

Physical Hazards	Reference
Flammable Potential Not considered flammable by ECHA. Flashpoint of 127ºC, Auto-ignition temperature of 398ºC.	ECHA 2014; ATSDR 2010

Explosive Potential Not considered explosive by ECHA. Explosive limits are reported as 3.20 – 53%	ECHA 2014; ATSDR 2010

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LD_{Lo} (lowest lethal dose), male, lethal dose 48 hrs after single ingestion	4071 mg/kg	ATSDR 2010
LD_{Lo}, lethal dose in 6/11 after single exposure	2379 mg/kg	ATSDR 2010
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral, female	4000 mg/kg /day	ATSDR 2010
Rat, oral	7712 mg/ kg	ECHA 2014
Mouse, dermal	> 3500 mg/kg	ECHA 2014
LC_{50}		
Rat, 6 hr exposure	> 2.5 mg/L air (> 2500 mg/m^3)	ECHA 2014
High Chronic/Repeat Dose Toxicity		
LOAEL, humans, inhalation, respiratory tract irritation	140 mg/m^3	ATSDR 2010
LOAEL, rats, 10 d, drinking water, renal toxicity	2615 mg/kg/day	ATSDR 2010
LOAEL, rats, male, 90 d drinking water, renal toxicity	947 mg/kg/day	ATSDR 2010
LOAEL, rats, female, 90 d drinking water, renal toxicity	3 087 mg/kg/day	ATSDR 2010
LOAEL, rats, male, 16 w dietary study, renal toxicity	180 mg/kg/day	ATSDR 2010
LOAEL, mice, oral, developmental toxicity	500 mg/kg/day	ATSDR 2010
LOAEL, rats, oral, developmental toxicity	750 mg/kg/day	ATSDR 2010
LOAEL, rabbit, 14 d GW, female, renal toxicity	2000 mg/kg/day	ATSDR 2010

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NDF – No data found within the limits of the search strategy

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	NDF	ATSDR 2010, Not classified by IARC
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	ATSDR 2010
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	No	See below
Endocrine Disruption[1]	No	Listed as Category 3C on priority by EC (EC 2000)
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No	ATSDR 2010
Mutagenicity/Genotoxicity (GHS Category 2)	No	ATSDR 2010
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	Yes	Development toxicity observed in animal studies, ATSDR 2010.
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg [2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L [3] (or mg/m^3) (vapour)	No	See below
High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d [2]; • dermal LOAEL ≤ 20 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes [3]	No	See below
Corrosive (irreversible effect)	No	ECHA 2014
Respiratory sensitiser	No	ECHA 2014
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [3]	Yes	Prolonged or repeat does exposure may cause damage to the kidney (ATSDR 2010), GHS Category 2 (ECHA 2014)
Skin Sensitiser	No	ECHA 2014
Hazard Band 1		
Acute Toxicity • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours) [3]	No	LD_{50}, rat, oral – 4 000 mg/kg/day (ATSDR 2010)
Irritant (reversible effect)	Yes	Respiratory tract irritation (ATSDR 2010)
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**	No	
Physical Hazards		

Flammable potential	No	
Explosive potential	No	
Hazard Evaluation (highest band) not including physical hazards	3	**Reproductive, developmental, teratogenic and neurological effects in animals.**
Uncertainty analysis /data confidence (out of 12 parameters)	11/12	**92%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1] *Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.*

[2] *milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)*

[3] *Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed)". (p 18, NICNAS 2013).*

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	52 mg/ m^3 (vapour) 10 mg/ m^3 (particulate)	HSIS 2005
STEL	104 mg/ m^3 (vapour)	HSIS 2005
Peak Limitation	NDF	
Minimal Risk Levels (MRLs)		
Inhalation (acute exposure, 14 days or less)	2 mg/m^3	ATSDR 2010
Oral (acute exposure, 14 days or less)	0.8 mg/kg/day	ATSDR 2010
Environmental Exposure		
Air, ambient	NDF	
Air, indoor, residential	0.042 mg/m^3	USEPA 2014
Water, potable	4 mg/L	USEPA 2014
Water, recreational	NDF	
Soil, residential	1200 mg/kg	USEPA 2014
Soil, commercial/industrial	160 000 mg/kg	USEPA 2014

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

Qualifying Summary Comments

Ethylene glycol exhibits a diverse range of adverse toxicological outcomes in animal studies including reproductive, developmental and teratogenic effects and renal effects after chronic exposure, although it is not

considered highly acutely toxic via the oral, dermal and inhalation pathways. In humans it is considered to be acutely toxic. Furthermore, while ECHA has not classified ethylene glycol as a reproductive toxicant, ATSDR (2010) highlight the developmental toxicity of ethylene glycol in animals. Taking these concerns into account and subject to further evaluations of the animal data by regulatory agencies a Hazard Band 3 rating has been estimated. It is not flammable or explosive and burns with difficulty. While these properties warrant management for the occupational setting and where large scale emergency spills may result in local population exposure, data from river die-away tests suggest degradation is complete within 3 days at 20 deg C and 5-14 days at 8 deg C. (HSDB, 2012). This implies rapid degradation of ethylene glycol in surface water. This limits its ability for accumulation and sustained environmental presence even though its mobility characteristics are high.

References and Notes

ATSDR (Agency for Toxic Substances and Disease Registry), 2010. *Toxicological Profile for Ethylene Glycol*., Division of Toxicology and Environmental Medicine/Applied Toxicology Branch, Public Health Service, US Department of Health and Human Services. Available at http://www.atsdr.cdc.gov/ToxProfiles/TP.asp?id=86&tid=21, Accessed July 2014

ECHA (European Chemicals Agency Registered Chemical Substances Search) 2014. *Dossier of Ethane-1,2-diol*. Available at http://apps.echa.europa.eu/registered/data/dossiers/DISS-9d87859b-95d3-6682-e044-00144f67d249/AGGR-8f1e8288-2288-425d-af91-36c0825eec44_DISS-9d87859b-95d3-6682-e044-00144f67d249.html#L-36228e21-7009-4995-9a73-b8e50825a09f, Accessed July 2014

EC (European Commission) 2000. *European Commission Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption, preparation of a candidate list of substances as a basis for priority setting, Final Report (Incorporating corrigenda to final report dated 21 June 2000)*. BKH Consulting Engineers, Delft, The Netherlands in association with TNO Nutrition and Food Research, Zeist, The Netherlands Available at http://ec.europa.eu/environment/chemicals/endocrine/strategy/substances_en.htm#priority_list, Accessed July 2014

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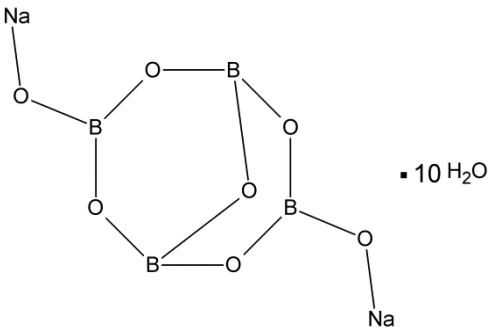
USEPA (United States Environmental Protection Authority) 2014. *Regional Screening Level – Screening Levels for Chemical Contaminants*, Updated May 2014. Available at http://www.epa.gov/region9/superfund/prg/, Accessed July 2014

Created by:	MR MGT	July 2013 20 July 2014

Reviewed by:	LT	July 2013 Rev0 21 July 2014 Rev1 16 September 2014 Rev2

Project number: 127635006
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: QGC

Name	Borax (SURROGATE FOR Sodium tetraborate 1330-43-4, anhydrous)
Synonyms	Borax, sodium tetraborate decahydrate, sodium pyroborate
CAS number	1303-96-4 (surrogate for 1330-43-4)
Molecular formula	B4Na2O7.10H2O (surrogate for B4Na2O7)
Molecular Structure	

Overview	References
Sodium tetraborate is a naturally occurring mineral distributed widely in the environment. Commonly known as borax, it occurs in arid regions and was deposited by evaporation of salt lakes in the Tertiary Period. Sodium tetraborate is a white crystalline solid with no odour and an alkaline taste. It is differentiated by the degree of hydration and ranges from the anhydrous form to the decahydrate which is referred to as borax. There are slight differences in toxicity based on the degree of hydration.	ATSDR 2010
Industrial uses of sodium tetraborate in the United States of America include glass and ceramics (70%), soaps, bleaches, and detergents (4%), fire retardants (2%), and agriculture (2%). Other uses, including metallurgy, nuclear applications; as an addition to enamels and glazes; and in ingredients for cosmetics or medical preparations which make up the remaining 19%.	ATSDR 2010
Borates are relatively soluble in water, and readily hydrolysed to form boric acid. Boron in aqueous solution may also be adsorbed by soils and sediments, with adsorption-desorption reactions expected to be the only significant mechanism that influences the fate of boron in water. The extent of boron adsorption depends on the pH of the water and the chemical composition of the soil, with the greatest adsorption generally observed at pH 7.5–9.0.	ATSDR 2010, Rai et al. 1986, Keren & Mezuman 1981, Keren et al. 1981
Human exposure to sodium tetraborate may occur through ingestion of boron in food and water, or through use of pesticides containing boron compounds; inhalation of boron-containing powders or dusts, or the use of boron in cosmetics or medical preparations.	ATSDR 2010
Boron concentrations in ambient non-occupational air samples in the United States have been reported to range from $<5x10^{-7}$ to $8x10^{-5}$ mg boron/m^3, with an average concentration of $2x10^{-5}$ mg boron/m^3. Workers in other industries, including fiberglass and other glass product manufacture, cleaning and laundry products, fertilizers, pesticides, and cosmetics, may also be exposed to boron compounds. Mean dust concentrations ranging from 3.3 to 18 mg particulates/m^3 were measured in air samples from U.S. facilities where borax was packaged and shipped. The dust samples reported were predominantly composed of various types of borates and ranged from 11.8 to 15.2% boron by weight.	ATSDR 2010
The primary health effect associated with inhalation exposure of humans to boron is 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 have been associated with mild irritation of the eyes, throat, and nose, as well as with cough and breathlessness.	ATSDR 2010

Oral exposure animal studies have clearly identified the reproductive system and developing foetus as the most sensitive targets for boron toxicity. Adverse developmental effects have been identified for acute-and intermediate-duration exposures. Human case reports have reported 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 doses appears quite large.	ATSDR 2010
The primary health effects associated with dermal exposure are irritation of the eyes and reversible skin changes. Case reports of human occupational exposures have suggested that acute dermal exposure to boron as borax may cause localized hair loss from the scalp.	ATSDR 2010
No epidemiology studies have identified an association between boron exposure and the development of cancer. The International Agency for Research on Cancer (IARC) has not assessed the carcinogenic potential of boron, sodium tetraborate or other borates. The United States Environment Protection Agency (USEPA) has stated that boron and associated compounds are not classifiable as to their carcinogenic potential on the basis of inadequate data.	IARC 2014, IRIS 2004

Human Health Toxicity Summary	Reference
Carcinogenicity Inadequate data for classification ('Boron and compounds') (USEPA). Boron, sodium tetraborate or other borates have not been evaluated by the International Agency for Research on Cancer Carcinogen (IARC) list.	IRIS 2004 IARC 2014
Mutagenicity/Genotoxicity Negative results have been reported from studies in *in vivo* bacteria, mammalian cells and mice.	IRIS 2004
Reproductive Toxicity Disodium tetraborate (anhydrous, pentahydrate and decahydrate) is classified as a presumed human reproductive toxicant based on animal studies (GHS Reproductive Category 1B (at concentration of > 4.5%)). Oral exposure to the substance may damage fertility. The Australian Hazardous Substances Information System lists disodium tetraborate, anhydrous as GHS Reproductive Category 2, however, a recent updating based on GHS (produced as a list (June 2014) has also reported the anhydrous form of Borax as a Reproductive Category 1B. Testes are a sensitive target of boron toxicity in rats and mice (oral studies). Testicular effects from these studies have included reduced organ weight and organ:body weight ratio, atrophy, degeneration of the spermatogenic epithelium, impaired spermatogenesis, reduced fertility, and sterility.	ECHA 2014, HSIS 2009; 2014 Weir & Fisher, 1972; Seal & Weeth, 1980; NTP, 1987; Fail et al.,1991 (in IRIS, 2004)
Developmental Toxicity/Teratogenicity Disodium tetraborate (anhydrous, pentahydrate and decahydrate) is classified as a presumed human reproductive toxicant based on animal studies (GHS Reproductive Category 1B (at concentration of > 4.5%)). Oral exposure to the substance may damage the unborn child. Foetuses from rats (Sprague-Dawley) exposed to boric acid in their feed had reduced foetal body weight and short and wavy ribs with effects disappearing during the postnatal period. A LOAEL for developmental toxicity of 76 mg/kg/day was determined. Boric acid administered to rabbits (New Zealand White) by gavage was found to be toxic to dams and result in foetal resorption and cardiac or great vessel malformations in surviving foetuses. A LOAEL for maternal and developmental toxicity of 250 mg/kg/day was determined.	ECHA 2014
Endocrine Disruption Changes in testicular characteristics following exposure to boric-acid have suggested the involvement of an endocrine mechanism, however, boron and borates are not listed as priority	Weir and Fisher, 1972 (in IRIS 2004),

Endocrine Disrupting substances by the European Commission.	EC 2000
Acute Toxicity (oral, dermal, inhalation) Acute *oral* exposure of humans to boron and its soluble salts (including sodium tetraborate) have been lethal at sufficiently high doses. The minimum 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. Adverse developmental effects have been identified for acute-duration oral exposures in mice and rats. Acute *dermal* exposure of humans to sodium tetraborate may cause localized hair loss from the scalp. In animals, exposure to boron dust and aqueous solution applied to the eyes has resulted in conjunctivitis, mild irritancy of the epithelium and superficial stroma. Acute *inhalational* exposure of humans to boron can cause acute respiratory irritation and increased nasal secretions.	ATSDR 2010
Chronic/repeat dose toxicity (oral, dermal, inhalation) Chronic *oral* exposure of humans to borate salts in drinking water (9–25 mg boron/L) found no evidence of reproductive effects. Chronic *dermal* exposure of industrial workers to sodium tetraborate dust has been documented to cause chronic eczema. Chronic *inhalational* exposure of humans to sodium tetraborate dust has been documented to cause symptoms of persistent respiratory irritation meeting the definition of chronic simple bronchitis. Testicular atrophy has been observed in rats exposed to 81 mg boron/kg/day and mice exposed to 201 mg boron/kg/day for 2 years. Several systemic effects have also been observed in chronic animal studies, including haematological effects, desquamated skin and chronic inflammation of the liver.	ATSDR 2010; Garabrant et al. 1984; International Labour Office 1983
Sensitisation of the skin or respiratory system Not classified as a skin or respiratory sensitiser by ECHA. *In vivo* Buehler tests (OECD guideline 406) carried out on male/female guinea pigs (Hartley) concluded boric acid was not a skin sensitiser. The dose applied epi-cutaneously (occlusive) was 0.4 g, 95% w/w. Chronic *dermal* exposure of industrial workers to sodium tetraborate dust has been documented to cause chronic eczema.	ECHA 2014 ATSDR 2010
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye Not classified as corrosive/irritating to the skin by ECHA. Disodium tetraborate (anhydrous, pentahydrate, decahydrate) is classified as an eye irritant (Eye Irrit. 2 H319). Eye irritation is caused by the glassy nature of the crystals of the substance (physical effect) and not a chemical effect of irritation. Disodium tetraborate decahydrate is used as a buffer in eyewashes. Not corrosive. Irritant to the skin and mucous membranes of the eyes, nose and other parts of the respiratory tract.	ECHA 2014 ECHA 2014 ACGIH 2001

Physical Hazards	Reference
Flammable Potential Not considered flammable by ECHA.	ECHA 2014
Explosive Potential Not considered explosive by ECHA.	ECHA 2014

Toxicity Values	Value	Reference
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	396 – 5 660 mg/kg	USEPA (1988), O'Neill (ed) (2001)
Rabbit, dermal	>10 000 mg/kg	Tomlin (ed) (2003 – 2004)
LC_{50}		
Rat	>2 mg/m3/4 hrs	Bingham et al. (2001)
High Chronic/Repeat Dose Toxicity		
LOAEL, oral, maternal toxicity (organ weight), rats	28.5 mg B/ kg	Heindel et al. (1992); Price et al. (1990) (in IRIS 2004)
LOAEL, oral, developmental toxicity, rats	13.6 – 25.3 mg B/kg	Heindel et al. (1992); Price et al. (1990) (in IRIS 2004)
LOAEL, oral, developmental toxicity, rats	76 mg/kg/day	ECHA 2014
LOAEL, oral, developmental and maternal toxicity, rabbits	250 mg/kg/day	ECHA 2014
NOAEL, oral, developmental toxicity, rats	55 mg/kg/day	ECHA 2014
NOAEL, oral, developmental and maternal toxicity, rabbits	125 mg/kg/day	ECHA 2014

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NDF – No data found within the limits of the search strategy

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	NDF	
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	ECHA 2014; IRIS 2004
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	Yes	ECHA 2014, Category 1B; HSIS 2014
Endocrine Disruption[1]	No	EC (2000)
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	NDF	
Mutagenicity/Genotoxicity (GHS Category 2)	No	ECHA 2014; IRIS 2004
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	No	ECHA 2014; HSIS 2014
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg [2] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L [3] (or mg/m^3) (vapour)	No	ATSDR 2010
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d [2]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes [3]	No	ECHA 2014; ATSDR 2010; Garabrant et al. 1984; International Labour Office 1983.
Corrosive (irreversible effect)	No	ECHA 2014
Respiratory sensitiser	No	ECHA 2014
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [3]	Yes	Based on decreased fetal body weight (Heindel et al., 1992; Price et al., 1996) Occupational exposure to sodium borate dust (Garabrant et al., 1984)
Skin Sensitiser	No	ECHA 2014
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[3]	No	USEPA 1988; O'Neill (ed) 2001
Irritant (reversible effect)	Yes	ECHA 2014, Evidence for eye irritation
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	No	ECHA 2014
Explosive potential	No	ECHA 2014
Hazard Evaluation (highest band) not including physical hazards	**Band 4**	Based on reproductive and developmental toxicity

Uncertainty analysis /data confidence (out of 12 parameters)	11/12	**91%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1] *Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.*

[2] *milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)*

[3] *Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed)". (p 18, NICNAS 2013).*

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	5 mg/m^3 (Disodium tetraborate decahydrate) 1 mg/m^3 (Disodium tetraborate, pentahydrate) 1 mg/m^3 (Disodium tetraborate, anhydrous)	HSIS (2009)
STEL	6 mg/m^3 (sodium tetraborate)	ACGIH (2006) (in ATSDR, 2010)
Peak Limitation	NDF	All proposed data sources
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	0.021 mg/ m^3 (boron and borates) – residential air 0.088 mg/ m^3 (boron and borates) – industrial air	USEPA Region 9 RSLs (2012)
Water, potable	4 mg/L (boron)	NEPM (1999; amended 2013)
Water, recreational	NDF	All proposed data sources
Soil, residential	4,500 mg/kg (boron); Setting A – low density residential 40,000 mg/kg (boron); Setting B – high density residential	NEPM (1999; amended 2013)
Soil, commercial/industrial	300,000 mg/kg (boron); Setting D – commercial/industrial	NEPM (1999; amended 2013)

Footnotes:

OEL = Occupational Exposure Limit

TWA= 8 h Time-Weighted Average

STEL = (15 min) Short-term Exposure Limit

Qualifying Summary Comments

Boric acid is an inorganic, white, odourless, crystalline solid. Its primary uses (along with sodium salts of boron (primarily borax, or disodium tetraborate decahydrate)) are in industrial processes such as the manufacture of glass, as a fire retardant, in laundry additives, in fertilisers and in herbicides. Low concentrations of simple inorganic borates (e.g. boric acid, disodium tetraborate pentahydrate, boric oxide and disodium octaborate tetrahydrate) will predominately exist as un-dissociated boric acid in aqueous solutions at physiological and acidic pH. Sodium tetraborate exhibits a Hazard Band Rating of 4 based on its reproductive toxicity potential in animal studies. In addition, anhydrous boric acid and aqueous solutions have been reported as being irritating to the eye. There appears a greater potential for irritancy associated with the less hydrated forms. It is not flammable

and explosive but as a powder it may result in contact and inhalation exposures in occupational settings which can lead to adverse respiratory, dermal and ocular effects. In the environmental setting its solubility and resultant persistence as the metal in various forms combined with its identified toxicity warrants closer evaluation of frequency of use, masses of chemical used and potential distribution in water, soils and sediments.

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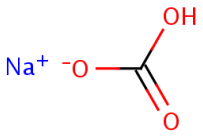
Project number: 127635006
Project name: Hydraulic Stimulation Chemicals Assessment, Southwest Queensland
Client name: QGC

Name	Sodium Bicarbonate
Synonyms	Sodium hydrogen carbonate, carbonic acid sodium (1:1), carbonic acid monosodium salt, baking soda, Acidosan, bicarbonate of soda, Crystol carbonate. monosodium carbonate, sodium acid carbonate.
CAS number	144-55-8
Molecular formula	$NaHCO_3$
Molecular Structure	

Overview	References
Sodium bicarbonate is not a classified substance according to the Global Harmonised System (GHS) classification.	ECHA (2014)
Sodium bicarbonate is a white, odourless, crystalline solid at 20°C with a water solubility of 93.4 g/L and a pH of 8.4 at 20°C.	ECHA (2014)
Sodium bicarbonate has numerous uses including in the production of pulp and paper, in the formulation of cleaning products, in non-industrial spraying, as a laboratory reagent, and in cosmetics and personal care products. Sodium bicarbonate is commonly used as a pH buffering agent, an electrolyte replenisher, systemic alkaliser and in topical cleansing solutions.	ECHA (2014) & US EPA (2014)
Sodium bicarbonate has a long history of use in foodstuff, feed and industrial processes. The bicarbonate ion is a normal constituent in vertebrates, as the principal extracellular buffer in the blood and interstitial fluid is the bicarbonate buffer system. Excess sodium and bicarbonate ions are readily excreted in the urine. It is therefore assumed that normal handling and use will not have any adverse effects.	OECD (2002)
Sodium bicarbonate is classified by the U.S. Food and Drug Administration (FDA) as a 'Generally Recognised as Safe' (GRAS) ingredient in food.	US FDA (1975)

Human Health Toxicity Summary	Reference
Carcinogenicity	
Not listed on International Agency for Research on Cancer (IARC) Database.	IARC (2011)
One study on carcinogenesis concluded that $NaHCO_3$ alone did not have a carcinogenic effect on the urinary bladder of rats.	ECHA (2014)
Based on the available information there are no indications that sodium bicarbonate has carcinogenic effects.	OECD (2002)
Mutagenicity/Genotoxicity	
Two in vitro studies on genotoxicity presented in the ECHA database, one on DNA damage and/or repair and another on gene mutation provided negative results.	ECHA (2014)
Reproductive Toxicity	
NDF	

Developmental Toxicity/Teratogenicity In one study, aqueous solutions of sodium bicarbonate were administered daily via oral intubation to pregnant mice at doses ranging from 5.8 mg/kg/d to 580 mg/kg/d during days 6 to15 of gestation. No adverse effects were observed at the highest dose resulting in a NOAEL for development toxicity of ≥ 580 mg/kg/d. Two other studies also identified an oral NOAEL for developmental toxicity; ≥ 330 mg/kg/d for rabbit and ≥ 340 mg/kg/d for rat.	ECHA (2014)
Endocrine Disruption No data available and chemical not on listed on the European Commission list of identified possible endocrine disruptors.	EC (2000)
Neurotoxicity NDF	
Acute Toxicity (oral, dermal, inhalation) In one study the oral LD_{50} in rats was >4 000 mg/kg. Following the death of one female dosed with 4 000 mg/kg during the study a no observable adverse effects level (NOAEL) was determined as 4 000 mg/kg in males and 3 000 mg/kg in females. In another study an oral LD_{50} for rats was about 4 220 mg/kg and about 8 290 mg/kg. The study reports the two values for 'male/female' but does not specifically state which value is attributed to which sex. . For the inhalational LC_{50} in rats was >4.74 mg/L after 4.5 h exposure. Acute oral ingestion by the patients may result in a ruptured stomach due to excessive gas development.	ECHA (2014) OECD (2002)
Chronic/repeat dose toxicity (oral, dermal, inhalation) There are no directly relevant studies on repeated dose exposure; however, knowledge of prior use and available literature does not indicate any adverse effects of long-term use of exposure via any route. Acute or chronic excessive oral ingestion may cause metabolic alkalosis, cyanosis and hypernatremia. These conditions are usually reversible.	OECD (2002)
Sensitisation of the skin or respiratory system NDF	
Corrosion (irreversible)/irritation (reversible) effects on the skin or eye One study on rabbits, the application of 0.5 g of sodium carbonate as a moistened solid to the skin resulted in reversible effects within 24 h and 48 h after application. Sodium bicarbonate was scored as slightly irritating. Application of 0.05 mL to 0.07 mL (bump volume) sodium bicarbonate to the eye of rabbits resulted in all rabbits having a slight to moderate conjunctival erythema (redness) 1 h after the instillation, which was resolved at 48 h observation. Two out of three animals also exhibited mild chemosis (swelling), which was resolved at 24 h observation.	ECHA (2014)

Physical Hazards	Reference
Flammable Potential Not considered flammable by ECHA.	ECHA (2014)
Explosive Potential Not considered flammable. Sodium bicarbonate starts decomposing when heated over 50°C, releasing CO_2, H_2O and Na_2CO_3, with total decomposition at 270°C and therefore a melting and boiling point cannot be determined.	OECD (2002)

Toxicity Values	Value	Reference
Human Toxicity Data		
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	
LOAEL	NDF	
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rat, oral	> 4 000 mg/kg	ECHA (2014)
Rat, oral	4 220 mg/kg	ECHA (2014)
Rat, oral	8 290 mg/kg	ECHA (2014)
Mouse, oral	NDF	
Rabbit, oral	NDF	
Rat, dermal	NDF	
Rabbit, dermal	NDF	
Mouse, dermal	NDF	
NOAEL	Oral: 4 000 mg/kg (male rats) 3 000 mg/kg (female rats)	ECHA (2014)
LC_{50}		
Rat	>4.74 mg/L	ECHA (2014)
High Chronic/Repeat Dose Toxicity		
LOAEL	NDF	
LOAEC	NDF	
NOAEL	Development toxicity ≥ 580 mg/kg/d (oral mouse) ≥ 330 mg/kg/d (rabbit) ≥ 340 mg/kg/d (rat)	ECHA (2014)

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NOAEL – No Observed Adverse Effect Level
NDF – no data found within the limits of the search strategy

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity (IARC Group 1 or 2A)	No	IARC (2011), ECHA (2014), OECD (2002)
Mutagenicity/Genotoxicity (GHS Category 1A and 1B)	No	ECHA (2014)
Reproductive Toxicity/Developmental toxicity (GHS Category 1, 1A and 1B)	Reproductive: NDF Developmental: No	ECHA (2014)
Endocrine Disruption[1]	NDF	
Hazard Band 3		
Carcinogenicity (IARC Group 2B)	No	IARC (2011), ECHA (2014), OECD (2002)
Mutagenicity/Genotoxicity (GHS Category 2)	No	ECHA (2014)
Reproductive Toxicity/Developmental toxicity (GHS Category 2)	Reproductive: NDF Developmental: No	ECHA (2014)
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg [2] • dermal LD_{50} ≤ 1 000 mg/kg • inhalation LC_{50} ≤ 10 mg/L [3] (or mg/m^3) (vapour)	Oral: No Dermal: NDF Inhalation: NDF (LC_{50} > 4.74 mg/L)	ECHA (2014)
Possible carcinogenicity, mutagenicity, reproductive or High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d [2] • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes [3]	Oral: No (developmental toxicity – mouse) Dermal: NDF Inhalation: NDF	ECHA (2014)
Corrosive (irreversible effect)	No	Considered as slightly irritating (ECHA, 2014)
Respiratory sensitiser	NDF	
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [3]	Oral: No (developmental toxicity – mouse) Dermal: NDF Inhalation: NDF	ECHA (2014)
Skin Sensitiser	NDF	
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2 000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2 000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours) [3]	**Oral:** No **Dermal:** NDF **Inhalation:** NDF	ECHA (2014)
Irritant (reversible effect)	Yes	ECHA (2014)

Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**	No	
Physical Hazards		
Flammable potential	No	ECHA (2014)
Explosive potential	No	OECD (2002)
Hazard Evaluation (highest band) not including physical hazards	1	Considered slightly irritating
Uncertainty analysis /data confidence (out of 12 parameters)	75%	

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]*Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.*

[2] *milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)*

[3] *Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed)". (p 18, NICNAS 2013).*

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)	NDF	
8-h TWA	NDF	
STEL	NDF	
Peak Limitation	NDF	
Environmental Exposure		
Air, ambient	NDF	
Air, indoor	NDF	
Water, potable	180 mg/L (Na)	Sodium aesthetic (taste threshold), no health value (ADWG, 2011)
Water, recreational	NDF	
Soil, residential	NDF	
Soil, commercial/industrial	NDF	

Footnotes:
OEL = Occupational Exposure Limit
TWA= 8-h Time-Weighted Average
STEL = (15 min) Short-term Exposure Limit
NDF – no data found within the limits of the search strategy

Summary Concluding Comments

Sodium bicarbonate has been assigned to Hazard Band 1 because of its classification as a slight/mild irritant to the eyes and skin.

Sodium bicarbonate at room temperature is a white crystalline powder. It is used in foodstuff, feed and industrial processes, is found to occur naturally within the body and is classified by the FDA as a 'Generally Recognised as Safe' food ingredient. Sodium bicarbonate has a high solubility in water and will dissociate to sodium and bicarbonate ions in water, the latter of which will always act to buffer the water to a pH of around 8.34, if in sufficient quantity. The addition of sodium bicarbonate to water will, therefore, only result in an increase in the concentration of sodium, an ion which is abundant in the environment. It is considered that with the use of appropriate Personal Protective Equipment (PPE), as outlined in the relevant MSDS, the risk present from its use during hydraulic fracturing is low.

References

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Created by:	CM	18/12/2013
Reviewed by:	PDM	21/01/2014

APPENDIX C

Ecotoxicology Profiles

Project number: 127635006

ORGANIC

Name	Xanthan Gum
Synonyms	Polysaccharide B 1549, Corn sugar gum
CAS Number	11138-66-2
Molecular Formula	(C35H49O29)n

Physical Properties	Value	Reference
PhaseState:	Dry cream coloured powder	Garcia-Ochoa et al., (2000)
Molecular Weight (g/mol):		
Melting Point (°C):		
Boiling Point (°C):		
Density / Specific Gravity (Enter Unit):		
Vapour Pressure (mm Hg at 25°C):		
Solubility (mg/L):		
Henry's Law Constant (atm m³/mole):		
Organic carbon partition coefficient (Koc):		
Log organic carbon partition coefficient (log Koc):		
Log octanol - water partition coefficient (log Kow):		

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):		
Biowin 4 (Primary Biodegradation):		
EPISUITE Ready Biodegradability:		
Biowin 7 (Anaerobic Model Prediction):		
Fugacity_Air: (%)		
Fugacity_Water: (%)		
Fugacity_Soil: (%)		
Fugacity_Sediment: (%)		
Bioconcentration factor (BCF):		
Biotransformation half - life (Days):		

Project number: 127635006

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
	Rainbow trout	Fish LC50	Mortality	Mortality	4	420	ECOTOX 2012

Terrestrial Ecotoxicological Data

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Mice	Mammalian LD50	Mortality	Mortality		> 1000	IPCS Inchem 19 86	mg/kg bw

Created By: Lisa Brooks/Naomi Cooper Date: 19/07/2014

Checked By: Carolyn Brumley Date: 25/07/2014

Project number: 127635006

ORGANIC

Name	Sorbitol
Synonyms	D-Sorbitol, Glucitol
CAS Number	50-70-4
Molecular Formula	C6H14O6

Physical Properties	Value	Reference
PhaseState:	Powder, flakes	HSDB 2010
Molecular Weight (g/mol):	182.17	HSDB 2010
Melting Point (°C):	111.00	HSDB 2010
Boiling Point (°C):	295	HSDB 2010
Density / Specific Gravity (g/cm3):	1.49	HSDB 2010
Vapour Pressure (mm Hg at 25°C):	0.0000000099	HSDB 2010
Solubility (mg/L):	2,750,000.00	HSDB 2010
Henry's Law Constant (atm m³/mole):	0.00000000000073	HSDB 2010
Organic carbon partition coefficient (Koc):	2.00	HSDB 2010
Log organic carbon partition coefficient (log Koc):	0.30	Calculated
Log octanol - water partition coefficient (log Kow):	-2.20E+00	HSDB 2010

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	3.7564	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	4.3616	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	1.0212	EPISUITE 2011 v4.1
Fugacity_Air: (%)	0.00411	EPISUITE 2011 v4.1
Fugacity_Water: (%)	24	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	76	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.0362	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	1	HSDB 2010
Biotransformation half - life (Days):	0.0000906	EPISUITE 2011 v4.1

Project number: 127635006

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
	Fish	Fish LC50	MOR	Mortality	4	4.73E+06	ECOSAR 2012
	Daphnid	Invertebrate LC50	MOR	Mortality	2	1.69E+06	ECOSAR 2012
	Green algae	Plant EC50	GRO	Growth	4	1.86E+05	ECOSAR 2012

Terrestrial Ecotoxicological Data

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Rat	Mammalian LD50	MOR	Mortality		15900	HSDB 2010	mg/kg

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Earthworm	1	MOR	Mortality	14	1048	ECOSAR 2012	mg/L

Created By: Naomi Cooper Date: 25/06/2014

Checked By: Carolyn Brumley Date: 27/06/2014

Project number: 127635006

ORGANIC

Name	Ethane 1,2 diol
Synonyms	Ethylene glycol, ethylene alcohol
CAS Number	107-21-1
Molecular Formula	C2H6O2

Physical Properties	Value	Reference
PhaseState:	Liquid	HSDB 2012
Molecular Weight (g/mol):	62.068	HSDB 2012
Melting Point (°C):	-12.69	HSDB 2012
Boiling Point (°C):	197.3	HSDB 2002
Density / Specific Gravity (g/cm3):	1.11	HSDB 2012
Vapour Pressure (mm Hg at 25°C):	0.092	HSDB 2012
Solubility (mg/L):	1,000,000.00	EPISUITE 2011 v4.1
Henry's Law Constant (atm m³/mole):	0.00000006	HSDB 2012
Organic carbon partition coefficient (Koc):	0.20	HSDB 2012
Log organic carbon partition coefficient (log Koc):	-0.70	Calculated
Log octanol - water partition coefficient (log Kow):	-1.36E+00	HSDB 2012

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	3.3819	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	4.0171	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	1.1563	EPISUITE 2011 v4.1
Fugacity_Air: (%)	1.44	EPISUITE 2011 v4.1
Fugacity_Water: (%)	36	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	62	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.0638	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	10	HSDB 2012
Biotransformation half - life (Days):	0.0065	EPISUITE 2011 v4.1

Project number: 127635006

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Pimephales promelas	Fathead minnow	Fish LC50			4	8050	ECOTOX 2012
Daphnia magna	Water flea	Invertebrate LC50			2	6900	ECOTOX 2012

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Pimephales promelas	Fathead minnow	Fish NOEC			7	6090	ECOTOX 2012
Ceriodaphnia dubia	Water flea	Invertebrate EC50			7	4.2	ECOTOX 2012

Terrestrial Ecotoxicological Data

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Rat	Mammalian LD50	MOR	Mortality		4700	HSDB 2012	mg/kg
Mouse	Mammalian LD50	MOR	Mortality		7500	HSDB 2012	mg/kg bw
Rat	Mammalian LD50	MOR	Mortality		4700	HSDB 2012	
Mouse	Mammalian LD50	MOR	Mortality		7500	HSDB 2012	

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Earthworm	1	MOR	Mortality		231.62	ECOSAR 2012	mg/L
Earthworm	1	MOR	Mortality		232	ECOSAR 2012	

Created By: Naomi Cooper Date: 24/06/2014

Checked By: Carolyn Brumley Date: 27/06/2014

Name	Sodium Tetraborate
Synonyms	Sodium tetraborate decahydrate, Boric acid, Boron sodium oxide, Sodium orthoborate, Sodium pyroborate
CAS Number	1330-43-4
Molecular Formula	B4O7.2Na

Physical Properties	Value	Reference
PhaseState:	Colourless glassy solid	HSDB 2007
Molecular Weight (g/mol):	201.22	HSDB 2007
Melting Point (°C):	743.00	HSDB 2007
Boiling Point (°C):	1575	HSDB 2007
Solubility (mg/L):	31,000.00	HSDB 2007

Other Relevant Factors	Value	Reference
Reactivity		
Species:		
Reaction type:		
pH / Acidity		
acid / alkaline		
pH (10% solution)		

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Daphnia magna	Water flea	Invertebrate LC50	MOR	Mortality	2	141	HSDB 2007
Pseduokirchneriella subcapitata	Green algae	Plant EC50	GRO	Growth	4	15.4	ECOTOX 2012
Lepomis macrochirus	Bluegill	Fish LC50	MOR	Mortality	1	15	ECOTOX 2012

Project number: 127635006

INORGANIC

Terrestrial Ecotoxicological Data

Common Name	Endpoint	Effect	Effect Measure	Test Time (Days)	Conc	Reference	Units
Rat	Mammalian LD50	MOR	Mortality		2660	HSDB 2007	

Created By: Naomi Cooper Date: 18/05/2013

Checked By: Kirsten Broadgate Date: 24/05/2013

Name	Sodium Bicarbonate
Synonyms	Baking soda, sodium hydroxide carbonate, monosodium carbonate
CAS Number	144-55-8
Molecular Formula	CH2O3.Na

Physical Properties	Value	Reference
PhaseState:	Powder	ECHA 2013
Molecular Weight (g/mol):	84.01	HSDB 2006
Melting Point (°C):		
Boiling Point (°C):		
Solubility (mg/L):	93,400.00	ECHA 2013

Other Relevant Factors	Value	Reference
Reactivity		
Species:		
Reaction type:		
pH / Acidity		
acid / alkaline		
pH (10% solution)		

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Oncorhynchus mykiss	Rainbow trout	Fish LC50	MOR	Mortality	5	1000	ECOTOX 2012
Ceriodaphnia magna	Water flea	Invertebrate LC50	MOR	Mortality	2	983	ECOTOX 2012
Nitzschia linearis	Diatom	Plant EC50	MOR	Mortality	5	650	ECOTOX 2012

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Pimephales promelas	Fathead minnows	Fish NOEC	GRO	Growth	7	630	ECOTOX 2012
Ceriodaphnia dubia	Water flea	Invertebrate NOEC	REP	Reproduction	9	122	ECOTOX 2012
	Green algae	Plant NOEC	GRO	Biomass	63	> 45	ECOTOX 2012
Pimephales promelas	Fathead minnows	Fish LOEC	GRO	Growth	7	1260	ECOTOX 2012

Ceriodaphnia dubia	Water flea	Invertebrate LOEC	REP	Reproduction	9	212	ECOTOX 2012

Project number: 127635006

INORGANIC

Terrestrial Ecotoxicological Data

Common Name	Endpoint	Effect	Effect Measure	Test Time (Days)	Conc	Reference	Units
Mouse	Mammalian LD50	MOR	Mortality		3360	ChemIDPlus 201	mg/kg

Created By: Naomi Cooper Date: 19/08/2014

Checked By: Carolyn Brumley Date: 19/08/2014

Appendix C: Table A - Aquatic Hazard Assessment: Calculated Scores for Persistence, Bioaccumulation and Toxicity

			Persistence										Bioaccumulation		Toxicity									SUMMARY				
Chemical	Constituent Name	CAS Number	ORGANIC Solubility in water (mg/L)	INORGANIC Solubility in water (mg/L)	Solubility Considered in Conjunction with Acute Toxicity	Log Koc	Henry's Law (atm m3/mole)	EPISUITE Ready Biodegradability	EPISUITE Biowin 3 Ultimate Survey Biodegradation	EPISUITE Biowin 4 Primary Biodegradation	EPISUITE Biowin 7 Anaerobic Biodegradation	Fish BCF	Log Kow / Log Pow	FISH Chronic NOEC (mg/L)	INVERT Chronic NOEC (mg/L)	PLANT Chronic NOEC (mg/L)	FISH Chronic LOEC/MATC /EC_{10} (mg/L)	INVERT Chronic LOEC/MATC /EC_{10} (mg/L)	PLANT Chronic LOEC/MATC /EC_{10} (mg/L)	FISH Acute LC/EC50 (mg/L)	INVERT Acute LC/EC50 (mg/L)	PLANT Acute LC/EC50 (mg/L)	Persistence	Bioaccumulation	Toxicity	Overall Score	Data Gaps %
Xantham gum		11138-66-2																		1					**1.0**	**1.0**	**94%**
Ethane-1,2-diol		107-21-1	1			1	2	1	1	1	1	1	1	1				1		1	1		**1.1**	**1.0**	**1.0**	**1.0**	**28%**
Sorbitol		50-70-4	1			1	3	1	1	1	1	1	1							1	1	1	**1.3**	**1.0**	**1.0**	**1.1**	**33%**
Sodium tetraborate		1330-43-4		3	3															2	1	2	3		2.0	2.5	55%
Sodium bicarbonate		144-55-8		3	3									1	1	1	1	1		1	1	1	3		1.0	2.0	9%

Comments

Inorganic	
Organic	
Surrogate	
Not assessed	
3	High hazard
2	Moderate hazard
1	Low hazard

Appendix 3: Table B - Terrestrial Toxicity QSAR data

Constituent Name	CAS Number	Hulzebos QSAR Lettuce LC50 (mg/L)	ECOSAR QSAR Earthworm (mg/L)	Van Gestel QSAR Earthworm LC50 Soil (mg/kg)
Xantham gum	11138-66-2	-	no data	-
Ethane-1,2-diol	107-21-1	2.70E-01	232	8.60E+00
Sorbitol	50-70-4	9.02E-01	1048	2.31E+03
Sodium tetraborate	1330-43-4	-	no data	-
Sodium bicarbonate	144-55-8	-	no data	0.00E+00

APPENDIX D

Important Information

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