Santos

Chemical Risk Assessment Framework

Santos Towrie Gas Development

Petroleum Lease (PL) 1059

Date	Rev	Reason For Issue	Author	Checked	Approved
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1.0 Introduction

1.1 Background

This Chemical Risk Assessment Framework (CRAF) has been developed for the risk assessment of chemicals proposed to be used in coal seam gas operations (drilling and completions and hydraulic fracturing) within the Santos Towrie Development, Petroleum Lease (PL) 1059. The CRAF incorporates best practice risk assessment methodology for the assessment of the potential impacts of the chemicals proposed to be used in, or arising from, coal seam gas operations on matters of national environmental significance (MNES).

The CRAF is based on existing Santos approved chemical risk assessment frameworks and aligns with the chemical assessment guidance provided by National Industrial Chemicals Notifications and Assessment Scheme (NICNAS) and approach used for industrial chemicals. This allows for a defined and streamlined process to:

1. identify low hazard chemicals that can be addressed simply through a hazard assessment process;
2. identify higher hazard chemicals that should be assessed through completion of a quantitative risk assessment
3. identify very high hazard chemicals that should be encouraged not to be used as part of the process;
4. identify very high hazard chemicals that cannot to be used as part of the process; and
5. incorporate the outcomes of the assessment into environmental mitigation and management controls.

1.2 Statement of Aim

The aim of the chemical risk assessment(s) is to evaluate the potential risks and effects of chemicals used during coal seam gas operations (defined as drilling and completions and hydraulic fracturing) to MNES.

The aim of the chemical risk assessment(s) is to also evaluate the potential risks and effects of geogenic chemicals to MNES that may be present in recovered drilling fluids and produced waters during coal seam gas operations.

1.3 Goal of the Risk Assessment

The goal of the chemical risk assessment is to demonstrate that potential risks to MNES associated with the chemicals used in coal seam gas operations have been eliminated or reduced as much as is reasonably practicable.

This assessment process is designed to align with national guidance and other regulatory frameworks and assesses the full lifecycle of chemicals that are stored, handled, used and/or disposed during or following drilling and completions and hydraulic fracturing activities.

Accidental or unintentional release scenarios are not included; however, the outcomes of the assessment are used to inform contingency response actions for these types of releases (**Appendix 10**).

2.0 Chemical Risk Assessment Framework

2.1 Framework Process

The framework is to be adopted for all chemicals used in coal seam gas operations and will involve a two-step process:

- Step 1 – classification of chemicals.
- Step 2 – assessment of chemicals.

Chemicals are to be classified into five Tiers (Tier 1 through 5) based on the following criteria:

- Assessment of whether chemicals are identified on chemical databases used by NICNAS as indicators that these chemicals are of concern. These included:
  - European Union Substance of Very High Concern (EU SVHC).
  - US National Toxicology Program (US NTP) Report on Carcinogens or International Agency Research on Cancer (IARC) Monographs.
  - European Commission Endocrine Disruptors Strategy - list of Category 1 substances with endocrine disrupting capacity.
  - Chemical Substances Control Law of Japan (CSCL) Class I and II Specified Chemical.
  - Polymers identified as of low concern by NICNAS
- Completion of a formal persistent, bioaccumulative and toxic (PBT) substances assessment (using environmental reference values contained within the categorisation guidelines) and the factors discussed in the meeting to develop the tiered framework.
- Evaluation of any other concerns associated with persistence in the environment (especially for inorganics) which is not captured in the PBT assessment but may be a consideration in the context of project activities (for example, irrigation of produced water).

The criteria to be used in the chemical category classification within this framework is provided as **Appendix 1**.

A low risk chemical is defined as a chemical that is not identified as a Persistent Bioaccumulative Toxic chemical and is not listed as a chemical of concern on the following databases:

- European Union Substance of Very High Concern (EU SVHC).
- US National Toxicology Program (US NTP) Report on Carcinogens or International Agency Research on Cancer (IARC) Monographs.
- European Commission Endocrine Disruptors Strategy - list of Category 1 substances with endocrine disrupting capacity.
- Chemical Substances Control Law of Japan (CSCL) Class I and II Specified Chemical.

A high risk chemical is defined as a chemical that is identified as a Persistent Bioaccumulative Toxic chemical, or a chemical which exhibits toxicity of potential concern, or is listed as a chemical of concern on the following chemical databases:

- European Union Substance of Very High Concern (EU SVHC).
- US National Toxicology Program (US NTP) Report on Carcinogens or International Agency Research on Cancer (IARC) Monographs.
- European Commission Endocrine Disruptors Strategy - list of Category 1 substances with endocrine disrupting capacity.
- Chemical Substances Control Law of Japan (CSCL) Class I and II Specified Chemical.

For the purposes of this CRAF, chemicals categorised as Tier 1 or Tier 2 chemicals are designated as 'low risk' chemicals. Chemicals categorised as Tier 3, Tier 4 or Tier 5 chemicals are designated as 'high risk' chemicals.

Based on the category classification of the chemical (and its potential toxicity, persistence and bioaccumulation potential in the environment), different levels of assessment will be conducted with the most robust assessment conducted on the highest classification (**Table 1**).

Table 1: Risk Assessment Requirements

Tier	Risk Category	Screening Assessment and Categorisation (Appendix 1)	Toxicological Profile (Appendices 2, 3 and 4)	Qualitative Risk Assessment (Appendix 5)	Quantitative Risk Assessment (Appendix 6)	Site Specific Assessment	Prohibited from Use on Project
1	Low Risk	X	X				
2		X	X	X			
3	High Risk	X	X	X	X		
4		X	X	X	X	X	
5		X					X

Consistent with the screening matrix in **Appendix 1** and **Table 1**:

- Tier 1 chemicals, which are effectively low toxicity and therefore low hazard, would be subject to only the screening assessment.
- Tier 2 chemicals, in addition to the screening assessment, will be subjected to a qualitative risk assessment.
- Tier 3 and Tier 4 chemicals will be subject to an additional quantitative risk assessment with Tier 4 chemicals requiring an additional site-specific quantitative risk assessment.

  Site-specific risk assessment for Tier 4 chemicals will require site-specific per use approval by the Minister.
- Tier 5 chemicals will not be used and no further discussion will be provided.

The assessment of geogenic chemicals recovered during drilling activities or within produced water will be assessed against risk-based criteria depending on their end fate (i.e. use and/or disposal).

Based on the outcomes of the *National Assessment of the Chemicals used in Coal Seam Gas in Australia* (DoEE 2016), hypothetical accidental releases associated with delivery truck rollovers, including into watercourses, represented the greatest potential risk to MNES. Given the highly regulated nature of transportation of chemicals (at both a Commonwealth and State level), transport related scenarios and assessment will not be incorporated into the risk assessment process.

The movement of chemicals will be performed only by transport contractors with the relevant qualifications and licences required for the movement of each category of goods. Haulage will be performed to the satisfaction of relevant legislative requirements, including but not limited to *Australian Dangerous Goods Code* and Queensland *Transport Operations (Road Use Management – Dangerous Goods) Regulation 2008* as well as Santos traffic management principles identified in Section 4.3.

The chemical risk assessment will however be used to inform decisions on a case by case basis regarding site assessment, risk management/clean-up and rehabilitation should a transport-related or other accidental release occur in accordance with **Appendix 10**.

2.2 Framework Templates

A template of the Register of Assessed Chemicals, including document control requirements, is provided in **Appendix 2**.

Templates of the toxicological profiles (dossiers) for Tier 1, 2 and 3 chemicals, completed for an example chemical(s), are provided as **Appendices 3**, **4** and **5**, respectively.

Depending on the category of the chemical being assessed (i.e. Tier 1, 2, 3 or 4), the toxicological profiles (dossiers) include chemical identification, physical and chemical properties, environmental fate properties, human health and environmental hazard assessments, derivation of non-cancer and cancer screening levels, a persistent, bioaccumulative and toxic (PBT) assessment, and regulatory status.

An example Tier 2 qualitative risk assessment and Tier 3 quantitative risk assessment is provided as **Appendix 6** and **Appendix 7** respectively.

All future chemical assessments must be conducted using these templates.

2.3 MNES Values and Potential Receptors

This section describes the MNES values and potential receptors subject to the Qualitative and Quantitative Risk Assessment Processes (Tier 2, 3 and 4 chemicals).

For the purposes of the risk assessment, petroleum workers, managed under Australian workplace health and safety legislation are excluded from assessment.

The project activities, site setting and associated MNES values described in the *Matters of National Environmental Significance – Ecology assessment – Towrie Development* report (AECOM 2021) are the MNES values for the purpose of this chemical risk assessment.

The MNES values listed under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act), including springs, comprise:

- listed flora or fauna (terrestrial and aquatic);
- threatened ecological communities; and
- water resources.

Consistent with the broad definition of MNES associated with water resources, the potential risks to both the MNES water resources and non-MNES receptors exposed to the water resource must be evaluated. This may include human and livestock through the consumption of water containing chemicals and aquatic flora and fauna where a release to waters is authorised. Accidental release scenarios are not to be included; however, the outcomes of the assessment should be used to inform emergency response actions. The chemical risk assessments will be limited to MNES receptors and those non-MNES receptors associated the with MNES water resources.

2.4 Exposure Pathways Subject to the Risk Assessment Process

This section defines the exposure pathways subject to the risk assessment process.

The list of exposure pathways associated with project activities and are subject to the risk assessment process is provided in **Appendix 8**. These exposure pathways must be evaluated as part of qualitative assessments (Tier 2) and quantitative risk assessments (Tier 3 and Tier 4). If an exposure pathway is deemed to be not complete for a specific chemical, this must be discussed in the chemical specific risk assessment.

Exposure pathways are categorised as either:

- **Complete exposure** – when a source, a migration pathway, a mechanism for exposure and a potential receptor are present.
- **Incomplete exposure** – when any one or more of the four elements (source, pathway, mechanism and receptor) that make a complete exposure pathway are not present.
- **Insignificant / low probability exposure** – where the potential risks are limited due to attenuation, fate and transport mechanisms, infrequent exposure occurrence, and / or minimal projected chemical concentrations at the point of exposure (i.e. there is no hazard).

For MNES values to be included in the risk assessment process there must be:

- the potential for MNES values to be present (receptor) and an exposure pathway to the chemical additive(s) from an authorised activity, or
- the potential for MNES values to be present (receptor) and an exposure pathway to media (soils or water resources (surface or groundwater)) affected by an authorised activity.

For a non-MNES value(s) to be included in the risk assessment there must be:

- an MNES water resource (surface water and / or groundwater) affected or potentially affected by chemical additive(s) from an authorised gas extraction activity, and
- a complete or potentially complete exposure pathway to the non-MNES receptor.

2.5 Qualitative and Quantitative Risk Assessment

The chemical risk assessment program must be undertaken in accordance with best practice risk assessment methodologies including those contained within the international standards and Australian risk assessment guidance documents (e.g. NEPM, 2013; enHealth, 2012a,b) referenced in **Appendix 9**. The example qualitative and quantitative risk assessment frameworks provided as **Appendix 6** and **Appendix 7** have been developed in accordance with these standards and guidelines.

The best practice methodologies and guidelines for quantitative risk assessment is the same for both Tier 3 and Tier 4 chemicals. However, the Tier 4 quantitative risk assessment is 'site-specific', requiring more detailed site-specific information to inform use and reuse, as opposed to more generic field level information required for a Tier 3 quantitative risk assessment. The Tier 4 assessment is to be tailored towards discrete use and reuse (e.g. a tailored hydraulic fracturing campaign at discrete well locations, or a discrete (authorised) discharge to a watercourse) rather than field scale application.

Tier 4 quantitative risk assessments are to include of a food chain risk assessment to evaluate uptake and accumulation/bioaccumulation within higher trophic organisms, persistence in soil and cumulative impacts; the model to be selected is dependent on the constituent, receptor and media of exposure. The scope of a site-specific risk assessment for a Tier 4 chemical(s) requires assessment and approval by the Department. Tier 4 chemicals require site-specific per use approval by the Minister prior to use.

The data sources for the risk assessment toxicological profiles (dossiers) include the Inventory Multi-Tiered Assessment and Prioritisation (IMAP) framework established by NICNAS. The risk assessment toxicological profiles (dossiers) must be prepared in accordance with the *Organisation for Economic Cooperation and Development's (OECD's) Hazard Assessment – Gathering and Evaluating Existing Information and Assessing the Hazards* and *Exposure Assessment – Environmental Fate and Pathways (*http://www.oecd.org/env/ehs/summarytableofavailabletoolsforriskassessment.htm).

In the assessment of exposure pathways and risks, only authorised operational activities must be considered (i.e. activities that are authorised in the Queensland Environmental Authority and Commonwealth Approval). Where activities are specifically precluded (for example release or disposal of wastes to surface or ground waters are explicitly not authorised) these will not be considered in the risk assessment.

Further the qualitative and quantitative risk assessments must specifically consider management plans developed (as part of Commonwealth and State approvals) which have been developed to avoid, mitigate, manage and monitor potential impacts.

2.6 Geogenic Screening Risk Assessment

The assessment of geogenic chemicals recovered during drilling activities or within produced water will be subject to a screening assessment and if required qualitatively assessed against published or derived risk-based criteria depending on their end fate (i.e. use and/or disposal).

The screening assessment must be undertaken in accordance with best practice risk assessment methodologies including those contained within the international standards and Australian risk assessment guidance documents, as provided in **Appendix 9**.

In the assessment of exposure pathways and risks, only authorised operational activities must be considered (i.e. activities that are authorised in the Queensland Environmental Authority and Commonwealth Approval). Accidental release scenarios are not to be included; however, the outcomes of the assessment will be used to inform emergency response actions, as provided in **Appendix 10**.

2.7 Cumulative Risk Assessment

The chemical risk assessment must qualitatively assess the potential for one or more hazards associated with the chemicals used in coal seam gas operations to impact MNES. The assessment must consider the potential causes of cumulative impacts from authorised activities in relation to MNES for Tier 3 and Tier 4 chemicals only (due to their potential persistence and/or potential to bioaccumulate).

3.0 Chemical Risk Assessment Format, Approval Process and Document Control

As noted above, the assessments must be conducted on each chemical in accordance with the respective templates provided (**Appendices 3** to **5** and **6** and **7**).

The requirements for chemical risk assessment review, update, notification and approval are provided in **Table 2** below.

Table 2: Chemical Risk Assessment Review and Approval Requirements

Delivery Scope	Tier			
	1	2	3	4
Complete screening assessment and categorisation and develop a toxicological profile for each chemical.	X	X	X	X
Complete a qualitative risk assessment for the proposed use(s) of the chemical (refer **Appendix 6**)		X		
Appoint an independent chemical risk assessment expert to review the toxicological profile and/or qualitative risk assessment.	X	X		
Notify the Department in writing that a new chemical has been assessed and reviewed, including the assessment outcome and reference to Register of Assessed Chemicals	X	X		
Negotiate scope of site-specific quantitative risk assessment with the Department.				X
Complete a quantitative risk assessment for the proposed use(s) of the chemical (refer **Appendix 7**).			X	X
Submit toxicological profiles and quantitative risk assessment to Department/Minister approval			X	X
Update Register of Assessed Chemicals, including document control	X	X	X	X
Publish the chemical toxicological profile(s) and if applicable qualitative/quantitative risk assessments on the Santos website.	X	X	X	X

3.1 Approval Process

3.1.1 Low Risk Chemicals

Toxicological profiles, risk assessments and a signed and dated statement from the independent chemical risk assessment expert for each low risk chemical (Tier 1 and Tier 2) will be entered into the Register of Assessed Chemicals. This same information will also be provided to the Department. Low risk chemicals must not be used in coal seam gas operations until all of these steps have been undertaken. No further approval is necessary, prior to the use of the chemical in coal seam gas operations.

Compliance checklists and checklists for peer review, provided in **Appendix 11**, define the scope of the review relevant to the level of assessment performed. If any part of the scope is determined to not be applicable, then the reviewer must document this and state the reason as to why it is not applicable.

3.1.2 High Risk Chemicals

Toxicological profiles and respective risk assessments for each high risk chemical (Tier 3 and Tier 4) will be submitted to the Department for review and approval. These will not be reviewed by an independent chemical risk assessment expert. Toxicological profiles and respective risk assessments will be added to the Register of Assessed Chemicals following Department approval. High risk chemicals must not be used in coal seam gas operations until all of these steps have been undertaken and approval has been provided by the Minister.

When the risk assessment for a new chemical identifies the need for additional mitigation and management measures to ensure the potential risks to MNES have been reduced as much as is reasonably practicable the following steps must occur:

- provide a statement with the submitted risk assessment that identifies that additional mitigation and management control(s) is required, including details of the additional controls required and a process to monitor and report on their efficacy;
- following approval of the toxicological profile and respective risk assessment for that chemical, update the Environmental Management Plan (EMP) to include the relevant mitigation and management control(s); and
- submit the revised EMP to the Department in accordance with approval conditions.

3.2 Register of Assessed Chemicals

A Register of Assessed Chemicals is to be published and maintained on the Santos website.

The Register of Assessed Chemicals will, for each published chemical, provide a summary of the outcomes of the screening assessment, including the Tier (and Risk Level) categorisation, the activities the chemical has been assessed for (i.e. drilling and completions, hydraulic fracturing or water treatment, where required) and the assessed end use /fate of the chemical. The Register for Assessed Chemicals must include the following document control information:

- date of Register of Assessed Chemical publication;
- date of chemical assessment;
- date of independent chemical risk assessment expert review (Tier 1 and 2 chemicals only);
- date of notification to Department (Tier 1 and 2 chemicals)/date of lodgement to Department (Tier 3 and 4 chemicals);
- date of approval from Minister; and
- date of chemical re-evaluation (only if chemical is still in use).

Supporting information (i.e. dossiers, qualitative and quantitative risk assessments) for each assessed chemical are to be made readily accessible via the Register of Assessed Chemicals.

The template for the Register of Assessed Chemicals is in **Appendix 2**.

3.3 Review Process

Tier 1, 2, 3 and 4 risk assessment information for chemicals still in use must be re-evaluated and peer reviewed every five (5) years, commencing from the date of approval of this CRAF. The peer review undertaken by a chemical risk assessment expert, must be completed before the end of each 5-year anniversary of the approval of the CRAF. Peer review is only required for chemicals that are still in use.

A signed statement detailing the findings of the 5-year peer review, including evidence of any concerns raised by the peer review have been addressed, must be submitted to the Department within 60 business days of completion of the peer review.

4.0 Mitigation and Management

Mitigation and management controls are required to be developed and implemented to ensure the potential risks associated with the use of chemicals to MNES have been eliminated or reduced to as low as reasonably practicable.

The risk assessments must consider the management plans developed as part of Commonwealth and State approvals. Unless specifically identified within an assessment, the mitigation and management controls outlined in these management plans are considered adequate for Tier 1 and 2; and Tier 3 chemicals. Where a risk assessment, including a Tier 4 site-specific risk assessment, identifies new or additional mitigation and/or management measures beyond those documented in an existing management plan, the relevant management plan must be updated to include the new mitigation and/or management measures and be submitted to the Department in accordance with approval conditions as per Section 3.1.2.

Key plans integral to the management of the risk of impacts to MNES associated with planning, use and transportation including processes to monitor and review controls are provided in the sections below.

4.1 Environmental Management Plan

The EMP refers to and contains existing mitigation and management controls that are in place for chemical constituents associated the extraction of coal seam gas. These controls are considered sufficient to address the risk of adverse impact to MNES associated with Tier 1, 2, 3 and 4 chemicals.

Where the outcome(s) of the chemical risk assessment (including the outcome of assessment of cumulative risk) inform the need for additional mitigation and management controls beyond those presented in the EMP, these will be identified within the chemical risk assessment documentation.

Where required, updates to management controls will be incorporated into the EMP and provided or submitted to the Department in accordance with approval conditions (see Section 3.1.2). These controls will be receptor specific and based on the potential exposure pathway and will include early warning indicators and action triggers, where required. The assessment of the efficacy of each monitoring, mitigation and management control is specified in the EMP.

4.2 Constraints Protocol

The Towrie Development (PL1059) Environmental Protocol for Constraints Planning and Field Development (the Constraints Protocol) describes the location and selection process for project activities.

Assessment of fate and transport of constituents in the subsurface indicates that conservative constituents (soluble and mobile) will sufficiently attenuate in the subsurface such that beyond 90 m there are no potential unacceptable risks associated with potential releases during drilling. As such, production wells will not be installed within 90m of a landholder bore.

For Tier 3 and Tier 4 chemicals, the outcome of the chemical risk assessment (including the outcome of the cumulative assessment) may inform the need for additional mitigation and management controls such as greater offset distances. These additional controls will be identified within the chemical risk assessment documentation and submitted in accordance with the approval process (see Section 3.1.2). These controls will be receptor specific and based on the potential exposure pathway.

4.3 Traffic Management Principles

The principles behind Santos' road and traffic management are:

- to maintain road-user safety by efficiently planning and optimising traffic movements;
- to mitigate impacts to road-user safety and the environment by ensuring adherence to transport regulations (e.g. dangerous goods code);

- to mitigate impacts on public road infrastructure by using field roads and limiting Santos Project traffic to approved routes; and
- to enforce rules on employees and contractors operating in the Surat Basin, including the planning, monitoring and consolidation of vehicle movements.

To achieve these principles the following mitigation and management controls have been developed and implemented:

- Santos implements approved roads/routes for use by both heavy and light vehicles. The approved routes seek to optimise the use of field and public roads to avoid inefficient road movements and unnecessary impacts on the community. Approved route information is communicated through induction training, general communications and via the Eastern Queensland Road Report.
- Implementation of no-go zones for those roads not approved through negotiations with local Authorities for use by Project traffic. No-go zones are also deemed necessary when Project use may adversely impact this road network or there is a potential safety design issue with the road.
- Santos Management Standards require in-vehicle monitoring systems (IVMS) in all vehicles involved in Project development. IVMS functionality also provide pass-through of real-time vehicle location to Santos.
- All traffic movements are restricted to daylight hours under Santos Health and Safety standards.
- Santos project personnel and contractors will adhere to all prescribed heavy vehicle permit conditions and dangerous goods requirements under local, state and Commonwealth Regulations.
- During wet weather events, Santos will liaise with the local and state Authorities about road restrictions or closures to minimise potential impacts on the road network and the community. In the event of road closures no travel is permitted and work stops unless drivers are advised of an alternative suitable route that has been cleared for use by the relevant road authority together with any specific conditions.
- Additional temporary signage will be deployed in consultation with local and state Authorities to ensure that any road limitations are clearly identifiable. Additional signage in road corridors will be requested on roads on an as-need-basis or when a safety issue is to be addressed.
- Movement of dangerous and/or hazardous goods will be performed only by transport contractors with the relevant qualifications and licences required for the movement of each category of goods.

These existing mitigation and management controls are considered sufficient to address the risk of adverse impact to MNES from the transportation of chemical constituents associated with produced water and residual drilling materials.

Monitoring and reporting on traffic management principles will be undertaken in accordance with Santos Management Standards and IVMS. If an adverse impact to MNES is detected during the transportation of chemicals, the Department is to be notified in writing within 15 business days of detection. The notification must specify the location, date and time of the adverse impact and include a short description of the adverse impact and the MNES adversely impacted.

4.4 Hydraulic Fracturing Monitoring and Reporting

Monitoring and reporting on the scale of hydraulic fracturing, and implementation of any mitigation and management measures undertaken during hydraulic fracturing, will be undertaken in accordance with relevant legislative requirements identified in the Queensland *Petroleum and Gas (General Provisions) Regulation 2017*, as amended from time to time, including but not limited to operational summary information required in the hydraulic fracturing activities completion report as follows:

- the name and address of the lease holder, operator of the well(s) or bore(s), and the company that performed hydraulic fracturing activities;

- the names of each well or bore and wellbore, where applicable, treated or used for observation;
- the start and end dates of hydraulic fracturing activities for each well;
- details of the equipment and techniques used to perform and monitor the hydraulic fracturing activities;
- details of tubular installations (casing, liner, tubing) and any perforations;
- details of any significant impacts to planned operations such as hazards encountered, attempted remedies and their outcome; and
- a hydraulic fracturing fluid statement containing compositional information of the hydraulic fracturing fluid used including the name of any chemical compound contained in the fluid as well as the quantity and concentration of each component of the fluid.

If an adverse impact to MNES is detected during the use and handling of chemicals, the Department is to be notified in writing within 15 business days of detection. The notification must specify the location, date and time of the adverse impact and include a short description of the adverse impact and the MNES adversely impacted.

Appendix 1 – Chemical Category Classification Matrix

Criteria	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
General PBT Assessment Step					
Combined PBT Assessment Category	Not a PBT	Not a PBT	Not a PBT	Identified as a PBT	N/A
Chemical Databases of Concern Assessment Step					
Listed as a chemical of concern on relevant databases	Not listed as a chemical of potential concern on the following databases: - European Union Substance of Very High Concern (EU SVHC). - US National Toxicology Program (US NTP) Report on Carcinogens or International Agency Research on Cancer (IARC) Monographs. - European Commission Endocrine Disruptors Strategy - list of Category 1 substances with endocrine disrupting capacity. - Chemical Substances Control Law of Japan (CSCL) Class I and II Specified Chemical.	Not listed as a chemical of potential concern on the following databases: - European Union Substance of Very High Concern (EU SVHC). - US National Toxicology Program (US NTP) Report on Carcinogens or International Agency Research on Cancer (IARC) Monographs. - European Commission Endocrine Disruptors Strategy - list of Category 1 substances with endocrine disrupting capacity. - Chemical Substances Control Law of Japan (CSCL) Class I and II Specified Chemical.	Listed as a chemical of concern on the following databases: - European Union Substance of Very High Concern (EU SVHC). - US National Toxicology Program (US NTP) Report on Carcinogens or International Agency Research on Cancer (IARC) Monographs. - European Commission Endocrine Disruptors Strategy - list of Category 1 substances with endocrine disrupting capacity. - Chemical Substances Control Law of Japan (CSCL) Class I and II Specified Chemical.	Listed as a chemical of concern on the following databases: - European Union Substance of Very High Concern (EU SVHC). - US National Toxicology Program (US NTP) Report on Carcinogens or International Agency Research on Cancer (IARC) Monographs. - European Commission Endocrine Disruptors Strategy - list of Category 1 substances with endocrine disrupting capacity. - Chemical Substances Control Law of Japan (CSCL) Class I and II Specified Chemical.	Chemicals noted in the Rotterdam Accord including: - octabromodiphenyl ether - pentabromodiphenyl ether - perfluorooctane sulfonic acid - perfluorooctane sulfonates - perfluorooctane sulfonamides - perfluorooctane sulfonyls - polybromated biphenyls - short chain chlorinated paraffins - tetramethyl lead - tributyl tin compounds Chemicals restricted in the State of Queensland including: - Benzene* - Toluene* - Ethylbenzene* - m-&p- and o-Xylene*
Identified as Polymer of Low Concern	Yes (no further assessment required)	No	No	No	N/A
Persistence Assessment Step					
Persistence	Not persistent as defined by: Air - Half life < 2 days Water - Half life < 60 days Soil and Sediment - Half life < 6 months	Not persistent as defined by: Air - Half life < 2 days Water - Half life < 60 days Soil and Sediment - Half life < 6 months	Persistent as defined by: Air - Half life ≥ 2 days Water - Half life ≥ 60 days Soil and Sediment - Half life ≥ 6 months	Persistent as defined by: Air - Half life ≥ 2 days Water - Half life ≥ 60 days Soil and Sediment - Half life ≥ 6 months	N/A
Other Persistence Concerns – Chemical identified as potentially accumulating in soil and posing risks	No potential concerns with accumulation in soil and impacts on flora and fauna	No potential concerns with accumulation in soil and impacts on flora and fauna	Potential concerns with accumulation in soils based on ANZECC assessment b (for example metals such as Cd)	Potential concerns with accumulation in soils based on ANZECC assessment b (for example metals such as Cd)	N/A
Bioaccumulative Assessment Step					
Bioaccumulative	Does not Bioaccumulate as defined by: - Aquatic - BAF < 2000 or BCF < 2000 or log KoW < 4.2 (if BAF and BCF are not available) -Terrestrial - log Koa < 6 and log Kow < 2 - Food Chain Bioaccumulation Potential - BMF < 1	Does not Bioaccumulate as defined by: - Aquatic - BAF < 2000 or BCF < 2000 or log KoW < 4.2 (if BAF and BCF are not available) -Terrestrial - log Koa < 6 and log Kow < 2 - Food Chain Bioaccumulation Potential - BMF < 1	Does not Bioaccumulate as defined by: - Aquatic - BAF < 2000 or BCF < 2000 or log KoW < 4.2 (if BAF and BCF are not available) -Terrestrial - log Koa < 6 and log Kow < 2 - Food Chain Bioaccumulation Potential - BMF < 1	Does Bioaccumulate as defined by: - Aquatic - BAF ≥ 2000 or BCF ≥ 2000 or log KoW ≥ 4.2 (if BAF and BCF are not available) -Terrestrial - log Koa ≥ 6 and log Kow ≥ 2 - Food Chain Bioaccumulation Potential - BMF > 1	N/A
Toxicity Assessment Step					
Toxicity	Acute Toxicity: Fish -96h LC 50 >10 mg/L Invertebrates - 48h EC50 > 10 mg/L Algae and other aquatic plants -72 or 96h ErC50 > 10 mg/L	Acute Toxicity: Fish -96h LC 50 >1 to < 10 mg/L Invertebrates - 48h EC50 >1 to < 10 mg/L Algae and other aquatic plants -72 or 96h ErC50 >1 to < 10 mg/L	Acute Toxicity: Fish -96h LC 50 ≤ 1 mg/L Invertebrates - 48h EC50 ≤ 1 mg/L Algae and other aquatic plants -72 or 96h ErC50 ≤ 1 mg/L	Acute Toxicity: Fish -96h LC 50 ≤ 1 mg/L Invertebrates - 48h EC50 ≤ 1 mg/L Algae and other aquatic plants -72 or 96h ErC50 ≤ 1 mg/L	N/A
	Chronic Toxicity: Fish NOEC or Ecx >1 mg/L Invertebrates NOEC or Ecx > 1 mg/L Algae and other aquatic plants -NOEC or Ecx > 1 mg/L	Chronic Toxicity: Fish NOEC or Ecx >0.1 to < 1 mg/L Invertebrates NOEC or Ecx >0.1 to < 1 mg/L Algae and other aquatic plants - NOEC or Ecx >0.1 to < 1 mg/L	Chronic Toxicity: Fish NOEC or Ecx ≤ 0.1 mg/L Invertebrates NOEC or Ecx ≤ 0.1 mg/L Algae and other aquatic plants - NOEC or Ecx ≤ 0.1 mg/L	Chronic Toxicity: Fish NOEC or Ecx ≤ 0.1 mg/L Invertebrates NOEC or Ecx ≤ 0.1 mg/L Algae and other aquatic plants -NOEC or Ecx ≤ 0.1 mg/L	N/A
Risk Assessment Actions Required					
Risk Assessment Action Required	Hazard Assessment only. Do screening only and note it meets the above criteria. Develop toxicological profile	Hazard Assessment and Qualitative Assessment Only. Do screening only and note it meets the above criteria. Develop toxicological profile and PNECs for water and soil and provide qualitative discussion of risk	Quantitative Risk Assessment: Complete PBT, qualitative and quantitative assessment of risk. Quantitative assessment of risk will consider only Tier 3 chemicals in end use determination.	Quantitative Risk Assessment and Full Life Cycle Assessment. Need to demonstrate that the chemical cannot be substituted. If retained will need to conduct a full life cycle quantitative risk assessment including food chain risk assessment. Scope to be agreed with Department.	Banned from Use on Project. Would require specific assessment process and require extensive consultation prior to assessment.

** Above levels prescribed in the Queensland Environment Protection Regulation 1999*

Appendix 2 – Register of Assessed Chemicals (Template)

{Excel Tab 1 – **Document Control**}

Date	Rev	Reason For Issue
dd/mm/yy	*0*	*Publish Register following CRAF Approval*
dd/mm/yy	*1*	*Addition of "New Chemical A"*

*{Excel Tab 2 – **Register**}*

Chemical Name (incl. dossier hyperlink)	CAS No.	Document Control					Screening Assessment											Assessed Activity(ies)			Assessed Uses(s)					
							Overall PBT Assessment[1]	Chemical Databases of Concern Assessment Step		Persistence Assessment Step		Bioaccumulative Assessment Step	Toxicity Assessment Step			Tier (incl. RA hyperlink)	Risk Level									
		Chemical Assessment Date	Independent Peer Reviewer[1]	Department Notification Department Date	Department Approval Date	Chemical Re-evaluation Date		Listed as a COC on relevant databases?	Identified as Polymer of Low Concern	P criteria fulfilled?	Other P Concerns	B criteria fulfilled?	T criteria fulfilled?	Acute Toxicity[3]	Chronic Toxicity			Drilling and Completions	Hydraulic Fracturing	Water Treatment	Residual Drilling Material	Irrigation	Stock Watering	Surface Water	Dust Suppression/ Construction	TBA
Example Chemical	***1234-12-3***	*dd/mm/yy*	*NA*	*dd/mm/yy*	*dd/mm/yy*	*NA*	*Not a PBT*	*1*	*No*	*Yes*	*No*	*No*	*No*	*1*	*1*	***1***	***Low***	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	

1 – Only required for new Tier 1 and Tier 2 chemicals
2 – PBT Assessment based on PBT Framework (see Table 1); see dossiers for individual chemical PBT information.
3 – Acute and chronic aquatic toxicity evaluated consistent with assessment criteria (see Appendix 1).
4 – See risk dossier for environmental hazard assessment information.

Notes:
NA = Not Applicable
NT = Non-Toxic
PBT = Persistent, Bioaccumulative and Toxic
B = bioaccumulative
P = persistent
T = toxic

Appendix 3 – Example Tier 1 Toxicological Profile

SODIUM POLYACRYLATE

This dossier on sodium polyacrylate does not represent an exhaustive or critical review of all available data. Rather, it presents the most critical studies pertinent to the risk assessment of sodium polyacrylate in its use in drilling muds and hydraulic fracturing fluids. The majority of information presented in this dossier was obtained from the HERA document on polyacrylic acid homopolymers and their sodium salts (CAS 9003-04-7) (HERA, 2014). Where possible, study quality was evaluated using the Klimisch scoring system (Klimisch et al., 1997).

Screening Assessment Conclusion: sodium polyacrylate is classified as a ***tier 1*** *chemical and requires a hazard assessment only.*

1. BACKGROUND

Sodium polyacrylate are a group of polymers that range in molecular weight from 1,000 to 78,000. The sodium polyacrylates mostly used in detergents have a typical molecular weight of approximately 4,500 (HERA, 2014). These polymers are not readily biodegradable but are partly accessible to ultimate biodegradation. They are not expected to bioaccumulate. Sodium acrylate exhibits a low toxicity concern for aquatic organisms, terrestrial invertebrates, and plants.

2. CHEMICAL NAME AND IDENTIFICATION

Chemical Name (IUPAC): 1-Propenoic acid, homopolymer, sodium salt

CAS RN: 9003-04-7

Molecular formula: $(C_3H_4O_2)$x-.x-Na

Molecular weight: Variable

Synonyms: 2-Propenoic acid, homopolymer, sodium salt; polyacrylic acid, sodium salt, sodium polyacrylate; acrylic acid, polymers, sodium salt; poly(acrylic acid), sodium salt; polyacrylate sodium salt

3. PHYSICO-CHEMICAL PROPERTIES

Sodium polyacrylates are polymers that range in molecular weight (MW) from 1,000 to 78,000 (HERA, 2014). The sodium polyacrylates mostly used in detergents have a typical molecular weight of approximately 4,500 (HERA, 2014). For sodium polyacrylate (MW 4,500), the melting point is >150^{o}C, where is decomposes; and the water solubility is >400 g/L (HERA, 2014).

4. DOMESTIC AND INTERNATIONAL REGULATORY INFORMATION

A review of international and national environmental regulatory information was undertaken. This chemical is listed on the Australian Inventory of Chemical Substances – AICS (Inventory). No conditions for its use were identified. No specific environmental regulatory controls or concerns were identified within Australia and internationally for sodium polyacrylate.

Table 1 Existing International Controls

Convention, Protocol or other international control	Listed Yes or No?
Montreal Protocol	No
Synthetic Greenhouse Gases (SGG)	No
Rotterdam Convention	No
Stockholm Convention	No
REACH (Substances of Very High Concern)	No
United States Endocrine Disrupter Screening Program	No
European Commission Endocrine Disruptors Strategy	No

5. ENVIRONMENTAL FATE SUMMARY

A. Summary

Sodium polyacrylates are not readily biodegradable. Due to their high molecular weights, sodium polyacrylates are not expected to bioaccumulate. In addition, these water-soluble polymers can form insoluble calcium salts in natural waters, suggesting that bioaccumulation is unlikely.

B. Abiotic Degradation

Abiotic degradation mechanisms like photolytic and hydrolytic processes do not significantly influence the environmental fate of sodium polyacrylates (HERA, 2014).

C. Biodegradation

Sodium polyacrylates are not readily biodegradable, but are partly accessible to ultimate biodegradation particularly under long incubation conditions. Sodium polyacrylates with MW of <2,000 are partly biodegradable under the conditions of soil and sediment inoculation. Test results with activated sludge inoculum indicate different elimination degrees, apparently due to adsorption and precipitation processes. The removal degrees of different sodium polyacrylates show no clear relationship between elimination extent and molecular weight (HERA, 2014).

D. Bioaccumulation

No experimental studies are available on sodium polyacrylates. Estimated bioconcentration factors based on octanol-water coefficients are not appropriate since the molecular weights of these polymers are higher than the molecular weight range for the QSAR models. Due to their high molecular weights, sodium polyacrylates are not expected to bioaccumulate. In addition, these water-soluble polymers can form insoluble calcium salts in natural waters, suggesting that bioaccumulation is unlikely.

6. ENVIRONMENTAL EFFECTS SUMMARY

A. Summary

Sodium polyacrylates are a low toxicity concern for aquatic organisms, terrestrial invertebrates, and plants.

B. Aquatic Toxicity

Acute Studies

Table 2 lists the results of acute aquatic toxicity studies on sodium polyacrylates.

Table 2: Acute Aquatic Toxicity Studies on Sodium Polyacrylates

Mean MW	Test Species	Endpoint	Results (mg/L)	Klimisch score	Reference
1,000	*Brachydanio rerio*	96-hr LC_{50}	>200	1	HERA, 2014
1,000	*Salmo gairdneri*	96-hr LC_{50}	>1,000	1	HERA, 2014
1,200	*Leuciscus idus*	96-hr LC_{50}	>500	1	HERA, 2014
2,000	*Brachydanio rerio*	96-hr LC_{50}	>200	1	HERA, 2014
2,500	*Leuciscus idus*	96-hr LC_{50}	>500	1	HERA, 2014
4,500	*Lepomis macrochirus*	96-hr LC_{50}	>1,000	1	HERA, 2014
4,500	*Lepomis macrochirus*	96-hr LC_{50}	>1,000	1	HERA, 2014
8,000	*Leuciscus idus*	96-hr LC_{50}	>500	1	HERA, 2014
10,000	*Lepomis macrochirus*	96-hr LC_{50}	>1,000	1	HERA, 2014
15,000	*Leuciscus idus*	96-hr LC_{50}	>10,000	1	HERA, 2014
78,000	*Brachydanio rerio*	96-hr LC_{50}	>400	2	HERA, 2014
1,000	*Daphnia magna*	48-hr EC_{50}	>200	1	HERA, 2014
1,000	*Daphnia magna*	48-hr EC_{50}	>1,000	1	HERA, 2014
2,000	*Daphnia magna*	48-hr EC_{50}	>200	1	HERA, 2014
4,500	*Daphnia magna*	48-hr EC_{50}	>200	1	HERA, 2014
4,500	*Daphnia magna*	48-hr EC_{50}	>1,000	1	HERA, 2014
78,000	*Daphnia magna*	24-hr EC_{50}	276	2	HERA, 2014
8,000	*Selenastrum capricornutum*	72-hr EC_{50}	40	1	HERA, 2014
78,000	*Scenedesmus subspicatus*	96-hr EC_{50}	44	2	HERA, 2014

Chronic Studies

Table 3 lists the results of chronic aquatic toxicity studies on sodium polyacrylates.

Table 3: Chronic Aquatic Toxicity Studies on Sodium Polyacrylates (HERA, 2014)

Mean MW	Test Species	Endpoint	Results (mg/L)	Klimisch score	Reference
4,500	*Pimephales promelas*	32-d NOEC	56	2	HERA, 2014
4,500	*Brachydanio rerio*	28-d NOEC	>450	1	HERA, 2014
78,000	*Brachydanio rerio*	14-d NOEC	>400	2	HERA, 2014

Mean MW	Test Species	Endpoint	Results (mg/L)	Klimisch score	Reference
4,500	*Daphnia magna*	21-d NOEC	450	1	HERA, 2014
4,500	*Daphnia magna*	21-d NOEC	58	1	HERA, 2014
4,500	*Daphnia magna*	21-d NOEC	12	2	HERA, 2014
78,000	*Daphnia magna*	21-d NOEC	100	2	HERA, 2014
4,500	*Scenedesmus subspicatus*	96-hr NOEC	180	2	HERA, 2014
78,000	*Scenedesmus subspicatus*	96-hr NOEC	32.8	2	HERA, 2014

There is considerable variability in the chronic aquatic toxicity results for *Daphnia magna* for sodium polyacrylates with the same molecular weight of 4,500. This was discussed in HERA (2014) and was explained by the solubility of sodium polyacrylates in water. In distilled water, the solubility of sodium polyacrylates with the molecular weight of 4,500 is >400 mg/L; however, under test conditions water solubility will decrease due to the presence of Ca^{++} and Mg^{++} (as measured by water hardness). In a study by BASF (reviewed in HERA, 2014), the water solubility of sodium polyacrylate (MW 4,500) was determined with radiolabelled compounds in a test system with a calcium concentration of 70 mg/L, which corresponds to the mean water hardness to the media used in an OECD TG 202 test. Under these conditions, the water solubility of sodium polyacrylate was 1.3 mg/L after 24 hours. So, one explanation for the variability of the chronic *Daphnia* studies may be due to differences in water hardness.

C. Toxicity to Sediment Organisms

The 96-hr EC_0 to *Chironomus riparius* (larvae) is >4,500 mg/kg sediment dry weight (HERA, 2014).

D. Terrestrial Toxicity

The results of terrestrial toxicity studies on sodium polyacrylate polymers are listed below.

Table 4: Terrestrial Toxicity Studies on Sodium Polyacrylates (HERA, 2014)

Mean MW	Test Species	Endpoint	Results (mg/L)	Klimisch score	Reference
4,500	*Eisenia foetida foetida*	14-d EC_0	1,000	1	HERA, 2014
78,000	*Eisenia foetida andrei*	14-d EC_0	1,000	2	HERA, 2014
78,000	*Brassica rapa*	21-d NOEC	1,000	2	HERA, 2014
4,500	Nitrogen transformation*	28-d EC_{10}	>2,500	1	HERA, 2014
4,500	Carbon transformation*	28-d EC_{10}	>2,500	1	HERA, 2014

*Soil organisms

7. CATEGORISATION AND OTHER CHARACTERISTICS OF CONCERN

A. PBT Categorisation

The methodology for the Persistent, Bioaccumulative and Toxic (PBT) substances assessment is based on the Australian and EU Reach Criteria methodology (DEWHA, 2009, ECHA, 2008).

The sodium polyacrylates are not readily biodegradable; thus they meet the screening criteria for persistence.

The sodium polyacrylates are expected to have high molecular weights and are not expected to be bioavailable. Thus these polymers do not meet the criteria for bioaccumulation.

Chronic NOECs for fish, daphnia and algae are available for sodium polyacrylates and the NOEC values are >0.1 mg/L. Thus sodium polyacrylates do not meet the screening criteria for toxic.

The overall conclusion is that sodium polyacrylates are not PBT substances.

B. Other Characteristics of Concern

No other characteristics of concern were identified for sodium polyacrylate.

8. SCREENING ASSESSMENT

Chemical Name	CAS No.	Overall PBT Assessment [1]	Chemical Databases of Concern Assessment Step		Persistence Assessment Step		Bioaccumulative Assessment Step	Toxicity Assessment Step			Risk Assessment Actions Required[3]
			Listed as a COC on relevant databases?	Identified as Polymer of Low Concern	P criteria fulfilled?	Other P Concerns	B criteria fulfilled?	T criteria fulfilled?	Acute Toxicity [2]	Chronic Toxicity[2]	
Sodium Polyacrylate	9003-04-7	Not a PBT	No	Yes	Yes		No	No	1	1	1

Footnotes:

1 - PBT Assessment based on PBT Framework.

2 - Acute and chronic aquatic toxicity evaluated consistent with assessment criteria (see Framework).

3 – Tier 1 – Hazard Assessment only.

Notes:

PBT = Persistent, Bioaccumulative and Toxic

B = bioaccumulative

P = persistent

T = toxic

9. REFERENCES, ABBREVIATIONS AND ACRYNOYMS

A. References

Department of the Environment, Water, Heritage and the Arts (DEWHA). (2009). Environmental risk assessment guidance manual for industrial chemicals, Department of the Environment, Water, Heritage and the Arts, Commonwealth of Australia.

enHealth Human Risk Assessment (HHRA). (2012). Environmental Health Risk Assessment, Guidelines for Assessing Human Health Risks from Environmental Hazards. Office of Health Protection of the Australian Government Department of Health.

European Chemicals Agency (ECHA). (2008). Guidance on Information Requirements and Chemical Safety Assessment, Chapter R11: PBT Assessment, European Chemicals Agency, Helsinki, Finland.

HERA (2014). Human & Environmental Risk Assessment (HERA) on ingredients of European household cleaning products. Polycarboxylates used in detergents (Part I): Polyacrylic acid homopolymers and their sodium salts (CAS 9003-04-7). (http://www.heraproject.com/files/HERA_P-AA_final_v3_23012014.pdf)

Klimisch, H.J., Andreae, M., and Tillmann, U. (1997). A systematic approach for evaluating the quality of experimental and toxicological and ecotoxicological data. Regul. Toxicol, Pharmacol. 25:1-5.

B. Abbreviations and Acronyms

°C	degrees Celsius
DEWHA	Department of the Environment, Water, Heritage and the Arts
ECHA	European Chemicals Agency
EU	European Union
GHS	Globally Harmonised System of Classification and Labelling of Chemicals
HHRA	enHealth Human Risk Assessment
IUPAC	International Union of Pure and Applied Chemistry
LOAEL	lowest observed adverse effect level
mg/kg	milligrams per kilogram
mg/L	milligrams per litre
mg/m^3	milligrams per cubic metre
MW	molecular weight
NICNAS	The National Industrial Chemicals Notification and Assessment Scheme
NOAEL	no observed adverse effect level
NOEC	no observed effective concentration
OECD	Organisation for Economic Co-operation and Development

PBT	Persistent, Bioaccumulative and Toxic
ppm	parts per million
QSAR	quantitative structure–activity relationship
SDS	Safety Data Sheet
SMILES	simplified molecular-input line-entry system

Appendix 4 – Example Tier 2 Toxicological Profile

POLYDADMAC
[POLYDIALLYLDIMETHYLAMMONIUM CHLORIDE]

This dossier on polyDADMAC does not represent an exhaustive or critical review of all available data. Rather, it presents the most critical studies pertinent to the risk assessment of polyDADMAC in its use in water treatment systems. Where possible, study quality was evaluated using the Klimisch scoring system (Klimisch et al., 1997).

Screening Assessment Conclusion – PolyDADMAC was not identified in chemical databases used by NICNAS as an indicator that the chemical is of concern and is not a PBT substance. PolyDADMAC was assessed as a tier 2 chemical for acute and chronic toxicity. Therefore, polyDADMAC is classified overall as a ***tier 2*** *chemical and requires a hazard assessment and qualitative assessment of risk.*

1. BACKGROUND

Polydiallyldimethylammonium chloride (polyDADMAC) are highly charged cationic polymers with high molecular weights. They are expected to be poorly biodegraded, and adsorption would be expected to be the primary process that determines its ecological concentrations and mobility. As a cationic polymer, polyDADMAC will rapidly react with many kinds of naturally occurring substances, such as humic acids, lignins, silts, and clays. Due to its physical properties (i.e., molecular size), polyDADMAC is not expected to bioaccumulate. PolyDADMAC is not acutely toxic to humans by the oral route; nor does it exhibit any systemic toxicity from repeated exposures through ingestion. PolyDADMAC exhibits a moderate toxicity concern to aquatic organisms. The toxicity of these polymers is mitigated by the presence of dissolved organic carbon (DOC) and suspended solids. Cationic polymers react with DOC in environmental waters to form insoluble complexes, which settle out of water and therefore are not bioavailable to cause toxic effects.

2. CHEMICAL NAME AND IDENTIFICATION

Chemical Name: Polydiallyldimethylammonium chloride

CAS RN: 26062-79-3

Molecular formula: $(C_8H_{16}N.Cl)_x$-

Molecular weight: Variable

Synonyms: PolyDADMAC; 2-Propen-1-aminium, N,N-dimethyl-N-2-propenyl-, chloride, homopolymer; Poly-2-propen-1-aminium, N,N-dimethyl-N-2-propenyl-, chloride; N-N-dimethyl-N-2-propenyl-2-propen-1-aminium chloride, homopolymer; poly-N,N-dimethyl-N-N-diallyammonium chloride; polyquaternium-6

3. PHYSICO-CHEMICAL PROPERTIES

PolyDADMAC are highly charged cationic homopolymers with high molecular weights; those used in water treatment may have molecular weights less than 500,000 (Lyons and Vasconcellos, 1997).

Limited information is available on the physico-chemical properties of polyDADMAC. The information contained in Table 1 is based on DADMAC (CAS No. 7398-69-8). PolyDADMAC is a homopolymer of DADMAC.

Table 1: Overview of the Physico-chemical Properties of DADMAC

Property	Value	Klimisch score	Reference
Physical state at 20°C and 101.3 kPa	Liquid	-	ECHA
Melting Point/Freezing Point	-25 °C	1	ECHA
Boiling Point	118 °C	1	ECHA
Density	1.03 – 1.05 g/cm^3 @ 25°C	1	ECHA
Partition Coefficient (log K_{ow})	Estimated to be -2.49 using KOWWIN	2	ECHA
Water Solubility	Estimated to be 1,000 g/L @ 25°C	2	ECHA
Auto flammability	Study scientifically not necessary	-	ECHA

4. DOMESTIC AND INTERNATIONAL REGULATORY INFORMATION

A review of international and national environmental regulatory information was undertaken. This chemical is listed on the Australian Inventory of Chemical Substances – AICS (Inventory). No conditions for its use were identified. PolyDADMAC is also listed in Appendix B (Substances Considered Not To Require Control By Scheduling) of the *Standard for the Uniform Scheduling of Medicines and Poisons* (SUSMP) (Therapeutic Goods Administration [TGA] 2014). The reason given for listing in Appendix B is 'Low Toxicity' and the area of use of the chemical is 'Water treatment' (NICNAS, 2017a). No other specific environmental regulatory controls or concerns were identified within Australia and internationally for polyDADMAC.

Table 2 Existing International Controls

Convention, Protocol or other international control	Listed Yes or No?
Montreal Protocol	No
Synthetic Greenhouse Gases (SGG)	No
Rotterdam Convention	No
Stockholm Convention	No
REACH (Substances of Very High Concern)	No
United States Endocrine Disrupter Screening Program	No
European Commission Endocrine Disruptors Strategy	No

5. ENVIRONMENTAL FATE SUMMARY

A. Summary

PolyDADMAC are highly charged cationic polymers with high molecular weights. They are expected to be poorly biodegraded, and adsorption would be expected to be the primary process that determines its ecological concentrations and mobility (Lyons and Vasconcellos, 1997). As a cationic polymer, polyDADMAC will rapidly react with many kinds of naturally occurring substances, such as humic acids, lignins, silts, and clays (Lyons and Vasconcellos, 1997).

PolyDADMAC will dissociate into polyammonium cations and chloride anions in the aquatic environment. Chloride ions are an essential constituent of electrolytes in all biological fluids responsible for maintaining acid/base balance, transmitting nerve impulses and regulating fluid in and out of cells (NCBI 2015). The concentration of chloride ions is naturally regulated within organisms. Therefore, consistent with NICAS (NICNAS, 2017b), this discussion is focused on the environmental fate and effects of the synthetic polyammonium cations.

B. Biodegradation

Due to its physical properties (i.e., molecular size), polyDADMAC is expected to be poorly degraded. This finding is consistent with DADMAC which is not readily biodegradable according to the OECD criteria (ECHA) [Kl. score = 1].

C. Bioaccumulation

Due to its physical properties (*i.e.*, molecular size), polyDADMAC is not expected to bioaccumulate.

6. HUMAN HEALTH HAZARD ASSESSMENT

A. Summary

PolyDADMAC is not acutely toxic by the oral route; nor does it exhibit any systemic toxicity from repeated exposures through ingestion.

B. Acute Toxicity

There were no deaths in rats given a single oral dose of 5,000 mg/kg polyDADMAC. The oral LD50 in rats is >5,000 mg/kg (EPA, 2016a).

C. Irritation

No studies were located.

D. Sensitisation

No studies were located.

E. Repeated Dose Toxicity

Oral

Male and female SD rats were fed in their diet 0, 1,000, or 2,000 mg/kg polyDADMAC for six months. There were no clinical signs of toxicity. Two low-dose males were sacrificed in a moribund condition, while one low-dose male and one high-dose male died during the exposure period. Feed consumption was significantly increased in the treated groups compared to controls. Body weight gain was significantly lower in the treated animals compared to the controls. Final body weights were significantly lower in all dose groups compared to controls (10.4% and 19.5% in males; 6.6% and 10% in females for the low- and high-dose groups, respectively). Hematology and clinical chemistry parameters and urinalysis showed no biologically significant differences between treated and control groups. Relative liver weights were decreased in the ≥1,000 mg/kg males and 2,000 mg/kg females. Relative heart weights were decreased in the 2,000 mg/kg (both sexes), and relative kidney weights were decreased in the 2,000 mg/kg males. The histopathologic examination showed no treatment-related changes in these organs. No other compound-related pathology was observed, although histopathologic effects were seen in the lungs and urinary tract in animals of all groups. The LOAEL for this study is 1,000 mg/kg-day based on reduced body weights and body weight gain; a NOAEL was not established (EPA, 2016b).

Inhalation

No studies were located.

Dermal

No studies were located.

F. Genotoxicity

No studies were located.

G. Carcinogenicity

No studies were located.

H. Reproductive Developmental Toxicity

No studies were located.

I. DERIVATION OF TOXICOLOGICAL REFERENCE AND DRINKING WATER GUIDANCE VALUES

The toxicological reference values developed for polyDADMAC follow the methodology discussed in enHealth (2012). The approach used to develop drinking water guidance values is described in the Australian Drinking Water Guidelines (ADWG, 2011).

Non-Cancer

PolyDADMAC was tested in a six-month rat feeding study. No target organs were identified and a NOAEL was not established. The LOAEL was 1,000 mg/kg-day based on reduced body weights and body weight gain. It is unclear from the limited data whether these changes in the treated animals are due to a direct or indirect effect of polyDADMAC. PolyDADMAC has a high molecular weight and would not be expected to be absorbed from the gastrointestinal tract. Feed consumption was significantly increased in the treated rats (both dose groups) even though body weights and body weight gain were reduced. A likely explanation for these findings is that the weight changes and feed consumption reflect the nutritional status of the treated animals due to the bulk presence of high levels of polymer in the feed and not to systemic toxicity. Given the absence of any other effects, it is proposed that the NOAEL for systemic toxicity in this study is 2,000 mg/kg-day, the highest dose tested.

The NOAEL of 2,000 mg/kg-day will be used for determining the oral Reference Dose (RfD) and the drinking water guidance value.

Oral Reference Dose (oral RfD)

Oral RfD = NOAEL / (UF_A x UF_H x UF_L x UF_{Sub} x UF_D)

Where:
- UF_A (interspecies variability) = 10
- UF_H (intraspecies variability) = 10
- UF_L (LOAEL to NOAEL) = 1
- UF_{Sub} (subchronic to chronic) = 3
- UF_D (database uncertainty) = 1

Oral RfD = 2,000/(10 x 10 x 1 x 3 x 1) = 2,000/300 = 7 mg/kg-day

Drinking water guidance value

Drinking water guidance value = (animal dose) x (human weight) x (proportion of intake from water) / (volume of water consumed) x (safety factor)

Using the oral RfD,

Drinking water guidance value = (oral RfD) x (human weight) x (proportion of water consumed) / (volume of water consumed)

Where:
- Human weight = 70 kg (ADWG, 2011)
- Proportion of water consumed = 10% (ADWG, 2011)
- Volume of water consumed = 2L (ADWG, 2011)

Drinking water guidance value = (6.7 x 70 x 0.1)/2 = 23 mg/L

Cancer

No carcinogenicity studies were located; thus, a cancer reference value was not derived.

J. HUMAN HEALTH HAZARD ASSESSMENT OF PHYSICO-CHEMICAL PROPERTIES

PolyDADMAC does not exhibit the following physico-chemical properties:

- Explosivity
- Flammability
- Oxidizing potential

7. ENVIRONMENTAL EFFECTS SUMMARY

A. Summary

PolyDADMAC exhibits a moderate toxicity concern to aquatic organisms. However, under environmental conditions, the toxicity of these polymers is mitigated by the presence of DOC and suspended solids. Cationic polymers react with DOC in environmental waters to form insoluble complexes, which settle out of water and therefore are not bioavailable to cause toxic effects. It has previously been established that a reduction in likely toxicity by a factor of 110 is appropriate to apply to laboratory test results for cationic polymers with a high charge density to account for the mitigating effects of DOC on toxicity in natural environmental waters (Boethling and Nabholz 1997).

B. Aquatic Toxicity

Acute Studies

Table 3 lists the results of acute aquatic toxicity studies conducted on polyDADMAC.

Table 3: Acute Aquatic Toxicity Studies on polyDADMAC

Test Species	Endpoint	Results (mg/L)	Reference
Bluegill	96-hr LC_{50}	0.9	EPA, 2016c
Bluegill	96-hr LC_{50}	0.32	EPA, 2016d
Rainbow trout	96-hr LC_{50}	0.32	EPA, 2016d
Rainbow trout	96-hr LC_{50}	0.42	EPA, 2016e
Rainbow trout	96-hr LC_{50}	0.77	EPA, 2016f
Fathead minnow	96-hr LC_{50}	0.3	EPA, 2016g
Fathead minnow	96-hr LC_{50}	6.51*	EPA, 2016g
Fathead minnow	96-hr LC_{50}	0.46	Cary et al., (1987)
Fathead minnow	96-hr LC_{50}	6.5***	Cary et al., (1987)
Daphnia magna	48-hr EC_{50}	0.23	EPA, 2016g
Daphnia magna	48-hr EC_{50}	11.8**	EPA, 2016g
Daphnia magna	48-hr EC_{50}	0.33	EPA, 2016h
Daphnia magna	48-hr EC_{50}	0.2	Cary et al., (1987)

Test Species	Endpoint	Results (mg/L)	Reference
Daphnia magna	48-hr EC_{50}	7.4***	Cary et al., (1987)

*10 mg/L humic acid in standard laboratory water.
**10 mg/L TOC in standard laboratory water.
***50 mg/L humic acid in standard laboratory water.

In standard acute aquatic toxicity tests, PolyDADMAC, as a highly charged cationic polymer, is very toxic to fish and *Daphnia*. The toxicity of cationic polymers to fish is from the binding of the polymer to gill tissue, disrupting gill structure and function. Physical damage to fish gill by cationic polymers has been shown by Beisinger and Stokes (1986).

The presence of dissolved organic carbon and suspended solids is known to significantly mitigate the toxicity of cationic polymers under typical environmental exposure conditions (Boethling and Nabholz 1997). Table 3 also shows the change in acute toxicity when suspended solids or total organic carbon (TOC) is added to the standard laboratory water used in the toxicity tests. In the presence of humic acid or TOC, the $E(L)C_{50}$ values for fathead minnow and *Daphnia magna* increase by 21.7-fold and 51.3-fold, respectively. A similar effect of humic acid on the acute toxicity of polyDADMAC on fish and *Daphnia magna* was reported by Cary et al. (1987). The studies by Cary et al. (1987) also showed increases in varying amounts in the $E(L)C_{50}$ values for fathead minnow and *Daphnia magna* with bentonite, illite, kaolin, silica, tannic acid, lignin, lignosite, and fulvic acid. The concentrations of suspended solids and DOC in the studies by Cary et al. (1987) were considered to be low estimates of levels found in the natural environments. These findings demonstrate that toxicity tests conducted on cationic polymers, such as polyDADMAC, using water with no organic carbon will likely overestimate the toxicity of these polymers in the environment.

Chronic Studies

No studies were located for polyDADMAC. The ratio of the acute toxicity to chronic toxicity for polyDADMAC is expected to be low. In 21-day *Daphnia magna* reproduction studies, three cationic polymers had 21-day threshold levels for survival that were higher by order of magnitude than the 48-hr TL_{50} values. The test solutions in these studies were renewed several times along with food, which served as new organic matter. The cationic polymer bioavailability was likely reduced from the adsorption to the food (Biesinger et al., 1976). In another study, low acute to chronic ratios was observed for a cationic polymer for *Ceriodaphnia dubia* and fathead minnows (Godwin-Saad et al., 1994).

It cannot be determined from the standard chronic tests if the adsorbed polymer is ingested or simply becomes unavailable by flocculating and/or settling. In any case, the low acute to chronic ratios of these cationic polymers appears to be best correlated with acute effects (Lyons and Vasconcellos, 1997).

C. Terrestrial Toxicity

No studies were located.

D. Calculation of PNEC

The PNEC calculations for polyDADMAC follow the methodology discussed in DEWHA (2009).

PNEC water

Experimental results are available for two trophic levels. Acute $E(L)C_{50}$ values are available for fish (0.2 mg/L) and *Daphnia* (0.3 mg/L) in standard laboratory water; and for fish (6.5 mg/L) and *Daphnia* (11.8 mg/L) in standard laboratory water with the addition of humic acid or TOC. The PNEC water will be based on the $E(L)C_{50}$ values from the acute toxicity tests conducted with humic acid in the dilution water because this most likely represents the environmental conditions for which this assessment is being conducted for. Furthermore, an assessment factor of 50 is proposed because chronic toxicity is expected to be similar to the acute toxicity of polyDADMAC (when tested in the presence of humic acid) because of the adsorption of the polymer to organic matter (food source) that would occur in standard test methods; hence, an assessment factor will be used for chronic testing for two trophic levels. An assessment factor of 50 has been applied to the $E(L)C_{50}$ value of 6.5 mg/L for fish. The $PNEC_{water}$ is 0.13 mg/L.

PNEC sediment

There are no toxicity data for sediment-dwelling organisms. The K_{ow} and K_{oc} have not been experimentally derived for polyDADMAC; these values cannot estimate using QSAR models because of the high molecular weight of polyDADMAC. Thus, the equilibrium partitioning method cannot be used to calculate the $PNEC_{sed}$.

PNEC soil

There are no toxicity data for soil-dwelling organisms. The K_{ow} and K_{oc} have not been experimentally derived for polyDADMAC; these values cannot estimate using QSAR models because of the high molecular weight of polyDADMAC. Thus, the equilibrium partitioning method cannot be used to calculate the $PNEC_{soil}$.

8. CATEGORISATION AND OTHER CHARACTERISTICS OF CONCERN

A. PBT Categorisation

The methodology for the Persistent, Bioaccumulative and Toxic (PBT) substances assessment is based on the Australian and EU Reach Criteria methodology (DEWHA, 2009; ECHA, 2008).

PolyDADMAC is a high molecular weight polymer; it is expected to be poorly biodegraded. Thus, it meets the screening criteria for persistence.

PolyDADMAC is a high molecular weight polymer that is not expected to be bioavailable to aquatic or terrestrial organisms. Thus, it is not expected to bioaccumulate.

No chronic aquatic toxicity studies have been conducted on polyDADMAC. The $E(L)C_{50}$ values of fish and *Daphnia* for acute toxicity tests conducted with humic acid or TOC in dilution water were >1 mg/L. Thus, polyDADMAC does not meet the screening criteria for toxicity.

The overall conclusion is that polyDADMAC is not a PBT substance.

B. Other Characteristics of Concern

No other characteristics of concern were identified for polyDADMAC.

9. SCREENING ASSESSMENT

Chemical Name	CAS No.	Overall PBT Assessment [1]	Chemical Databases of Concern Assessment Step		Persistence Assessment Step		Bioaccumulative Assessment Step	Toxicity Assessment Step			Risk Assessment Actions Required[3]
			Listed as a COC on relevant databases?	Identified as Polymer of Low Concern	P criteria fulfilled?	Other P Concerns	B criteria fulfilled?	T criteria fulfilled?	Acute Toxicity [2]	Chronic Toxicity[2]	
PolyDADMAC	26062-79-3	Not a PBT	No	No	Yes		No	No	2	2	2

Footnotes:

1 - PBT Assessment based on PBT Framework.

2 - Acute and chronic aquatic toxicity evaluated consistent with assessment criteria (see Framework).

3 - Tier 2 - Hazard Assessment and Qualitative Assessment Only. Develop toxicological profile and PNECs for water and soil and provide qualitative discussion of risk.

Notes:

PBT = Persistent, Bioaccumulative and Toxic

B = bioaccumulative

P = persistent

T = toxic

10. REFERENCES, ABBREVIATIONS AND ACRONYMS

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B. Acronyms and Glossary

°C	degrees Celsius
ADWG	Australian Drinking Water Guidelines
DEWHA	Department of the Environment, Water, Heritage and the Arts
EC	effective concentration
ECHA	European Chemicals Agency
EU	European Union
GHS	Globally Harmonised System of Classification and Labelling of Chemicals
HHRA	enHealth Human Risk Assessment
IUPAC	International Union of Pure and Applied Chemistry
Kl	Klimisch scoring system
LOAEL	lowest observed adverse effect level
mg/kg	milligrams per kilogram
mg/L	milligrammes per litre
MW	molecular weight
NICNAS	The National Industrial Chemicals Notification and Assessment Scheme
NOAEC	No Observed Adverse Effect Concentration
NOAEL	no observed adverse effect level
NOEC	no observed effective concentration
OECD	Organisation for Economic Co-operation and Development
PBT	Persistent, Bioaccumulative and Toxic
PNEC	Predicted No Effect Concentration
ppm	parts per million
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
RfD	Reference Dose
SDS	Material Safety Data Sheet
USEPA	United States Environmental Protection Agency

Appendix 5 – Example Tier 3 Toxicological Profile

DIALUMINIUM CHLORIDE PENTAHYDROXIDE

This dossier on dialuminium chloride pentahydroxide does not represent an exhaustive or critical review of all available data. Rather, it presents the most critical studies pertinent to the risk assessment of dialuminium chloride pentahydroxide in water treatment systems. The majority of information presented in this dossier was obtained from the ECHA database that provides information on chemicals that have been registered under the EU REACH (ECHA). Where possible, study quality was evaluated using the Klimisch scoring system (Klimisch et al., 1997).

*Screening Assessment Conclusion – Dialuminium chloride pentahydroxide was not identified in chemical databases used by NICNAS as an indicator that the chemical is of concern and is not a PBT substance. Dialuminium chloride pentahydroxide was assessed as a tier 3 chemical for acute toxicity and as a tier 1 chemical for chronic toxicity. Therefore, dialuminium chloride pentahydroxide is classified overall as a **tier 3** chemical and requires a quantitative risk assessment for end uses.*

1. BACKGROUND

Dialuminium chloride pentahydroxide is very soluble in water and will dissociate to form aluminium hydroxide species and chloride ions. Biodegradation is not applicable to dialuminium chloride pentahydroxide. The aluminium hydroxide hydrolysis products will adsorb to colloidal matter. Dialuminium chloride pentahydroxide is not expected to bioaccumulate in aquatic organisms. Dialuminium chloride pentahydroxide has low acute toxicity by the oral and dermal routes. It is non-irritating to the skin and slightly irritating to the eyes. It is not a skin sensitizer. No systemic, reproductive, or developmental toxicity was seen in rats at oral doses up to 1,000 mg/kg-day aluminium hydroxychloride (a structurally similar compound) in a combined repeated dose toxicity and reproductive/developmental toxicity screening (OECD 422) study. Dialuminium chloride pentahydroxide is not genotoxic. The Australian drinking water guideline (ADWG) values for aluminium (acid-soluble) is 0.2 mg/L based on aesthetics. ADWG has concluded that there is insufficient data to set a guidance value based on health considerations. The ANZECC water quality guideline (2000) used acute and chronic laboratory toxicity data for the derivation of trigger values for aluminium, which are 55 µg/L at pH >6.5 and 0.8 µg/L at pH of <6.5.

2. CHEMICAL NAME AND IDENTIFICATION

Chemical Name (IUPAC): Dialuminium chloride pentahydroxide

CAS RN: 12042-91-0

Molecular formula: $Al_2ClH_5O_5$; general formula $Al(OH)_x(Cl)_{(3-x)}$ with x between 2.3 and 2.6

Molecular weight: 174.45

Synonyms: Dialuminium chloride pentahydroxide; dialuminium chloride pentahydroxide; aluminium chlorohydroxide; aluminium hydroxychloride dehydrate; aluminium chloride hydroxide, dihydrate

3. PHYSICO-CHEMICAL PROPERTIES

Table 1: Overview of the Physico-chemical Properties of Dialuminium Chloride Pentahydroxide

Property	Value	Klimisch score	Reference
Physical state at 20°C and 101.3 kPa	Solid; fine flakes	1	ECHA
Melting Point	No melting point below 400°C could be determined.	1	ECHA
Boiling Point	No boiling point below 400°C could be determined.	1	ECHA
Density	1.95 g/cm^3 @ 20°C	1	ECHA
Partition Coefficient (log K_{ow})	-	-	-
Water Solubility	>1,000 g/L @ 20°C (sample pH was 3.3)	1	ECHA
Auto flammability	Not auto flammable.	1	ECHA

Polyaluminium coagulants, which have been developed for water treatment applications, have the general formula $(Al_n(OH)_mCl_{(3n-m)})_x$. The length of the polymerised chain, molecular weight, and the number of ionic charges is determined by the degree of polymerization. The polyaluminium coagulants include polyaluminium chloride (n=2; m=3), dialuminium chloride pentahydroxide (n=2; m=5), and polydialuminium chloride pentahydroxide (similar to dialuminium chloride pentahydroxide) (Gebbie, 2001).

On hydrolysis, various mono- and polymeric species are formed, with an important cation being $Al_{13}O_4(OH)_{24}^{7+}$. A less predominant species is $Al_8(OH)_{20}^{4+}$.

Depending on the pH, the following reaction takes place (Gebbie, 2006):

$$Al_2(OH)_5Cl \rightarrow Al_2(OH)_5^+ + Cl^- + H_2O \rightarrow 2Al(OH)_3 + H^+ + Cl^-$$

This reaction will typically take place at a water pH of 5.8 to 7.5. Within this pH, colour and the colloidal matter are removed by adsorption onto/within the metal hydroxide hydrolysis products that are formed (Gebbie, 2006).

4. DOMESTIC AND INTERNATIONAL REGULATORY INFORMATION

A review of international and national environmental regulatory information was undertaken. This chemical is listed on the Australian Inventory of Chemical Substances – AICS (Inventory). No conditions for its use were identified. No specific environmental regulatory controls or concerns were identified within Australia and internationally for dialuminium chloride pentahydroxide.

Table 2 Existing International Controls

Convention, Protocol or other international control	Listed Yes or No?
Montreal Protocol	No
Synthetic Greenhouse Gases (SGG)	No

Convention, Protocol or other international control	Listed Yes or No?
Rotterdam Convention	No
Stockholm Convention	No
REACH (Substances of Very High Concern)	No
United States Endocrine Disrupter Screening Program	No
European Commission Endocrine Disruptors Strategy	No

5. ENVIRONMENTAL FATE SUMMARY

A. Summary

Dialuminium chloride pentahydroxide is very soluble in water and will dissociate to form aluminium hydroxide species and chloride ions. Biodegradation is not applicable to dialuminium chloride pentahydroxide. The aluminium hydroxide hydrolysis products will adsorb to colloidal matter. Dialuminium chloride pentahydroxide is not expected to bioaccumulate in aquatic organisms.

B. Biodegradation

Biodegradation is not applicable to dialuminium chloride pentahydroxide.

C. Bioaccumulation

Fish accumulate aluminium in and on the gill, and it has been suggested that the rate of transfer of aluminium into the body is either slow or negligible under natural environmental conditions (Spry and Wiener, 1991). The initial uptake of aluminium by fish occurs mainly on the gill mucous layer (Wilkinson and Campbell, 1993); both mucus and bound aluminium may be rapidly eliminated following exposure. Roy (1999) calculated the BCFs in fish to range from 400 to 1,365.

The BCF for *Daphnia magna* varied from 10,000 at pH 6.5 to 0 at pH 4.5, based on the results of Havas (1985). Most of the metal appears to be adsorbed to external surfaces and is not internalised (Havas, 1985; Frick and Hermann, 1990).

The accumulation of aluminium by the algae *Chlorella pyrenoidosa* increased with the concentration of inorganic monomeric aluminium (Parent and Campbell, 1994). A comparison of assays performed at different pH values but the same concentration of aluminium showed suppression of that aluminium accumulation at low pH.

6. HUMAN HEALTH HAZARD ASSESSMENT

A. Summary

Dialuminium chloride pentahydroxide has low acute toxicity by the oral and dermal routes. It is non-irritating to the skin and slightly irritating to the eyes. It is not a skin sensitizer. No systemic, reproductive, or developmental toxicity was seen in rats at oral doses up to 1,000 mg/kg-day aluminium hydroxychloride (a structurally similar compound) in a combined repeated dose toxicity and reproductive/developmental toxicity screening (OECD 422) study. Dialuminium chloride pentahydroxide is not genotoxic.

B. Acute Toxicity

No oral acute toxicity studies are available for dialuminium chloride pentahydroxide. The oral LD_{50} of aluminium hydroxychloride in rats is >2,000 mg/kg (ECHA) [Kl. score = 2].

The dermal LD_{50} of dialuminium chloride pentahydroxide in rats is >2,000 mg/kg (ECHA) [Kl. score = 2].

C. Irritation

No skin irritation studies area available for dialuminium chloride pentahydroxide. Application of 0.5 mL of aluminum hydroxychloride to the skin of rabbits for 4 hours under semi-occlusive conditions was not irritating. The mean of the 24, 48 and 72 hour scores were zero for both erythema and edema (ECHA). [Kl. score = 1]

Dialuminium chloride pentahydroxide was slightly irritating to the eyes of rabbits. The mean of the 24, 48, and 72-hour conjunctival redness scores was 1.00; all other parameters were zero (ECHA). [Kl. score = 1]

D. Sensitization

Dialuminium chloride pentahydroxide was not a skin sensitizer in a guinea pig maximisation test (ECHA) [Kl. score = 1].

E. Repeated Dose Toxicity

Oral

No studies are available on dialuminium chloride pentahydroxide.

Aluminium chloride, basic (aluminium hydroxychloride) was tested in a combined repeated dose toxicity and reproductive/developmental screening toxicity (OECD 422) study. Male and female Wistar rats were dosed by oral gavage with 0, 40, 200, or 1,000 mg/kg aluminium chloride, basic; these doses correspond to 0, 3.6, 18, or 90 mg/kg-day aluminium. There were no effects in the females at any dose level. In males, there were effects indicative of stomach irritation at the high-dose; no other effects were noted. The NOAEL for systemic effects in this study is 1,000 mg/kg-day, the highest dose tested. The NOAEL for localized effects (site-of-contact) is 200 mg/kg-day (ECHA). [Kl. score = 2]

Inhalation

No adequate studies were located.

Dermal

No studies are available.

F. Genotoxicity

In Vitro Studies

Dialuminium chloride pentahydroxide was not mutagenic to *S. typhimurium* strains TA98, TA100, TA1535, TA1537 and *E. coli* strain WP2*uvr*A in the absence or presence of metabolic activation (ECHA). [Kl. score = 1]

The *in vitro* genotoxicity studies on the structurally similar compound aluminium hydroxychloride is shown below in table 2.

Table 3: *In Vitro* Genotoxicity Studies on Aluminium Hydroxychloride

Test System	Results*		Klimisch Score	Reference
	-S9	+S9		
Bacterial reverse mutation (S. typhimurium and E. coli strains)	-	-	1	ECHA
Mammalian cell gene mutation (mouse lymphoma L5178Y cells)	-	-	1	ECHA
Micronucleus (peripheral human lymphocytes)	-	-	1	ECHA

*+, positive; -, negative

In Vivo Studies

Male and female NMRI mice were given an oral gavage dose of 0 or 2,000 mg/kg dialuminium chloride pentahydroxide on two consecutive days. There were no increases in the frequency of micronucleated polychromatic erythrocytes in the bone marrow of the treated mice compared to the controls (ECHA). [Kl. score = 1]

G. Carcinogenicity

No studies are available.

H. Reproductive/Developmental Toxicity

No studies are available for dialuminium chloride pentahydroxide.

Aluminium chloride, basic (aluminium hydroxychloride) was tested in a combined repeated dose toxicity and reproductive/developmental screening toxicity (OECD 422) study. Male and female Wistar rats were dosed by oral gavage with 0, 40, 200, or 1,000 mg/kg aluminium chloride, basic; these doses correspond to 0, 3.6, 18, or 90 mg/kg-day aluminium. There was no reproductive or developmental toxicity at any dose level. The NOAELs for reproductive and developmental toxicity is 1,000 mg/kg-day, the highest dose tested (ECHA). [Kl. score = 1]

I. DERIVATION OF TOXICOLOGICAL REFERENCE AND DRINKING WATER GUIDANCE VALUES

Toxicological reference values were not derived for dialuminium chloride pentahydroxide.

The ADWG value for aluminium (acid-soluble) is 0.2 mg/L based on aesthetics. ADWG has concluded that there is insufficient data to set a guidance value based on health considerations (ADWG, 2011).

The ADWG value for chloride is 250 mg/L based on aesthetics (ADWG, 2011).

J. HUMAN HEALTH HAZARD ASSESSMENT OF PHYSICO-CHEMICAL PROPERTIES

Dialuminium chloride pentahydroxide does not exhibit the following physico-chemical properties:

- Explosivity
- Flammability
- Oxidizing potential

7. ENVIRONMENTAL EFFECTS SUMMARY

A. Summary

In the aquatic environment, aluminium compound toxicity is intimately related to ambient pH; changes in ambient acidity may affect aluminium compound solubility, dissolved aluminium compound speciation, and organism sensitivity to aluminium compounds. Toxicity testing on a similar aluminium salt compound identified a low toxicity concern for terrestrial invertebrates.

B. Aquatic Toxicity

Acute Studies on Aluminium Polychlorohydrate

Table 4 lists the results of acute aquatic toxicity studies conducted on aluminium salts.

Table 4 Acute Aquatic Toxicity Studies on Aluminium Salts

Test Species	Endpoint	Results (mg/L)	Klimisch Score	Reference
Zebrafish *(Danio rerio)*	96-hr LC_{10}	142 nominal (as Dis Al 0.58)	2	ECHA
Zebrafish	96-hr LC_{50}	186 nominal (as Dis Al 1.39)	2	ECHA
Zebrafish	96-hr EC_{50}	>0.357* as Dis Al	1	ECHA
Water Flea *(Daphnia magna)*	48-hr EC_{50}	98 nominal (as Dis Al <0.1)**	2	ECHA
Water Flea	48-hr EC_{50}	38*** nominal (as Dis Al 1.26)	2	ECHA
Pseudokidrchneriella subcapitata	72-hr EC_{50} growth rate	14 nominal (as Dis Al 0.24)	1	ECHA

*NOEC was >1,000 mg/L. pH of the test media was maintained at 7.5.
**Toxicity is driven by other causes than dissolved aluminium
*** Value for dialuminium chloride pentahydroxide.

The pH significantly alters the speciation and therefore bioavailability of the aluminium such that acutely toxic concentrations occur below a pH of 6 but that above 6 the bioavailable concentration necessary to achieve immobilisation in an acute study cannot be achieved (ECHA).

Data used by ANZECC for Aluminium water quality guideline

In developing a water quality guideline for aluminium (ANZECC 2000), ANZECC separated the screened freshwater toxicity data into those conducted at pH >6.5 and those at pH <6.5. These data are summarised below (it should be noted that only the acute toxicity data was used to derive a water quality guideline):

Freshwater pH >6.5:

Fish

The 48-96 hour LC_{50} values for 5 species were 600 to 106,000 µg/L (the lowest value was for *Salmo salar*). The chronic 8- to 28-day NOEC equivalents[1] from seven species were 34-7,100 µg/L. The lowest measured chronic value was an 8-day LC_{50} for *Micropterus* species of 170 µg/L.

Amphibian

The 96-hour LC_{50} values for *Bufo americanus* were 860-1,660 µg/L. The chronic 8-day LC_{50} for *Bufo americanus* was 2,280 µg/L.

Crustacean

The 48-hour LC_{50} values for one species were 2,300-36,900 µg/L. The chronic 7- to 28-day NOECs were 136-1,720 µg/L.

Algae

The 96-hour EC_{50} values were 460-570 µg/L based on population growth. The NOECs for two species were 800-2,000 µg/L.

Freshwater pH<6.5 (all between pH 4.5 and 6.0):

Fish

The 24-96-hour LC_{50} values for two species were 15-4,200 µg/L (the lowest value was for *Salmo trutta*). The 21- to 42-day LC_{50} values were 15-105 µg/L.

Amphibian

The 96- to 120-day LC_{50} values were 540-2,670 µg/L; the absolute range was 400-5,200 µg/L.

Algae

The NOEC from one species was 2,000 µg/L based on growth.

[1]Chronic toxicity values were a mixture of LC/EC_{50} LOEC, MATC, and NOEC values; where stated, these were converted to NOEC equivalents.

C. Terrestrial Toxicity

A study equivalent to the earthworm acute toxicity (OECD TG 207) test was conducted on sulfuric acid, aluminium salt (3:2), octadecahydrate (CAS No. 7784-31-8). The 14-day LC_{50} to earthworm *Eisenia andre*i was 316 mg/kg soil dry weight (van Gestel and Hoogerwerf, 2001; ECHA). [Kl. score = 2]

D. Calculation of PNEC

PNEC water

The ANZECC water quality guideline (2000) used acute and chronic laboratory toxicity data for the derivation of trigger values for aluminium. The guideline for freshwater is: *"A freshwater moderate reliability trigger value of 55 µg/L for aluminium at pH >6.5 using the statistical distribution method (Burr distribution as modified by SCIRO, Section 8.3.3.3) with 95% protection and an ACR of 8.2.*

"A freshwater low-reliability trigger value of 0.8 µg/L was derived for aluminium at pH of <6.5 using an AF of 20 (essential element) on the low pH trout figure."

"The low-reliability figures should only be used as indicative interim working levels."

PNEC sediment

No experimental toxicity data on sediment organisms are available. K_{ow} and K_{oc} parameters do not readily apply to inorganics, such as dialuminium chloride pentahydroxide. Thus, the equilibrium partitioning method cannot be used to calculate the $PNEC_{sed}$. Based on its properties, no adsorption of dialuminium chloride pentahydroxide to sediment is to be expected, and the assessment of this compartment will be covered by the aquatic assessment.

PNEC soil

No experimental toxicity data on soil organisms are available. The environmental distribution of dialuminium chloride pentahydroxide is dominated by its water solubility. Sorption of dialuminium chloride pentahydroxide should probably be regarded as a reversible situation, *i.e.*, the substance is not tightly nor permanently bound. K_{oc} and K_{ow} parameters do not readily apply to inorganics, such as dialuminium chloride pentahydroxide. Thus, the equilibrium partitioning methods cannot be used to calculate the $PNEC_{soil}$. Based on its properties, dialuminium chloride pentahydroxide is not expected to significantly adsorb to soil, and the assessment of this compartment will be covered by the aquatic assessment.

8. CATEGORISATION AND OTHER CHARACTERISTICS OF CONCERN

A. PBT Categorisation

The methodology for the Persistent, Bioaccumulative and Toxic (PBT) substances assessment is based on the Australian and EU Reach Criteria methodology (DEWHA, 2009; ECHA, 2008).

Dialuminium chloride pentahydroxide is an inorganic compound that dissociates in water to form chloride ions and various species of aluminium hydroxide hydrolysis. Biodegradation is not applicable to dialuminium chloride pentahydroxide. Both chloride ions and aluminium hydroxide ionic species can be found naturally in the environment. For the purposes of this PBT assessment, the persistent criteria are not considered applicable to this inorganic compound.

Fish accumulate aluminium in and on the gill, and it has been suggested that the rate of transfer of aluminium into the body is either slow or negligible under natural environmental conditions. Chloride ions are essential to all living organisms, and their intracellular, and extracellular concentrations are actively regulated. Thus, dialuminium chloride pentahydroxide and its dissociated ions are not expected to meet the criteria for bioaccumulation.

The lowest chronic NOEC value in fish for aluminium is <0.1 mg/L; thus, the dissolved aluminium from dialuminium chloride pentahydroxide meets the screening criteria for toxicity.

The overall conclusion is that dialuminium chloride pentahydroxide is not a PBT substance.

B. Other Characteristics of Concern

No other characteristics of concern were identified for dialuminium chloride pentahydroxide.

9. SCREENING ASSESSMENT

Chemical Name	CAS No.	Overall PBT Assessment [1]	Chemical Databases of Concern Assessment Step		Persistence Assessment Step		Bioaccumulative Assessment Step	Toxicity Assessment Step			Risk Assessment Actions Required[3]
			Listed as a COC on relevant databases?	Identified as Polymer of Low Concern	P criteria fulfilled?	Other P Concerns	B criteria fulfilled?	T criteria fulfilled?	Acute Toxicity [2]	Chronic Toxicity[2]	
Dialuminium Chloride Pentahydroxide	12042-91-0	Not a PBT	No	No	NA		No	Yes	3	1	3

Footnotes:

1 - PBT Assessment based on PBT Framework.

2 - Acute and chronic aquatic toxicity evaluated consistent with assessment criteria (see Framework).

3 - Tier 3 - Quantitative Risk Assessment: Complete PBT, qualitative and quantitative assessment of risk.

Notes:

NA = Not Applicable

PBT = Persistent, Bioaccumulative and Toxic

B = bioaccumulative

P = persistent

T = toxic

10. REFERENCES, ABBREVIATIONS AND ACRONYMS

A. References

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B. Abbreviations and Acronyms

°C	degrees Celsius
ADWG	Australian Drinking Water Guidelines
DEWHA	Department of the Environment, Water, Heritage and the Arts
EC	effective concentration
ECHA	European Chemicals Agency
EU	European Union
GHS	Globally Harmonised System of Classification and Labelling of Chemicals
HHRA	enHealth Human Risk Assessment
IUPAC	International Union of Pure and Applied Chemistry
Kl	Klimisch scoring system
LOAEL	lowest observed adverse effect level
mg/kg	milligrams per kilogram
mg/L	milligrammes per litre
mg/m^3	milligrammes per cubic metre
MW	molecular weight
NICNAS	The National Industrial Chemicals Notification and Assessment Scheme
NOAEC	No Observed Adverse Effect Concentration
NOAEL	no observed adverse effect level
NOEC	no observed effective concentration
OECD	Organisation for Economic Co-operation and Development
PBT	Persistent, Bioaccumulative and Toxic
PNEC	Predicted No Effect Concentration

ppm	parts per million
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
RfD	Reference Dose
SDS	Material Safety Data Sheet
SMILES	simplified molecular-input line-entry system
TGD	Technical Guidance Document
USEPA	United States Environmental Protection Agency
UVCB Materials	Unknown or Variable Composition, Complex Reaction Products and Biological
WHO	World Health Organisation
µm	micrometre

Appendix 6 – Example Tier 2 Qualitative Risk Assessment

Qualitative Tier 2 Assessment Example

PolyDADMAC

Consistent with the assessment framework, the assessment for a Tier 2 chemical includes the following components: completing the screening; developing a risk assessment dossier and Predicted No-Effects Concentrations (PNECs) for water and soil; and, providing a qualitative discussion of risk. Each of these components is detailed within this attachment.

Background

Cationic polymers are a component in a Water Management Facility (WMF) product (MAK MFC1) used as a coagulant during oily water treatment. A safety data sheet (SDS) for the WMF product is included as **Attachment 5-1**. Process and usage information for this chemical is included in **Attachment 5-2** and summarized in **Table 5-1** below.

Table 5-1 Water Management Facility Chemicals

Proprietary Name	Chemical Name	CAS No.	Use	Approximate Quantity Stored On-Site (plant available storage)
MAK MFC1 (multi floc coagulant)	Cationic Polymer[a] Aluminium Hydroxychloride Water	n/a 1327-41-9 7732-18-5	Polymer / coagulant	2 x 1000 L (IBC)

[a] Identity unknown. Read-across to polydiallyldimethylammonium chloride [polyDADMAC (CAS No. 26062-79-3)].
CAS No = Chemical Abstracts Service Number
n/a = not available
IBC = intermediate bulk container
L = litre

As noted above and detailed in the SDS, the identity of the cationic polymer in the vendor product is unknown. Therefore, a read-across to polyDADMAC (CAS RN 26062-79-3)[1] was conducted for this assessment. Information compiled for polyDADMAC is provided in the risk assessment dossier included as **Attachment 5-3**. Results of the screening assessment are included in the dossier.

The assessment of toxicity of this chemical was used to develop initial screening criteria for human health exposure scenarios and is presented in **Attachment 5-3**. PolyDADMAC is not a carcinogen; and, as a result, only a non-carcinogenic oral RfD was calculated. A detailed discussion of the derivation of the oral reference dose and drinking water guideline values is presented in the attachment. **Table 5-2** below provides a summary of the derivation.

[1] CAS RN - Chemical Abstracts Service Registry Number

Table 5-2 Oral Reference Doses and Derived Drinking Water Guidelines

Constituent (CAS No.)	Study	Critical Effect/ Target Organ(s)	NOAEL (mg/kg-day)	Uncertainty Factors	Oral Reference Dose (mg/kg-day)	Drinking Water Guideline (mg/L)
WMF Chemicals						
Cationic polymer[a]	6-month rat dietary study	None	2,000	300	7	23

Notes:
Refer to **Attachment 5-3** for information on the key studies selected for oral reference dose and drinking water level development.
CAS = Chemical Abstracts Service
NOAEL = No observed adverse effect level
a Identity unknown. Read-across to polydiallyldimethylammonium chloride [polyDADMAC] (CAS No. 26062-79-3).

For ecological receptors, the assessment utilises the information presented in the dossiers on the relative toxicity of the aquatic and terrestrial flora and fauna to the chemical. This assessment focuses on the aquatic invertebrate and fish species within the surface water resources, and the soil flora and fauna associated with releases to the soil.

The determination of toxicity reference values (TRVs) was conducted according to the PNEC guidance in the *Environmental Risk Assessment Guidance Manual for Industrial Chemicals* prepared by the Australian Environmental Agency (AEA, 2009). PNECs for freshwater and sediment were developed to assess aquatic receptors, and PNECs for soil were developed for terrestrial receptors.

Table 5-3 present the chemical, the endpoint, no observable effects concentration (NOEC) (mg/L), assessment factor, and the aquatic PNEC (mg/L). A PNEC for soil was not calculated for the chemical. Refer to **Attachment 5-3** and the dossier regarding the development of PNECs, or the rational for PNECs that do not have a calculated PNEC.

Table 5-3 PNECs Water

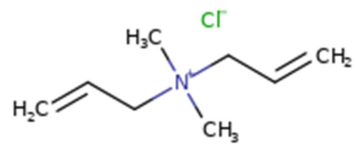
Constituents	Endpoint	$E(L)C_{50}$ or NOEC (mg/L)	Assessment Factor	$PNEC_{water}$ (mg/L)
WMF Chemicals				
Cationic polymer[a]	Acute fish	6.5	50	0.13

[a] Identity unknown. Read-across to polydiallyldimethylammonium chloride [polyDADMAC (CAS No. 26062-79-3).
$E(L)C_{50}$ = effects/level concentration – 50%
NOEC = no observable effects concentration
PNEC = predicted no effect concentration
Refer to **Attachment 5-3** for information on the development of PNECs listed above.

A detailed assessment of the risks posed by this Tier 2 chemical is provided in the following sections.

General Overview

PolyDADMAC is a highly charged cationic homopolymer with high molecular weights; those used in water treatment may have molecular weights less than 500,000 (Lyons and Vasconcellos, 1997). The molecular structure of polyDADMAC is presented in **Figure 5-1** below.



(monomer shown)

Figure 5-1 Molecular Structure of PolyDADMAC[2]

Synthetic polymers are persistent in the environment. They are expected to be poorly biodegraded, and adsorption would be expected to be the primary process that determines its ecological concentrations and mobility (Lyons and Vasconcellos, 1997). As a cationic polymer, polyDADMAC will rapidly react with many kinds of naturally occurring substances, such as humic acids, lignins, silts, and clays (Lyons and Vasconcellos, 1997). Due to its physical properties (i.e., molecular size and partitioning behaviour), polyDADMAC is not expected to bioaccumulate.

The PBT assessment for polyDADMAC is included in the dossier provided in **Attachment 5-3**. Based on physico-chemical properties and screening data detailed below, the overall conclusion was that polyDADMAC is not a PBT substance.

Human Health Hazards

There is a low concern for human health hazards. PolyDADMAC is not acutely toxic to humans by the oral route (LD50 > 5,000 mg/kg bw)[3]. Likewise, there are no adverse effects observed from repeated exposures through ingestion (lowest observed adverse effect level [LOAEL] of 1,000 milligrams per kilogram per day (mg/kg-day), a no observed adverse effect level [NOAEL] was not established).

During the water treatment, water conveyance and beneficial reuse processes, there is the potential for human receptors to be exposed to water treatment chemicals. Based on an assessment of land use and an understanding of the project description provided in the Environmental Impact Statement (URS, 2014), likely human exposure would include:

1. Workers at the WMF including operators, maintenance staff and supervisors.
2. First responders in contact with releases whilst responding to emergencies either at the WMF or along the transport or conveyance routes.
3. Trespassers who stray (either advertently or inadvertently) onto the WMF during operations. Trespassers would also have access to the road network and surface water features that receive runoff and/or releases from transportation accidents or site-related releases.
4. Agricultural workers/residents who have access to the road network; this cohort would also have access to surface water features that receive runoff and/or releases from conveyance or transportation related or site-related releases.
5. Agricultural workers at irrigation areas.
6. Recreational users who have access to areas adjacent to the road network. Recreational users would also have access to surface water features that receive runoff and/or releases from conveyance / transportation related or site-related releases.

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[2] Source https://chem.nlm.nih.gov/chemidplus/rn/26062-79-3

[3] LD50 = lethal dose of 50 percent of population; mg/kg bw – milligrams per kilogram body weight

Based on the treatment process described in **Attachment 5-2**, the cationic polymers would be bound to the solids present in the oily water and removed during clarification. As a result, this chemical would not be present in permeate, brine or treated water. Therefore, exposure pathways associated with the beneficial reuse of treated water and management of brine waste would be incomplete. Beneficial reuse of treated water includes project reuse (dust suppression, construction activities, drilling and completions), irrigation and stock watering.

Exposure of potential human receptors to polyDADMAC is possible via inadvertent spills and leaks. In terms of risks associated with transport of chemicals and wastes, this risk is considered to be managed to a level as low as reasonably practicable. This is because the potential for a release is controlled through implementation of a traffic management plan including use of designated trucking routes, vehicle signage, vehicle management systems (to manage speed and driving behaviour/habits) and in the unlikely event of a vehicular accident, implementation of incident and spill response procedures.

The management of chemicals and wastes is conducted using drums, totes and engineered tanks designed to contain the fluids. In the unlikely event of a release to ground, the potential for exposures (other than workers) is limited. The WMF is fenced and access is controlled, which limits access to the public. If water treatment chemicals are spilled to the ground then investigation, remediation and rehabilitation activities would be implemented to address soil impacts.

Lastly, chemical exposures to workers are controlled through engineering, management controls and personal protective equipment, which are focused on elimination and mitigation of the potential for dermal contact and potential for incidental ingestion.

As a result, potential exposures during treatment activities are low due to the employment of mechanical equipment/processes and engineering controls (including secondary containment). In addition, Australia SafeWork Place and Santos Occupational Safety Guidance are used to minimise human health exposure. Similarly, there is a low potential for human receptors exposed to surface water bodies that may receive runoff from an accidental release during transport, use or storage. Finally, the probability of any surface related discharge infiltrating subsurface soils and migrating to groundwater is very low and any exposures would be incomplete.

PolyDADMAC is listed in Attachment B (Substances Considered Not To Require Control By Scheduling) of the *Standard for the Uniform Scheduling of Medicines and Poisons* (SUSMP) (Therapeutic Goods Administration [TGA] 2014). The reason given for listing in Attachment B is 'Low Toxicity' and the area of use of the chemical is 'Water treatment' (NICNAS, 2017a). NICNAS identified polyDADMAC as a low concern for workers and the public under the operational scenarios assessed. Best practice chemical management was recommended to minimise worker and public exposure (NICNAS, 2017a).

Environmental Hazards

In standard acute aquatic toxicity tests, polyDADMAC, as a highly charged cationic polymer, is very toxic to aquatic life. PolyDADMAC will dissociate into polyammonium cations and chloride anions in the aquatic environment. Chloride ions are an essential constituent of electrolytes in all biological fluids responsible for maintaining acid/base balance, transmitting nerve impulses and regulating fluid in and out of cells (NCBI, 2015). The concentration of chloride ions is naturally regulated within organisms. Therefore, the toxicity of cationic polymers to fish is from the binding of the polyammonium cations in the polymer to the gill tissue, disrupting gill structure and function. Physical damage to fish gill by cationic polymers has been shown by Beisinger and Stokes (1986).

However, under environmental conditions, the toxicity of these polymers is mitigated by the presence of dissolved organic carbon (DOC) and suspended solids. Cationic polymers react with DOC in environmental waters to form insoluble complexes, which settle out of water and therefore are not bioavailable to cause toxic effects. It has previously been established that a reduction in likely toxicity by a factor of 110 is appropriate to apply to laboratory test results for cationic polymers with a high charge density to account for the mitigating effects of DOC on toxicity in natural environmental waters (Boethling and Nabholz 1997). In addition, based on engineering and management controls outlined in the previous section, there is a low potential for ecological receptors exposed to surface water bodies that may receive runoff from an accidental release during transport, use or storage. As discussed earlier, exposure pathways associated with the beneficial reuse of treated water and management of brine waste would be incomplete.

These findings are consistent with an assessment completed by NICNAS in 2017. Based on an assessment of environmental hazards, NICNAS identified polyDADMAC as a chemical of low concern to the environment (NICNAS, 2017b). Chemicals of low concern are unlikely to have adverse environmental effects if they are released to the environment from coal seam gas operations.

References

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Attachment 5-1 Safety Data Sheet

SAFETY DATA SHEET

1. IDENTIFICATION OF THE MATERIAL AND SUPPLIER

1.1 Product identifier

Product name	**MAK-MFC1**
Synonym(s)	MAK MFC1

1.2 Uses and uses advised against

Use(s)	WASTE WATER COAGULANT

1.3 Details of the supplier of the product

Supplier name	**MAK INDUSTRIAL WATER SOLUTIONS PTY LTD**
Address	2/24 Mercantile Way, Malaga, Western Australia, 6090, AUSTRALIA
Telephone	+61 8 9249 8007
Fax	+61 8 9249 8004
Email	service.wa@makwater.com.au
Website	http://makwater.com.au

1.4 Emergency telephone number(s)

Emergency	+61 8 9249 8007

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

CLASSIFIED AS HAZARDOUS ACCORDING TO SAFE WORK AUSTRALIA CRITERIA

GHS classification(s)	Serious Eye Damage / Eye Irritation: Category 2A Skin Corrosion/Irritation: Category 2

2.2 Label elements

Signal word	**WARNING**

Pictogram(s)

Hazard statement(s)

H315	Causes skin irritation.
H319	Causes serious eye irritation.

Prevention statement(s)

P264	Wash thoroughly after handling.
P280	Wear protective gloves/protective clothing/eye protection/face protection.

Response statement(s)

P302 + P352	IF ON SKIN: Wash with plenty of soap and water.
P305 + P351 + P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P321	Specific treatment is advised - see first aid instructions.
P332 + P337 + P313	If skin or eye irritation occurs: Get medical advice/ attention.
P362	Take off contaminated clothing and wash before re-use.

Storage statement(s)

None allocated.

Disposal statement(s)

None allocated.

2.3 Other hazards

No information provided.

3. COMPOSITION/ INFORMATION ON INGREDIENTS

3.1 Substances / Mixtures

Ingredient	CAS Number	EC Number	Content
ALUMINUM HYDROXYCHLORIDE	1324-41-9	-	40 to 60%
WATER	7732-18-5	231-791-2	20 to 60%
PROPRIETARY INGREDIENT(S)	-	-	20 to 40%

4. FIRST AID MEASURES

4.1 Description of first aid measures

Eye If in eyes, hold eyelids apart and flush continuously with running water. Continue flushing until advised to stop by a Poisons Information Centre, a doctor, or for at least 15 minutes.

Inhalation If inhaled, remove from contaminated area. Apply artificial respiration if not breathing.

Skin If skin or hair contact occurs, remove contaminated clothing and flush skin and hair with running water. Continue flushing with water until advised to stop by a Poisons Information Centre or a doctor.

Ingestion For advice, contact a Poison Information Centre on 13 11 26 (Australia Wide) or a doctor (at once). If swallowed, do not induce vomiting.

First aid facilities Eye wash facilities and safety shower are recommended.

4.2 Most important symptoms and effects, both acute and delayed

Irritating to the eyes and skin.

4.3 Immediate medical attention and special treatment needed

Treat symptomatically.

5. FIRE FIGHTING MEASURES

5.1 Extinguishing media

Use an extinguishing agent suitable for the surrounding fire.

5.2 Special hazards arising from the substance or mixture

Non flammable. May evolve toxic gases if strongly heated.

5.3 Advice for firefighters

Treat as per requirements for surrounding fires. Evacuate area and contact emergency services. Remain upwind and notify those downwind of hazard. Wear full protective equipment including Self Contained Breathing Apparatus (SCBA) when combating fire. Use waterfog to cool intact containers and nearby storage areas.

5.4 Hazchem code

None allocated.

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures

Wear Personal Protective Equipment (PPE) as detailed in section 8 of the SDS.

6.2 Environmental precautions

Prevent product from entering drains and waterways.

6.3 Methods of cleaning up

Contain spillage, then cover / absorb spill with non-combustible absorbent material (vermiculite, sand, or similar), collect and place in suitable containers for disposal.

6.4 Reference to other sections

See Sections 8 and 13 for exposure controls and disposal.

7. HANDLING AND STORAGE

7.1 Precautions for safe handling

Before use carefully read the product label. Use of safe work practices are recommended to avoid eye or skin contact and inhalation. Observe good personal hygiene, including washing hands before eating. Prohibit eating, drinking and smoking in contaminated areas.

7.2 Conditions for safe storage, including any incompatibilities

Store in a cool, dry, well ventilated area, removed from incompatible substances and foodstuffs. Ensure containers are adequately labelled, protected from physical damage and sealed when not in use. Check regularly for leaks or spills.

7.3 Specific end use(s)

No information provided.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

8.1 Control parameters

Exposure standards

No exposure standards have been entered for this product.

Biological limits

No biological limit values have been entered for this product.

8.2 Exposure controls

Engineering controls Avoid inhalation. Use in well ventilated areas. Maintain vapour levels below the recommended exposure standard.

PPE

Eye / Face	Wear splash-proof goggles.
Hands	Wear PVC or rubber gloves.
Body	When using large quantities or where heavy contamination is likely, wear coveralls.
Respiratory	Not required under normal conditions of use.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

Appearance	CLEAR TO SLIGHTLY HAZY LIQUID
Odour	SLIGHT ODOUR
Flammability	NON FLAMMABLE
Flash point	NOT RELEVANT
Boiling point	100°C
Melting point	NOT AVAILABLE
Evaporation rate	NOT RELEVANT
pH	3.5 to 4.0 (neat)
Vapour density	NOT AVAILABLE
Specific gravity	1.33 to 1.35
Solubility (water)	SOLUBLE
Vapour pressure	NOT AVAILABLE
Upper explosion limit	NOT RELEVANT
Lower explosion limit	NOT RELEVANT
Partition coefficient	NOT AVAILABLE
Autoignition temperature	NOT AVAILABLE
Decomposition temperature	NOT AVAILABLE

9.1 Information on basic physical and chemical properties

Viscosity	NOT AVAILABLE
Explosive properties	NOT AVAILABLE
Oxidising properties	NOT AVAILABLE
Odour threshold	NOT AVAILABLE

9.2 Other information

% Volatiles	50 %

10. STABILITY AND REACTIVITY

10.1 Reactivity

May evolve chlorine gas when in contact with very strong oxidising agents. There is some heat liberated when in contact with strong acids.

10.2 Chemical stability

Stable under recommended conditions of storage.

10.3 Possibility of hazardous reactions

Polymerization is not expected to occur.

10.4 Conditions to avoid

Avoid heat, sparks, open flames and other ignition sources.

10.5 Incompatible materials

Incompatible with oxidising agents (e.g. hypochlorites) and acids (e.g. nitric acid).

10.6 Hazardous decomposition products

Severe overheating may release hydrogen chloride gas and aluminium oxides once water has evaporated.

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Health hazard summary	Irritant. This product has the potential to cause adverse health effects with over exposure. Use safe work practices to avoid eye or skin contact and inhalation. Over exposure may result in irritation to the eyes, skin and respiratory system.
Eye	Irritant. Contact may result in irritation, lacrimation, pain and redness. May result in burns with prolonged contact.
Inhalation	Low to moderate irritant. Over exposure may result in irritation of the nose and throat, coughing, dizziness and headache.
Skin	Irritant. Contact may result in irritation, redness, rash and dermatitis. Prolonged or repeated contact may result in burns.
Ingestion	May be harmful. Ingestion may result in gastrointestinal irritation, nausea, vomiting, abdominal pain and diarrhoea.
Toxicity data	No LD50 data available for this product.

12. ECOLOGICAL INFORMATION

12.1 Toxicity

Not a persistent pollutant; can cause coagulation of solids in aqueous suspension, especially when highly diluted by the water in which the solids are suspended. Aluminium compounds are common in most soils and are the principle components of Bauxite and Gibbsite, which are common, naturally occurring minerals. When diluted by copious quantities of water (for example, to the point that the concentration is less than about 100 grams per cubic meter), this product will hydrolyse rapidly to form aluminium hydroxide, which can be expected to become a part of the natural soil profile if not recovered. When not highly diluted with water, this product may be slow to hydrolyse and may form a mixture of partially soluble aluminium species and heavy floc of aluminium hydroxide. Until further diluted, this mixture could affect marine life by clogging sensitive respiratory mechanisms in a similar fashion to muds and clays and possibly by toxic effects that are not yet well understood.

12.2 Persistence and degradability

No information provided.

12.3 Bioaccumulative potential

No information provided.

12.4 Mobility in soil

No information provided.

12.5 Other adverse effects

No information provided.

13. DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Waste disposal For small amounts, absorb with sand, vermiculite or similar and dispose of to an approved landfill site. Contact the manufacturer/supplier for additional information if disposing of large quantities (if required). Prevent contamination of drains and waterways as aquatic life may be threatened and environmental damage may result. This product can be neutralised with alkali to form a mixture of aluminium hydroxide and the chloride salt of the alkali. The resulting mixture is non-hazardous providing the resulting pH is between roughly 5 and 10.

Legislation Dispose of in accordance with relevant local legislation.

14. TRANSPORT INFORMATION

NOT CLASSIFIED AS A DANGEROUS GOOD BY THE CRITERIA OF THE ADG CODE, IMDG OR IATA

	LAND TRANSPORT (ADG)	SEA TRANSPORT (IMDG / IMO)	AIR TRANSPORT (IATA / ICAO)
14.1 UN Number	None Allocated	None Allocated	None Allocated
14.2 Proper Shipping Name	None Allocated	None Allocated	None Allocated
14.3 Transport hazard class	None Allocated	None Allocated	None Allocated
14.4 Packing Group	None Allocated	None Allocated	None Allocated

14.5 Environmental hazards No information provided

14.6 Special precautions for user

Hazchem code None Allocated

Other information There is a possibility that this product could be contained in a reagent set or kit composed of various compatible dangerous goods. If the item is part of a set or kit, the classification would change to the following: UN3316 Chemical Kit, Class 9, PG II or III.

15. REGULATORY INFORMATION

15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture

Poison schedule A poison schedule number has not been allocated to this product using the criteria in the Standard for the Uniform Scheduling of Medicines and Poisons (SUSMP).

Classifications Safework Australia criteria is based on the Globally Harmonised System (GHS) of Classification and Labelling of Chemicals.

The classifications and phrases listed below are based on the Approved Criteria for Classifying Hazardous Substances [NOHSC: 1008(2004)].

Hazard codes	Xi	Irritant
Risk phrases	R36/38	Irritating to eyes and skin.
Safety phrases	S24/25	Avoid contact with skin and eyes.
	S36/37/39	Wear suitable protective clothing, gloves and eye/face protection.

Inventory listing(s) **AUSTRALIA: AICS (Australian Inventory of Chemical Substances)**
All components are listed on AICS, or are exempt.
UNITED STATES: TSCA (US Toxic Substances Control Act)
All components are listed on the TSCA inventory, or are exempt.

16. OTHER INFORMATION

Additional information

PERSONAL PROTECTIVE EQUIPMENT GUIDELINES:
The recommendation for protective equipment contained within this report is provided as a guide only. Factors such as method of application, working environment, quantity used, product concentration and the availability of engineering controls should be considered before final selection of personal protective equipment is made.

HEALTH EFFECTS FROM EXPOSURE:
It should be noted that the effects from exposure to this product will depend on several factors including: frequency and duration of use; quantity used; effectiveness of control measures; protective equipment used and method of application. Given that it is impractical to prepare a ChemAlert report which would encompass all possible scenarios, it is anticipated that users will assess the risks and apply control methods where appropriate.

Abbreviations

ACGIH	American Conference of Governmental Industrial Hygienists
CAS #	Chemical Abstract Service number - used to uniquely identify chemical compounds
CNS	Central Nervous System
EC No.	EC No - European Community Number
GHS	Globally Harmonized System
IARC	International Agency for Research on Cancer
LC50	Lethal Concentration, 50% / Median Lethal Concentration
LD50	Lethal Dose, 50% / Median Lethal Dose
mg/m^3	Milligrams per Cubic Metre
OEL	Occupational Exposure Limit
pH	relates to hydrogen ion concentration using a scale of 0 (high acidic) to 14 (highly alkaline).
ppm	Parts Per Million
STEL	Short-Term Exposure Limit
STOT-RE	Specific target organ toxicity (repeated exposure)
STOT-SE	Specific target organ toxicity (single exposure)
SUSMP	Standard for the Uniform Scheduling of Medicines and Poisons
SWA	Safe Work Australia
TLV	Threshold Limit Value
TWA	Time Weighted Average

Revision history

Revision	Description
1.1	Standard SDS Review.
1.0	Converted to GHS.
0.2	Standard SDS Review

Report status

This document has been compiled by RMT on behalf of the manufacturer, importer or supplier of the product and serves as their Safety Data Sheet ('SDS').

It is based on information concerning the product which has been provided to RMT by the manufacturer, importer or supplier or obtained from third party sources and is believed to represent the current state of knowledge as to the appropriate safety and handling precautions for the product at the time of issue. Further clarification regarding any aspect of the product should be obtained directly from the manufacturer, importer or supplier.

While RMT has taken all due care to include accurate and up-to-date information in this SDS, it does not provide any warranty as to accuracy or completeness. As far as lawfully possible, RMT accepts no liability for any loss, injury or damage (including consequential loss) which may be suffered or incurred by any person as a consequence of their reliance on the information contained in this SDS.

Prepared by

Risk Management Technologies
5 Ventnor Ave, West Perth
Western Australia 6005
Phone: +61 8 9322 1711
Fax: +61 8 9322 1794
Email: info@rmt.com.au
Web: www.rmt.com.au.

Revision: 1.1
SDS date: 19 January 2015

[End of SDS]

Attachment 5-2 Vendor WMF Chemicals and EPC

Attachment 5-2
Summary of Exposure Point Concentration Development
(Water Treatment Chemicals)

Product Name	Chemical Name	CAS Number	%	Proper Shipping Name	Supplier	Area	Transport		Onsite Storage		Operation	
							mass/volume	concentration	mass/volume	concentration	mass/volume	concentration
MAK MFC1 (multi floc coagulant)	Cationic Polymer	n/a	20-40%	MAK MFC1	MAK Water Industrial	Oily Water Treatment Plant	1000L IBC		2 x 1000L (IBC)		0.8mg/L (AVG)	
	Aluminium Hydroxychloride	1327-41-9	40-60%									
	Water	7732-18-5	20-60%									

L = litres
mg/l = milligrams per litre
L/hr = litre per hour
AVG = average
mg/kg = milograms per kilogram
NA = not applicable

Attachment 5-2
Summary of Exposure Point Concentration Development
(Water Treatment Chemicals)

Product Name	Chemical Name	CAS Number	Annual Usage (ROP volumes based on peak rate of 10ML/d)	Purpose / Function	Fate	Assumed Chemical % For Transportation Release Scenario	Assumed Release Volume for Transportation Release Scenario	Transport Release Surface Water Concentration (mg/l)		
						%	L	100%	25%	5%
MAK MFC1 (multi floc coagulant)	Cationic Polymer	n/a		polymer / coagulant	Removed with oily water sludge (solid waste)	30%	1000	300000	75000	15000
	Aluminium Hydroxychloride	1327-41-9				50%	1000	500000	125000	25000
	Water	7732-18-5				20%	NA	200000	NA	NA

L = litres
mg/l = milligrams per litre
L/hr = litre per hour
AVG = average
mg/kg = milograms per kilogram
NA = not applicable

Attachment 5-2
Summary of Exposure Point Concentration Development
(Water Treatment Chemicals)

Product Name	Chemical Name	CAS Number	Transport Release Soil Concentration (mg/kg)	Permeate Concentration		COPC concentration in soil from release of permeate	COPC concentration in soil from 20 years of irrigation
			100%	(mg/l)	Permeate notes	(mg/kg)	mg/kg
MAK MFC1 (multi floc coagulant)	Cationic Polymer	n/a	36	NA	Oily water is clarified to remove solids and oils then run through the RO system. The amount relative to flux of RO system is <1%. Therefore, the net on permeate quality is deminimis. Therefore, no concentration of chemical in this product in the permeate.	NA	NA
	Aluminium Hydroxychloride	1327-41-9	60	NA	Oily water is clarified to remove solids and oils then run through the RO system. The amount relative to flux of RO system is <1%. Therefore, the net on permeate quality is deminimis. Therefore, no concentration of chemical in this product in the permeate.	NA	NA
	Water	7732-18-5	NA	NA		NA	NA

L = litres
mg/l = milligrams per litre
L/hr = litre per hour
AVG = average
mg/kg = milograms per kilogram
NA = not applicable

Product Name	Chemical Name	CAS Number	Brine Concentration (mg/l)	Brine Notes
MAK MFC1 (multi floc coagulant)	Cationic Polymer	n/a	NA	The oily water is clarified to seperate solids and oils; then run through the RO system. Estimate 5% residual in brine, the balance is sludge.
	Aluminium Hydroxychloride	1327-41-9	NA	The oily water is clarified to seperate solids and oils; then run through the RO system. Estimate 5% residual in brine, the balance is sludge. Estimate that chemical will dissociate to aluminium (Al) and Cl- at 40% Al and 55% Cl-.
	Water	7732-18-5	NA	

L = litres
mg/l = milligrams per litre
L/hr = litre per hour
AVG = average
mg/kg = milograms per kilogram
NA = not applicable

Attachment 5-3 Risk Assessment Dossier

POLYDADMAC
[POLYDIALLYLDIMETHYLAMMONIUM CHLORIDE]

This dossier on polyDADMAC does not represent an exhaustive or critical review of all available data. Rather, it presents the most critical studies pertinent to the risk assessment of polyDADMAC in its use in water treatment systems. Where possible, study quality was evaluated using the Klimisch scoring system (Klimisch et al., 1997).

Screening Assessment Conclusion – PolyDADMAC was not identified in chemical databases used by NICNAS as an indicator that the chemical is of concern and is not a PBT substance. PolyDADMAC was assessed as a tier 2 chemical for acute and chronic toxicity. Therefore, polyDADMAC is classified overall as a ***tier 2*** *chemical and requires a hazard assessment and qualitative assessment of risk.*

1. BACKGROUND

Polydiallyldimethylammonium chloride (polyDADMAC) are highly charged cationic polymers with high molecular weights. They are expected to be poorly biodegraded, and adsorption would be expected to be the primary process that determines its ecological concentrations and mobility. As a cationic polymer, polyDADMAC will rapidly react with many kinds of naturally occurring substances, such as humic acids, lignins, silts, and clays. Due to its physical properties (i.e., molecular size), polyDADMAC is not expected to bioaccumulate. PolyDADMAC is not acutely toxic to humans by the oral route; nor does it exhibit any systemic toxicity from repeated exposures through ingestion. PolyDADMAC exhibits a moderate toxicity concern to aquatic organisms. The toxicity of these polymers is mitigated by the presence of dissolved organic carbon (DOC) and suspended solids. Cationic polymers react with DOC in environmental waters to form insoluble complexes, which settle out of water and therefore are not bioavailable to cause toxic effects.

2. CHEMICAL NAME AND IDENTIFICATION

Chemical Name: Polydiallyldimethylammonium chloride

CAS RN: 26062-79-3

Molecular formula: $(C_8H_{16}N.Cl)_x$-

Molecular weight: Variable

Synonyms: PolyDADMAC; 2-Propen-1-aminium, N,N-dimethyl-N-2-propenyl-, chloride, homopolymer; Poly-2-propen-1-aminium, N,N-dimethyl-N-2-propenyl-, chloride; N-N-dimethyl-N-2-propenyl-2-propen-1-aminium chloride, homopolymer; poly-N,N-dimethyl-N-N-diallyammonium chloride; polyquaternium-6

3. PHYSICO-CHEMICAL PROPERTIES

PolyDADMAC are highly charged cationic homopolymers with high molecular weights; those used in water treatment may have molecular weights less than 500,000 (Lyons and Vasconcellos, 1997).

Limited information is available on the physico-chemical properties of polyDADMAC. The information contained in Table 1 is based on DADMAC (CAS No. 7398-69-8). PolyDADMAC is a homopolymer of DADMAC.

Table 1: Overview of the Physico-chemical Properties of DADMAC

Property	Value	Klimisch score	Reference
Physical state at 20°C and 101.3 kPa	Liquid	-	ECHA
Melting Point/Freezing Point	-25 °C	1	ECHA
Boiling Point	118 °C	1	ECHA
Density	1.03 – 1.05 g/cm^3 @ 25°C	1	ECHA
Partition Coefficient (log K_{ow})	Estimated to be -2.49 using KOWWIN	2	ECHA
Water Solubility	Estimated to be 1,000 g/L @ 25°C	2	ECHA
Auto flammability	Study scientifically not necessary	-	ECHA

4. DOMESTIC AND INTERNATIONAL REGULATORY INFORMATION

A review of international and national environmental regulatory information was undertaken. This chemical is listed on the Australian Inventory of Chemical Substances – AICS (Inventory). No conditions for its use were identified. PolyDADMAC is also listed in Appendix B (Substances Considered Not To Require Control By Scheduling) of the *Standard for the Uniform Scheduling of Medicines and Poisons* (SUSMP) (Therapeutic Goods Administration [TGA] 2014). The reason given for listing in Appendix B is 'Low Toxicity' and the area of use of the chemical is 'Water treatment' (NICNAS, 2017a). No other specific environmental regulatory controls or concerns were identified within Australia and internationally for polyDADMAC.

Table 2 Existing International Controls

Convention, Protocol or other international control	Listed Yes or No?
Montreal Protocol	No
Synthetic Greenhouse Gases (SGG)	No
Rotterdam Convention	No
Stockholm Convention	No
REACH (Substances of Very High Concern)	No
United States Endocrine Disrupter Screening Program	No
European Commission Endocrine Disruptors Strategy	No

5. ENVIRONMENTAL FATE SUMMARY

A. Summary

PolyDADMAC are highly charged cationic polymers with high molecular weights. They are expected to be poorly biodegraded, and adsorption would be expected to be the primary process that determines its ecological concentrations and mobility (Lyons and Vasconcellos, 1997). As a cationic polymer, polyDADMAC will rapidly react with many kinds of naturally occurring substances, such as humic acids, lignins, silts, and clays (Lyons and Vasconcellos, 1997).

PolyDADMAC will dissociate into polyammonium cations and chloride anions in the aquatic environment. Chloride ions are an essential constituent of electrolytes in all biological fluids responsible for maintaining acid/base balance, transmitting nerve impulses and regulating fluid in and out of cells (NCBI 2015). The concentration of chloride ions is naturally regulated within organisms. Therefore, consistent with NICAS (NICNAS, 2017b), this discussion is focused on the environmental fate and effects of the synthetic polyammonium cations.

B. Biodegradation

Due to its physical properties (i.e., molecular size), polyDADMAC is expected to be poorly degraded. This finding is consistent with DADMAC which is not readily biodegradable according to the OECD criteria (ECHA) [Kl. score = 1].

C. Bioaccumulation

Due to its physical properties (*i.e.*, molecular size), polyDADMAC is not expected to bioaccumulate.

6. HUMAN HEALTH HAZARD ASSESSMENT

A. Summary

PolyDADMAC is not acutely toxic by the oral route; nor does it exhibit any systemic toxicity from repeated exposures through ingestion.

B. Acute Toxicity

There were no deaths in rats given a single oral dose of 5,000 mg/kg polyDADMAC. The oral LD50 in rats is >5,000 mg/kg (EPA, 2016a).

C. Irritation

No studies were located.

D. Sensitisation

No studies were located.

E. Repeated Dose Toxicity

Oral

Male and female SD rats were fed in their diet 0, 1,000, or 2,000 mg/kg polyDADMAC for six months. There were no clinical signs of toxicity. Two low-dose males were sacrificed in a moribund condition, while one low-dose male and one high-dose male died during the exposure period. Feed consumption was significantly increased in the treated groups compared to controls. Body weight gain was significantly lower in the treated animals compared to the controls. Final body weights were significantly lower in all dose groups compared to controls (10.4% and 19.5% in males; 6.6% and 10% in females for the low- and high-dose groups, respectively). Hematology and clinical chemistry parameters and urinalysis showed no biologically significant differences between treated and control groups. Relative liver weights were decreased in the ≥1,000 mg/kg males and 2,000 mg/kg females. Relative heart weights were decreased in the 2,000 mg/kg (both sexes), and relative kidney weights were decreased in the 2,000 mg/kg males. The histopathologic examination showed no treatment-related changes in these organs. No other compound-related pathology was observed, although histopathologic effects were seen in the lungs and urinary tract in animals of all groups. The LOAEL for this study is 1,000 mg/kg-day based on reduced body weights and body weight gain; a NOAEL was not established (EPA, 2016b).

Inhalation

No studies were located.

Dermal

No studies were located.

F. Genotoxicity

No studies were located.

G. Carcinogenicity

No studies were located.

H. Reproductive Developmental Toxicity

No studies were located.

I. DERIVATION OF TOXICOLOGICAL REFERENCE AND DRINKING WATER GUIDANCE VALUES

The toxicological reference values developed for polyDADMAC follow the methodology discussed in enHealth (2012). The approach used to develop drinking water guidance values is described in the Australian Drinking Water Guidelines (ADWG, 2011).

Non-Cancer

PolyDADMAC was tested in a six-month rat feeding study. No target organs were identified and a NOAEL was not established. The LOAEL was 1,000 mg/kg-day based on reduced body weights and body weight gain. It is unclear from the limited data whether these changes in the treated animals are due to a direct or indirect effect of polyDADMAC. PolyDADMAC has a high molecular weight and would not be expected to be absorbed from the gastrointestinal tract. Feed consumption was significantly increased in the treated rats (both dose groups) even though body weights and body weight gain were reduced. A likely explanation for these findings is that the weight changes and feed consumption reflect the nutritional status of the treated animals due to the bulk presence of high levels of polymer in the feed and not to systemic toxicity. Given the absence of any other effects, it is proposed that the NOAEL for systemic toxicity in this study is 2,000 mg/kg-day, the highest dose tested.

The NOAEL of 2,000 mg/kg-day will be used for determining the oral Reference Dose (RfD) and the drinking water guidance value.

Oral Reference Dose (oral RfD)

Oral RfD = NOAEL / (UF_A x UF_H x UF_L x UF_{Sub} x UF_D)

Where:

UF_A (interspecies variability) = 10
UF_H (intraspecies variability) = 10
UF_L (LOAEL to NOAEL) = 1
UF_{Sub} (subchronic to chronic) = 3
UF_D (database uncertainty) = 1

Oral RfD = 2,000/(10 x 10 x 1 x 3 x 1) = 2,000/300 = 7 mg/kg-day

Drinking water guidance value

Drinking water guidance value = (animal dose) x (human weight) x (proportion of intake from water) / (volume of water consumed) x (safety factor)

Using the oral RfD,

Drinking water guidance value = (oral RfD) x (human weight) x (proportion of water consumed) / (volume of water consumed)

Where:

Human weight = 70 kg (ADWG, 2011)
Proportion of water consumed = 10% (ADWG, 2011)
Volume of water consumed = 2L (ADWG, 2011)

Drinking water guidance value = (6.7 x 70 x 0.1)/2 = 23 mg/L

Cancer

No carcinogenicity studies were located; thus, a cancer reference value was not derived.

J. HUMAN HEALTH HAZARD ASSESSMENT OF PHYSICO-CHEMICAL PROPERTIES

PolyDADMAC does not exhibit the following physico-chemical properties:

- Explosivity
- Flammability
- Oxidizing potential

7. ENVIRONMENTAL EFFECTS SUMMARY

A. Summary

PolyDADMAC exhibits a moderate toxicity concern to aquatic organisms. However, under environmental conditions, the toxicity of these polymers is mitigated by the presence of DOC and suspended solids. Cationic polymers react with DOC in environmental waters to form insoluble complexes, which settle out of water and therefore are not bioavailable to cause toxic effects. It has previously been established that a reduction in likely toxicity by a factor of 110 is appropriate to apply to laboratory test results for cationic polymers with a high charge density to account for the mitigating effects of DOC on toxicity in natural environmental waters (Boethling and Nabholz 1997).

B. Aquatic Toxicity

Acute Studies

Table 3 lists the results of acute aquatic toxicity studies conducted on polyDADMAC.

Table 3: Acute Aquatic Toxicity Studies on polyDADMAC

Test Species	Endpoint	Results (mg/L)	Reference
Bluegill	96-hr LC_{50}	0.9	EPA, 2016c
Bluegill	96-hr LC_{50}	0.32	EPA, 2016d
Rainbow trout	96-hr LC_{50}	0.32	EPA, 2016d
Rainbow trout	96-hr LC_{50}	0.42	EPA, 2016e
Rainbow trout	96-hr LC_{50}	0.77	EPA, 2016f
Fathead minnow	96-hr LC_{50}	0.3	EPA, 2016g
Fathead minnow	96-hr LC_{50}	6.51*	EPA, 2016g
Fathead minnow	96-hr LC_{50}	0.46	Cary et al., (1987)
Fathead minnow	96-hr LC_{50}	6.5***	Cary et al., (1987)
Daphnia magna	48-hr EC_{50}	0.23	EPA, 2016g
Daphnia magna	48-hr EC_{50}	11.8**	EPA, 2016g
Daphnia magna	48-hr EC_{50}	0.33	EPA, 2016h
Daphnia magna	48-hr EC_{50}	0.2	Cary et al., (1987)

Test Species	Endpoint	Results (mg/L)	Reference
Daphnia magna	48-hr EC_{50}	7.4***	Cary et al., (1987)

*10 mg/L humic acid in standard laboratory water.
**10 mg/L TOC in standard laboratory water.
***50 mg/L humic acid in standard laboratory water.

In standard acute aquatic toxicity tests, PolyDADMAC, as a highly charged cationic polymer, is very toxic to fish and *Daphnia*. The toxicity of cationic polymers to fish is from the binding of the polymer to gill tissue, disrupting gill structure and function. Physical damage to fish gill by cationic polymers has been shown by Beisinger and Stokes (1986).

The presence of dissolved organic carbon and suspended solids is known to significantly mitigate the toxicity of cationic polymers under typical environmental exposure conditions (Boethling and Nabholz 1997). Table 3 also shows the change in acute toxicity when suspended solids or total organic carbon (TOC) is added to the standard laboratory water used in the toxicity tests. In the presence of humic acid or TOC, the $E(L)C_{50}$ values for fathead minnow and *Daphnia magna* increase by 21.7-fold and 51.3-fold, respectively. A similar effect of humic acid on the acute toxicity of polyDADMAC on fish and *Daphnia magna* was reported by Cary et al. (1987). The studies by Cary et al. (1987) also showed increases in varying amounts in the $E(L)C_{50}$ values for fathead minnow and *Daphnia magna* with bentonite, illite, kaolin, silica, tannic acid, lignin, lignosite, and fulvic acid. The concentrations of suspended solids and DOC in the studies by Cary et al. (1987) were considered to be low estimates of levels found in the natural environments. These findings demonstrate that toxicity tests conducted on cationic polymers, such as polyDADMAC, using water with no organic carbon will likely overestimate the toxicity of these polymers in the environment.

Chronic Studies

No studies were located for polyDADMAC. The ratio of the acute toxicity to chronic toxicity for polyDADMAC is expected to be low. In 21-day *Daphnia magna* reproduction studies, three cationic polymers had 21-day threshold levels for survival that were higher by order of magnitude than the 48-hr TL_{50} values. The test solutions in these studies were renewed several times along with food, which served as new organic matter. The cationic polymer bioavailability was likely reduced from the adsorption to the food (Biesinger et al., 1976). In another study, low acute to chronic ratios was observed for a cationic polymer for *Ceriodaphnia dubia* and fathead minnows (Godwin-Saad et al., 1994).

It cannot be determined from the standard chronic tests if the adsorbed polymer is ingested or simply becomes unavailable by flocculating and/or settling. In any case, the low acute to chronic ratios of these cationic polymers appears to be best correlated with acute effects (Lyons and Vasconcellos, 1997).

C. Terrestrial Toxicity

No studies were located.

D. Calculation of PNEC

The PNEC calculations for polyDADMAC follow the methodology discussed in DEWHA (2009).

PNEC water

Experimental results are available for two trophic levels. Acute $E(L)C_{50}$ values are available for fish (0.2 mg/L) and *Daphnia* (0.3 mg/L) in standard laboratory water; and for fish (6.5 mg/L) and *Daphnia* (11.8 mg/L) in standard laboratory water with the addition of humic acid or TOC. The PNEC water will be based on the $E(L)C_{50}$ values from the acute toxicity tests conducted with humic acid in the dilution water because this most likely represents the environmental conditions for which this assessment is being conducted for. Furthermore, an assessment factor of 50 is proposed because chronic toxicity is expected to be similar to the acute toxicity of polyDADMAC (when tested in the presence of humic acid) because of the adsorption of the polymer to organic matter (food source) that would occur in standard test methods; hence, an assessment factor will be used for chronic testing for two trophic levels. An assessment factor of 50 has been applied to the $E(L)C_{50}$ value of 6.5 mg/L for fish. The $PNEC_{water}$ is 0.13 mg/L.

PNEC sediment

There are no toxicity data for sediment-dwelling organisms. The K_{ow} and K_{oc} have not been experimentally derived for polyDADMAC; these values cannot estimate using QSAR models because of the high molecular weight of polyDADMAC. Thus, the equilibrium partitioning method cannot be used to calculate the $PNEC_{sed}$.

PNEC soil

There are no toxicity data for soil-dwelling organisms. The K_{ow} and K_{oc} have not been experimentally derived for polyDADMAC; these values cannot estimate using QSAR models because of the high molecular weight of polyDADMAC. Thus, the equilibrium partitioning method cannot be used to calculate the $PNEC_{soil}$.

8. CATEGORISATION AND OTHER CHARACTERISTICS OF CONCERN

A. PBT Categorisation

The methodology for the Persistent, Bioaccumulative and Toxic (PBT) substances assessment is based on the Australian and EU Reach Criteria methodology (DEWHA, 2009; ECHA, 2008).

PolyDADMAC is a high molecular weight polymer; it is expected to be poorly biodegraded. Thus, it meets the screening criteria for persistence.

PolyDADMAC is a high molecular weight polymer that is not expected to be bioavailable to aquatic or terrestrial organisms. Thus, it is not expected to bioaccumulate.

No chronic aquatic toxicity studies have been conducted on polyDADMAC. The $E(L)C_{50}$ values of fish and *Daphnia* for acute toxicity tests conducted with humic acid or TOC in dilution water were >1 mg/L. Thus, polyDADMAC does not meet the screening criteria for toxicity.

The overall conclusion is that polyDADMAC is not a PBT substance.

B. Other Characteristics of Concern

No other characteristics of concern were identified for polyDADMAC.

9. SCREENING ASSESSMENT

Chemical Name	CAS No.	Overall PBT Assessment [1]	Chemical Databases of Concern Assessment Step		Persistence Assessment Step		Bioaccumulative Assessment Step	Toxicity Assessment Step			Risk Assessment Actions Required[3]
			Listed as a COC on relevant databases?	Identified as Polymer of Low Concern	P criteria fulfilled?	Other P Concerns	B criteria fulfilled?	T criteria fulfilled?	Acute Toxicity [2]	Chronic Toxicity[2]	
PolyDADMAC	26062-79-3	Not a PBT	No	No	Yes		No	No	2	2	2

Footnotes:

1 - PBT Assessment based on PBT Framework.

2 - Acute and chronic aquatic toxicity evaluated consistent with assessment criteria (see Framework).

3 - Tier 2 - Hazard Assessment and Qualitative Assessment Only. Develop toxicological profile and PNECs for water and soil and provide qualitative discussion of risk.

Notes:

PBT = Persistent, Bioaccumulative and Toxic

B = bioaccumulative

P = persistent

T = toxic

10. REFERENCES, ABBREVIATIONS AND ACRONYMS

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B. Acronyms and Glossary

°C	degrees Celsius
ADWG	Australian Drinking Water Guidelines
DEWHA	Department of the Environment, Water, Heritage and the Arts
EC	effective concentration
ECHA	European Chemicals Agency
EU	European Union
GHS	Globally Harmonised System of Classification and Labelling of Chemicals
HHRA	enHealth Human Risk Assessment
IUPAC	International Union of Pure and Applied Chemistry
Kl	Klimisch scoring system
LOAEL	lowest observed adverse effect level
mg/kg	milligrams per kilogram
mg/L	milligrammes per litre
MW	molecular weight
NICNAS	The National Industrial Chemicals Notification and Assessment Scheme
NOAEC	No Observed Adverse Effect Concentration
NOAEL	no observed adverse effect level
NOEC	no observed effective concentration
OECD	Organisation for Economic Co-operation and Development
PBT	Persistent, Bioaccumulative and Toxic
PNEC	Predicted No Effect Concentration
ppm	parts per million
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
RfD	Reference Dose
SDS	Material Safety Data Sheet
USEPA	United States Environmental Protection Agency

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Appendix 7 – Example Tier 3 Quantitative Risk Assessment

Qualitative and Quantitative Tier 3 Assessment Example

Dialuminium Chloride Pentahydroxide

Consistent with the assessment framework, the assessment for a Tier 3 chemical includes the following components: completing the screening; developing a risk assessment dossier and Predicted No-Effects Concentrations (PNECs) for water and soil; and, completing a qualitative and quantitative assessment of risk. Each of these components is detailed within this attachment.

Background

Dialuminium chloride pentahydroxide (also known as aluminium chlorohydrate) is a component in a Water Management Facility (WMF) product (Aluminium Chlorohydrate 50%) used as a coagulant during oily water treatment. A safety data sheet (SDS) for the WMF product is included as **Attachment 6-1**. Process and usage information for this chemical is included in **Attachment 6-2** and summarized in **Table 6-1** below.

Table 6-1 Water Management Facility Chemicals – Tier 3 Chemicals

Proprietary Name	Chemical Name	CAS No.	Use	Approximate Quantity Stored On-Site (plant available storage)
Aluminium Chlorohydrate 50%	Aluminium chlorohydrate Water	12042-91-0 7732-18-5	Coagulant	20000 L

CAS No = Chemical Abstracts Service Number
L = litre

The assessment of toxicity of this chemical was used to evaluate human health exposure scenarios and is presented in **Attachment 6-3**. Since an Australian Drinking Water Guideline (ADWG) Value is available (see **Table 6-2** on the following page), toxicological reference values were not derived for the chemical. A detailed discussion of the drinking water guideline values is presented in **Attachment 6-3**.

Table 6-2 Australian Drinking Water Screening Values

Constituent (CAS No.)	Drinking Water Screening Guideline	Drinking Water Screening Value
Aluminium chlorohydrate (12042-91-0)	Aluminum; chloride	0.2 mg/L (aesthetics); 250 mg/L (aesthetics)

CAS No = Chemical Abstracts Service Number
mg/L = milligram per litre

For ecological receptors, the assessment utilises the information presented in the dossiers on the relative toxicity of the aquatic and terrestrial flora and fauna to the chemical. The qualitative assessment focuses on the aquatic invertebrate and fish species within the surface water resources, and the soil flora and fauna associated with releases to the soil. The quantitative assessment includes evaluating the potential risks to these same aquatic and soil ecological receptors, in addition to higher trophic level organisms such as livestock and terrestrial wildlife.

The determination of TRVs was conducted according to the PNEC guidance in the *Environmental Risk Assessment Guidance Manual for Industrial Chemicals* prepared by the Australian Environmental Agency (AEA, 2009). PNECs for freshwater and sediment are developed to assess aquatic receptors, and PNECs for soil are developed for terrestrial receptors.

Table 6-3 present the chemical, the endpoint, NOEC (mg/L), assessment factor, and the aquatic PNEC (mg/L). A PNEC for soil was not calculated for the chemical. Refer to **Attachment 6-3** and the dossier regarding the development of PNECs, or the rational for PNECs that do not have a calculated PNEC.

Table 6-3 PNECs Water – Tier 3 Chemicals

Constituents	Endpoint	$E(L)C_{50}$ or NOEC (mg/L)	Assessment Factor	$PNEC_{water}$ (mg/L)
Aluminium chlorohydrate (12042-91-0)	-	-	-	0.0008[a]

[a] PNECwater for aluminium chlorohydrate is the ANZECC Water Quality Guideline – Freshwater Trigger Value for aluminium.
$E(L)C_{50}$ = effects/level concentration – 50%
NOEC = no observable effects concentration
PNEC = predicted no effect concentration
Refer to **Attachment 6-3** for information on the development of PNECs listed above.

A detailed assessment of the risks posed by this Tier 3 chemical is provided in the following sections.

General Overview

Polyaluminium coagulants, which have been developed for water treatment applications, have the general formula (Aln(OH)mCl(3n-m)x. The length of the polymerised chain, molecular weight, and the number of ionic charges is determined by the degree of polymerization (Gebbie, 2001). The molecular structure of dialuminium chloride pentahydroxide (n=2; m=5) is presented in **Figure 6-1** below.

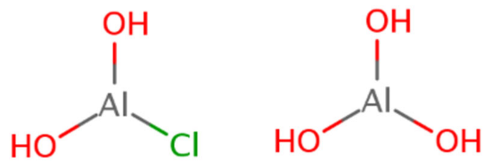

Figure 6-1 Molecular Structure of Dialuminium Chloride Pentahyroxide[1]

Dialuminium chloride pentahydroxide is very soluble in water and will dissociate to form aluminium hydroxide species and chloride ions. Biodegradation is not applicable to dialuminium chloride pentahydroxide. Both chloride ions and aluminium hydroxide ionic species can be found naturally in the environment. The aluminium hydroxide hydrolysis products will adsorb to colloidal matter.

Fish accumulate aluminium in and on the gill, and it has been suggested that the rate of transfer of aluminium into the body is either slow or negligible under natural environmental conditions (Spry and Wiener, 1991). Chloride ions are essential to all living organisms, and their intracellular, and extracellular concentrations are actively regulated. Thus, dialuminium chloride pentahydroxide is not expected to bioaccumulate in aquatic organisms.

The PBT assessment for dialuminium chloride pentahydroxide is included in the dossier provided in **Attachment 6-3**. Based on physico-chemical properties and screening data detailed below, the overall conclusion was that dialuminium chloride pentahydroxide is not a PBT substance.

Human Health Hazards

Dialuminium chloride pentahydroxide has low acute toxicity by the oral and dermal routes. It is non-irritating to the skin and slightly irritating to the eyes. It is not a skin sensitizer.

No systemic, reproductive, or developmental toxicity was seen in rats at oral doses up to 1,000 mg/kg-day aluminium hydroxychloride (a structurally similar compound) in a combined repeated dose toxicity and reproductive/developmental toxicity screening (OECD 422) study. Dialuminium chloride pentahydroxide is not genotoxic.

Toxicological reference values were not derived for dialuminium chloride pentahydroxide. The ADWG values for aluminium (acid-soluble) is 0.2 mg/L based on aesthetics. ADWG has concluded that there is insufficient data to set a guidance value based on health considerations (ADWG, 2011). The ADWG value for chloride is 250 mg/L based on aesthetics (ADWG, 2011).

During the water treatment, water conveyance and beneficial reuse processes, there is the potential for human receptors to be exposed to water treatment chemicals. Based on an assessment of land use and an understanding of the project description provided in the Environmental Impact Statement (EIS) (URS, 2014), likely human exposure would include:

1. Workers at the WMF including operators, maintenance staff and supervisors.
2. First responders in contact with releases whilst responding to emergencies either at the WMF or along the transport or conveyance routes.

[1] Source https://comptox.epa.gov/dashboard/dsstoxdb/results?search=DTXSID0051609

3. Trespassers who stray (either advertently or inadvertently) onto the WMF during operations. Trespassers would also have access to the road network and surface water features that receive runoff and/or releases from transportation accidents or site-related releases.
4. Agricultural workers/residents who have access to the road network; this cohort would also have access to surface water features that receive runoff and/or releases from conveyance or transportation related or site-related releases.
5. Agricultural workers at irrigation areas.
6. Recreational users who have access to areas adjacent to the road network. Recreational users would also have access to surface water features that receive runoff and/or releases from conveyance / transportation related or site-related releases.

Based on the treatment process described in **Attachment 6-2**, dialuminium chloride pentahydroxide is removed with Actiflo sludge (solid waste) during water treatment. As a result, this chemical is not directed to the permeate or brine waste streams and would not be present in permeate, brine or treated water. Therefore, exposure pathways associated with the beneficial reuse of treated water and management of brine waste would be incomplete. Beneficial reuse of treated water includes project reuse (dust suppression, construction activities, drilling and completions), irrigation and stock watering.

Exposure of workers to dialuminium chloride pentahydroxide is possible via inadvertent spills and leaks. In terms of risks associated with transport of chemicals and wastes, this risk is considered to be managed to a level as low as reasonably practicable. This is because the potential for a release is controlled through implementation of a traffic management plan including use of designated trucking routes, vehicle signage, vehicle management systems (to manage speed and driving behaviour/habits) and in the unlikely event of a vehicular accident, implementation of incident and spill response procedures.

The management of chemicals and wastes is conducted using drums, totes and engineered tanks designed to contain the fluids. In the unlikely event of a release to ground, the potential for exposures (other than workers) is limited. The WMF is fenced and access is controlled, which limits access to the public. If water treatment chemicals are spilled to the ground then investigation, remediation and rehabilitation activities would be implemented to address soil impacts.

Lastly, chemical exposures to workers are controlled through engineering, management controls and personal protective equipment, which are focused on elimination and mitigation of the potential for dermal contact and potential for incidental ingestion.

As a result, potential exposures during treatment activities are low due to the employment of mechanical equipment/processes and engineering controls (including secondary containment). In addition, Australia SafeWork Place and Santos Occupational Safety Guidance are used to minimise human health exposure. Similarly, there is a low potential for human receptors exposed to surface water bodies that may receive runoff from an accidental release during transport, use or storage. Finally, the probability of any surface related discharge infiltrating subsurface soils and migrating to groundwater is very low and any exposures would be incomplete.

Environmental Hazards

In the aquatic environment, aluminium compound toxicity is intimately related to ambient pH; changes in ambient acidity may affect aluminium compound solubility, dissolved aluminium compound speciation, and organism sensitivity to aluminium compounds. In acute toxicity tests, the pH significantly alters the speciation and therefore bioavailability of the aluminium such that acutely toxic concentrations occur below a pH of 6 but that above 6 the bioavailable concentration necessary to achieve immobilisation in an acute study cannot be achieved.

Toxicity testing on a similar aluminium salt compound (sulfuric acid, aluminium salt (3:2), octadecahydrate [CAS No. 7784-31-8]) identified a low toxicity concern for terrestrial invertebrates.

In developing a water quality guideline for aluminium (ANZECC 2000), ANZECC separated the screened freshwater toxicity data into those conducted at pH >6.5 and those at pH <6.5. The guideline for freshwater with a pH > 6.5 is 55 ug/L. This is identified as a moderate reliability trigger level. A freshwater low-reliability trigger value of 0.8 ug/L was derived for a pH < 6.5. This low-reliability value should only be used as an indicative interim working level.

No experimental toxicity data on sediment or soil organisms are available. Kow and Koc parameters do not readily apply to inorganics, such as dialuminium chloride pentahydroxide. Thus, the equilibrium partitioning method cannot be used to calculate PNECs for soil or sediment. Based on its properties, dialuminium chloride pentahydroxide is not expected to significantly adsorb to soil or sediment, and the assessment of these compartments is covered by the aquatic assessment.

During water treatment, water conveyance and beneficial reuse processes, there is the potential for environmental receptors to be exposed to water treatment chemicals such as dialuminium chloride pentahydroxide. Roads (where transportation of chemicals can occur) and pipelines (where treated water is conveyed) can transect sensitive ecological areas (including MNES). At the WMF, the potential for exposure of sensitive receptors (including MNES) is considered low as these facilities are existing and are operational industrial facilities (and thereby provide no habitat value). The industrial activities and operation of equipment do not make it a setting conducive to incursion of fauna. For instance, the WMF is fenced and access is controlled, which precludes entry by livestock.

Based on the engineering and management controls described in the previous section (Human Health Hazards), there is a low potential for ecological receptors exposed to surface water bodies that may receive runoff from an accidental release during transport, use or storage. As discussed earlier, exposure pathways associated with the beneficial reuse of treated water and management of brine waste would be incomplete.

Risk Characterization

The purpose of the risk characterisation portion of the assessment is to provide a conservative estimate of the potential risk resulting from exposure to dialuminium chloride pentahydroxide. The risk characterisation evaluates the toxicity of dialuminium chloride pentahydroxide and characterises the risk of the chemical assessed for specific exposure pathways identified in the previous sections.

A two-stage process is employed during risk characterization. First, risk ratios are developed for the chemical for potentially complete exposure pathways associated with applicable release scenarios. The risk ratio is calculated by dividing the exposure point concentration (EPC) by the applicable risk-based screening level (drinking water level or PNECs for aquatic and terrestrial receptors). If the ratio of exceedance of screening levels is less than 1.0, then there are no anticipated adverse effects associated with the exposure scenario evaluated. No risk / hazard reduction measures are required.

There should be no need for further management controls on the chemical additional to those already in place (DoEE, 2017).

If the ratio is greater than 1.0, then further quantitative analysis for permeate beneficial reuse via direct contact by trespassers, workers, agricultural workers and non-MNES (mammals and avian receptors) is conducted. Consistent with the assessment framework, quantitative assessment of risk will consider only Tier 3 chemicals in end use determination.

EPCs were developed for a transportation release scenario (see **Attachment 6-2**). In this scenario, the mass or volume of the product during transport was multiplied by the percentage of the COPC within the product. Where a range was provided for the chemical, the maximum percentage was used to calculate the chemical concentration in the release. Additionally, three release concentrations of the chemical was calculated to evaluate the potential for release to different size water bodies and account for potential dilution of the chemical: 100-percent, 25-percent, and 5-percent. To calculate the potential concentration of the chemical in soil from a release during transportation, 100-percent of the surface water concentration was multiplied by the transportation release area (assumed to be 0.25 hectare) to a depth of 0.15 metres divided by the mass of soil per hectare.

As previously noted, dialuminium chloride pentahydroxide is not directed to the permeate or brine waste streams and would not be present in permeate, brine or treated water. Therefore, EPCs were not developed for permeate accidental release scenarios or permeate beneficial use scenarios; and, likewise further quantitative analysis (i.e., calculation of hazards) for permeate beneficial reuse via direct contact by trespassers, workers, and agricultural workers and non-MNES (mammals and avian receptors) was not conducted.

Tables 6-4 through **6-8** present the comparison of the potentially complete exposure scenarios to drinking water levels and PNECs for aquatic and terrestrial receptors. *Note that a comparison to* $PNEC_{soil}$ *and permeate tables are included for reference only in this example, dialuminium chloride pentahydroxide is NA in each.*

As indicated in **Table 6-4**, the $PNEC_{water}$ risk ratios exceeded 10 in each scenario. Based on the screening, there is a potential for adverse impacts to surface water resources and associated aquatic flora and fauna as well as terrestrial ecological receptors from a potential release of dialuminium chloride pentahydroxide during transport indicating the requirement for management controls.

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Tables

Table 6-4
Comparison of Theoretical Transport Concentrations of COPCs to PNECs (Water)

Constituent Name	CAS No.	Estimated Vendor Transport Concentration (mg/l) Exposure Scenario			PNEC aquatic (mg/l)	Ratio of COPC Concentrations and Screening Criteria (Ratio greater than one = elevated potential risk) Exposure Scenario		
		100%	25%	5%		100%	25%	5%
Aluminium chlorohydrate	12042-91-0	5000000	1,250,000	250,000	8.00E-04	6.3E+09	1.6E+09	3.1E+08

Notes:
mg/l = milligrams per liter
- indicates PNEC not available. Refer to risk dossiers for discussion on PNEC development.
NA - not applicable

Table 6-5
Comparison of Theoretical Concentrations of COPCs in Soil from Release During Transport to PNECs (Solid)

Constituent Name	CAS No.	Estimated Vendor Chemical Concentration in Soil From Release During Transport (mg/kg)	PNECsoil (mg/kg)	Ratio of COPC Concentrations and Screening Criteria (Ratio greater than one = elevated potential risk)
				Soil
Aluminium chlorohydrate	12042-91-0	5000000	-	NA

Notes:
mg/kg = milligrams per kilogram
- indicates PNEC not available. Refer to risk dossiers for discussion on PNEC development.
NA - not applicable
a/ Refer to text on development of estimated vendor chemical concentrations in soil.

Table 6-6
Comparison of Theoretical Concentrations of COPCs to Drinking Water Guidelines

Constituent Name	CAS No.	Estimated Permeate Concentration (mg/l)	Estimated Permeate Vendor Chemical Concentrations Including Biodegredation (mg/l) — Exposure Scenario		Drinking Water Screening Level (mg/l)	Ratio of COPC Concentrations and Screening Criteria (Ratio greater than one = elevated potential risk) — Exposure Scenario	
			Permeate	Permeate Mixed with Produced Water (a)		Permeate	Permeate Mixed with Produced Water
Aluminium chlorohydrate	12042-91-0	NA	NA	NA	2.00E-01	NA	NA

Notes:
mg/l = milligrams per liter
- indicates Drinking Water Screening Level not available. Refer to risk dossiers for discussion.
NA - not applicable
a/ Permeate mixed at ratio of 1:1 with produced water.

Table 6-7
Comparison of Theoretical Concentrations of COPCs to PNECs (Water)

Constituent Name	CAS No.	Estimated Permeate Concentration (mg/l)	Estimated Permeate Vendor Chemical Concentrations Including Biodegredation (mg/l) — Exposure Scenario: Permeate	Estimated Permeate Vendor Chemical Concentrations Including Biodegredation (mg/l) — Exposure Scenario: Permeate Mixed with Produced Water (a)	PNEC aquatic (mg/l)	Ratio of COPC Concentrations and Screening Criteria (Ratio greater than one = elevated potential risk) — Exposure Scenario: Permeate	Ratio of COPC Concentrations and Screening Criteria (Ratio greater than one = elevated potential risk) — Exposure Scenario: Permeate Mixed with Produced Water
Aluminium chlorohydrate	12042-91-0	NA	NA	NA	8.00E-04	NA	NA

Notes:
mg/l = milligrams per liter
- indicates PNEC not available. Refer to risk dossiers for discussion on PNEC development.
NA - not applicable
a/ Permeate mixed at ratio of 1:1 with produced water.

Table 6-8
Comparison of Theoretical Concentrations of COPCs to PNECs (Solid)

Constituent Name	CAS No.	Estimated Vendor Chemical Concentration in Permeate in Soil From Release (mg/kg)	Estimated Vendor Chemical Concentration in Permeate Blended with Produced Water in Soil From Release (mg/kg)	Estimated Vendor Chemical Concentration in Soil After 20 Years Irrigation with Permeate (mg/kg)	Estimated Vendor Chemical Concentrationin Soil After 20 Years Irrigation (mg/kg)	PNECsoil (mg/kg)	Ratio of COPC Concentrations and Screening Criteria (Ratio greater than one = elevated potential risk)			
							Permeate Release to Soil	Permeate Blended with Produced Water Release to Soil	Soil Irrigated with Permeate	Soil Irrigated with Permeate Blended with Produced Water
Aluminium chlorohydrate	12042-91-0	NA	NA	NA	NA	-	NA	NA	NA	NA

Notes:
mg/kg = milligrams per kilogram
- indicates PNEC not available. Refer to risk dossiers for discussion on PNEC development.
NA - not applicable
a/ Refer to text on development of estimated vendor chemical concentrations in soil.

Attachment 6-1 Safety Data Sheet

1. IDENTIFICATION

Product Name	**Aluminium Chlorohydrate Liquid - Water Treatment Grade**
Other Names	ALUMINIUM CHLORIDE, BASIC; Aluminium hydroxy chlorosulphate; Aluminium hydroxychloride; Polyaluminium chlorosulphate
Uses	No Data Available
Chemical Family	No Data Available
Chemical Formula	No Data Available
Chemical Name	Aluminium Chlorohydrate Liquid – Water Treatment Grade
Product Description	No Data Available

Contact Details of the Supplier of this Safety Data Sheet

Organisation	Location	Telephone
Redox Pty Ltd	2 Swettenham Road Minto NSW 2566 Australia	+61-2-97333000
Redox Pty Ltd	11 Mayo Road Wiri Auckland 2104 New Zealand	+64-9-2506222
Redox Inc.	2132A E. Dominguez Street Carson CA 90810 USA	+1-424-675-3200
Redox Chemicals Sdn Bhd	No. 8, Block G, Ground Floor, Taipan 2 Jalan PJU 1A/3 Ara Damansara 47301, Petaling Jaya, Selangor, Malaysia	+60-3-7843-6833

Emergency Contact Details

For emergencies only; DO NOT contact these companies for general product advice.

Organisation	Location	Telephone
Poisons Information Centre	Westmead NSW	1800-251525 131126
Chemcall	Australia	1800-127406 +64-4-9179888
Chemcall	Malaysia	+64-4-9179888
Chemcall	New Zealand	0800-243622 +64-4-9179888
National Poisons Centre	New Zealand	0800-764766
CHEMTREC	USA & Canada	1-800-424-9300 CN723420 +1-703-527-3887

2. HAZARD IDENTIFICATION

Poisons Schedule (Aust) Not scheduled

Globally Harmonised System

Hazard Classification Hazardous according to the criteria of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS)

Hazard Categories		Serious Eye Damage/Irritation - Category 1 Corrosive to Metals - Category 1	
Pictograms			
Signal Word		Danger	
Hazard Statements		**H290**	May be corrosive to metals.
		H318	Causes serious eye damage.
Precautionary Statements	Prevention	**P234**	Keep only in original container.
		P280	Wear protective gloves/protective clothing.
	Response	**P305 + P351 + P338**	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
		P310	Immediately call a POISON CENTER or doctor/physician.
	Storage	**P406**	Store in corrosive resistant container with a resistant inner liner.

National Transport Commission (Australia)
Australian Code for the Transport of Dangerous Goods by Road & Rail (ADG Code)

Dangerous Goods Classification — NOT Dangerous Goods according to the criteria of the Australian Code for the Transport of Dangerous Goods by Road & Rail (ADG Code)

3. COMPOSITION/INFORMATION ON INGREDIENTS

Ingredients

Chemical Entity	Formula	CAS Number	Proportion
Water	No Data Available	7732-18-5	50.00 - 52.00 %
Aluminium chlorohydrate	No Data Available	1327-41-9	48.00 - 50.00 %

4. FIRST AID MEASURES

Description of necessary measures according to routes of exposure

Swallowed — Rinse mouth with water. Give water to drink. Do NOT induce vomiting. Neutralization may be accomplished by using aluminum hydroxide gel or milk of magnesia. Seek medical attention.

Eye — Immediately flush eyes with plenty of water for 15 minutes, holding eyelids open. In all cases of eye contamination, it is a sensible precaution to seek medical advice.

Skin — Remove contaminated clothing. Flush affected area with plenty of water. If irritation persists, seek medical attention

Inhaled — Remove victim from exposure to fresh air. If not breathing, apply artificial respiration. If breathing is difficult, give oxygen. Seek medical attention if effects persist.

Advice to Doctor — Treat symptomatically based on judgement of doctor and individual reactions of patient.

Medical Conditions Aggravated by Exposure — No information available on medical conditions aggravated by exposure to this product.

5. FIRE FIGHTING MEASURES

General Measures	If safe to do so, remove containers from the path of fire.
Flammability Conditions	Non-flammable liquid.
Extinguishing Media	In case of fire, use appropriate extinguishing media most suitable for surrounding fire conditions.
Fire and Explosion Hazard	Non-Combustible.
Hazardous Products of Combustion	If mix with Sodium Hypochlorite (NaOCl) can produce toxic chlorine gas.
Special Fire Fighting Instructions	Clear fire area of all non-emergency personnel. Stay upwind. Keep out of low areas. Eliminate ignition sources. Move fire exposed containers from fire area if it can be done without risk. Do NOT allow fire fighting water to reach waterways, drains or sewers. Store fire fighting water for treatment.
Personal Protective Equipment	Fire fighters should wear a positive-pressure self-contained breathing apparatus (SCBA) and protective fire fighting clothing (includes fire fighting helmet, coat, trousers, boots and gloves) or chemical splash suit.
Flash Point	No Data Available
Lower Explosion Limit	No Data Available
Upper Explosion Limit	No Data Available
Auto Ignition Temperature	No Data Available
Hazchem Code	No Data Available

6. ACCIDENTAL RELEASE MEASURES

General Response Procedure	Eliminate all sources of ignition. Increase ventilation. Avoid walking through spilled product as it may be slippery. Use clean, non-sparking tools and equipment.
Clean Up Procedures	Soak up spilled product using absorbent non-combustible material such as sand or soil. Avoid using sawdust or cellulose. When saturated, collect the material and transfer to a suitable, labelled chemical waste container and dispose of promptly.
Containment	Stop leak if safe to do so.
Decontamination	Neutralize with slake lime, soda ash or calcium carbonate. Wash affected area with water.
Environmental Precautionary Measures	Do not allow product to reach drains, sewers or waterways. If product does enter a waterway, advise the Environmental Protection Authority or your local Waste Authority.
Evacuation Criteria	Clear area of all unprotected personnel
Personal Precautionary Measures	Personnel involved in the clean up should wear full protective clothing as listed in section 8.

7. HANDLING AND STORAGE

Handling	Ensure an eye bath and safety shower are available and ready for use. Observe good personal hygiene practices and recommended procedures. Wash thoroughly after handling. Take precautionary measures against static discharges by bonding and grounding equipment. Avoid contact with eyes, skin and clothing. Do not inhale product fumes. The usual precaution for handling with acidity chemical should be observed. Transfer: Use feeding pump with non-acid property.
Storage	Store in a cool, dry, well-ventilated area. Keep containers tightly closed when not in use. Inspect regularly for deficiencies such as damage or leaks. Protect against physical damage. Store away from incompatible materials as listed in section 10. In a storage tank lined with non corrosive material. This product is not classified dangerous for transport according to The Australian Code for the Transport of Dangerous Goods By Road and Rail.
Container	Store in original packaging as approved by manufacturer.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

General	No exposure standard has been established for this product by the Australian Safety and Compensation Council (ASCC). NOTE: The exposure value at the TWA is the average airborne concentration of a particular substance when calculated over a normal 8 hour working day for a 5 day working week. These exposure standards are guides to be used in the control of occupational health hazards. All atmospheric contamination should be kept to as low a level as is workable. These exposure standards should not be used as fine

	dividing lines between safe and dangerous concentrations of chemicals. They are not a measure of relative toxicity
Exposure Limits	No Data Available
Biological Limits	No information available on biological limit values for this product.
Engineering Measures	A system of local and/or general exhaust is recommended to keep employee exposures as low as possible. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area.
Personal Protection Equipment	RESPIRATOR: No respirator generally required (AS1715/1716). EYES: Chemical safety goggles (AS1336/1337). HANDS: Protective gloves (AS2161). CLOTHING: Long-sleeved protective clothing and rubber boots (AS3765/2210).
Work Hygienic Practices	Avoid contact with eyes and skin. Avoid prolonged or repeated exposure. Always wash hands before smoking, eating, drinking or using the toilet.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State	Liquid
Appearance	Clear to Slightly Hazy Liquid
Odour	No Data Available
Colour	Clear to Slightly Hazy
pH	3.5 - 5.0
Vapour Pressure	No Data Available
Relative Vapour Density	No Data Available
Boiling Point	No Data Available
Melting Point	No Data Available
Freezing Point	No Data Available
Solubility	Very soluble
Specific Gravity	No Data Available
Flash Point	No Data Available
Auto Ignition Temp	No Data Available
Evaporation Rate	No Data Available
Bulk Density	No Data Available
Corrosion Rate	No Data Available
Decomposition Temperature	No Data Available
Density	No Data Available
Specific Heat	No Data Available
Molecular Weight	No Data Available
Net Propellant Weight	No Data Available
Octanol Water Coefficient	No Data Available
Particle Size	No Data Available
Partition Coefficient	No Data Available
Saturated Vapour Concentration	No Data Available
Vapour Temperature	No Data Available
Viscosity	No Data Available
Volatile Percent	No Data Available
VOC Volume	No Data Available
Additional Characteristics	Un-ignitable, incombustible, non-oxidative, non-self reactive and inactive liquid of extreme stability.
Potential for Dust Explosion	Product is a liquid.
Fast or Intensely Burning Characteristics	No Data Available
Flame Propagation or Burning Rate of Solid Materials	No Data Available

Non-Flammables That Could Contribute Unusual Hazards to a Fire	No Data Available
Properties That May Initiate or Contribute to Fire Intensity	No Data Available
Reactions That Release Gases or Vapours	No Data Available
Release of Invisible Flammable Vapours and Gases	No Data Available

10. STABILITY AND REACTIVITY

General Information	Non-combustible liquid
Chemical Stability	tends to gradually hydrolyze to a white turbid solution and lose the effectiveness, when it is kept long as diluted solution of less than 3% Aluminium oxide.
Conditions to Avoid	None known.
Materials to Avoid	Strong bases, such as Sodium Hydroxide (NaOH), Calcium carbonate ($CaCO_3$), Sodium Hypochlorite (NaOCl).
Hazardous Decomposition Products	If mix with Sodium Hypochlorite (NaOCl) can produce toxic chlorine gas.
Hazardous Polymerisation	Has not been reported.

11. TOXICOLOGICAL INFORMATION

General Information	Acute oral toxicity: LD50 oral, rat > 12.79 gm/kg
EyeIrritant	May cause serious eye damage.
Inhalation	Irritating to respiratory system.
Carcinogen Category	No Data Available

12. ECOLOGICAL INFORMATION

Ecotoxicity	The chemical is decomposed into aluminum hydroxide ($Al(OH)_3$) and hydrochloric acid (HCl) by hydrolysis.
Persistence/Degradability	No Data Available
Mobility	No Data Available
Environmental Fate	No Data Available
Bioaccumulation Potential	No Data Available
Environmental Impact	No Data Available

13. DISPOSAL CONSIDERATIONS

General Information	If utilisation or recycling of the product is not possible, it should be disposed of in accordance with all local, state and federal regulations. All empty packaging should be disposed of in accordance with Local, State, and Federal Regulations or recycled/reconditioned at an approved facility. Dispose of the chemical after neutralization with a chemical like slake lime, calcium carbonate or soda ash.
Special Precautions for Land Fill	Contact a specialist disposal company or the local waste regulator for advice. Incinerate at an approved site following all local regulations. This material may be suitable for approved landfill.

14. TRANSPORT INFORMATION

Land Transport (Australia)
ADG

Proper Shipping Name	Aluminium Chlorohydrate Liquid – Water Treatment Grade
Class	No Data Available
Subsidiary Risk(s)	No Data Available
	No Data Available
UN Number	No Data Available
Hazchem	No Data Available
Pack Group	No Data Available
Special Provision	No Data Available

Land Transport (Malaysia)
ADR Code

Proper Shipping Name	Aluminium Chlorohydrate Liquid – Water Treatment Grade
Class	No Data Available
Subsidiary Risk(s)	No Data Available
	No Data Available
UN Number	No Data Available
Hazchem	No Data Available
Pack Group	No Data Available
Special Provision	No Data Available

Land Transport (New Zealand)
NZS5433

Proper Shipping Name	Aluminium Chlorohydrate Liquid – Water Treatment Grade
Class	No Data Available
Subsidiary Risk(s)	No Data Available
	No Data Available
UN Number	No Data Available
Hazchem	No Data Available
Pack Group	No Data Available
Special Provision	No Data Available

Land Transport (United States of America)
US DOT

Proper Shipping Name	Aluminium Chlorohydrate Liquid – Water Treatment Grade
Class	No Data Available
Subsidiary Risk(s)	No Data Available
	No Data Available
UN Number	No Data Available
Hazchem	No Data Available
Pack Group	No Data Available
Special Provision	No Data Available

Sea Transport
IMDG

Proper Shipping Name	Aluminium Chlorohydrate Liquid – Water Treatment Grade
Class	No Data Available
Subsidiary Risk(s)	No Data Available
UN Number	No Data Available
Hazchem	No Data Available
Pack Group	No Data Available
Special Provision	No Data Available
EMS	No Data Available
Marine Pollutant	No

Air Transport
IATA

Proper Shipping Name	Aluminium Chlorohydrate Liquid – Water Treatment Grade
Class	No Data Available
Subsidiary Risk(s)	No Data Available
UN Number	No Data Available
Hazchem	No Data Available
Pack Group	No Data Available
Special Provision	No Data Available

National Transport Commission (Australia)
Australian Code for the Transport of Dangerous Goods by Road & Rail (ADG Code)

Dangerous Goods Classification	NOT Dangerous Goods according to the criteria of the Australian Code for the Transport of Dangerous Goods by Road & Rail (ADG Code)

15. REGULATORY INFORMATION

General Information	No Data Available
Poisons Schedule (Aust)	Not scheduled

Environmental Protection Authority (New Zealand)
Hazardous Substances and New Organisms Amendment Act 2015

Approval Code	Not Assessed

National/Regional Inventories

Australia (AICS)	Listed
Canada (DSL)	Not Determined
Canada (NDSL)	Not Determined
China (IECSC)	Not Determined
Europe (EINECS)	Not Determined
Europe (REACh)	Not Determined
Japan (ENCS/METI)	Not Determined

Korea (KECI)	Not Determined
Malaysia (EHS Register)	Not Determined
New Zealand (NZIoC)	Not Determined
Philippines (PICCS)	Not Determined
Switzerland (Giftliste 1)	Not Determined
Switzerland (Inventory of Notified Substances)	Not Determined
Taiwan (NCSR)	Not Determined
USA (TSCA)	Not Determined

16. OTHER INFORMATION

Related Product Codes
ALCHHY5000, ALCHHY5100, ALCHHY5200, ALCHHY5500, ALCHHY8000, ALCHHY9000, ALCHHY4000, ALCHHY3100, ALCHHY3110, ALCHHY3130, ALCHHY3200, ALCHHY3115

Revision
1

Revision Date
17 Jul 2014

Key/Legend

< Less Than
> Greater Than
AICS Australian Inventory of Chemical Substances
atm Atmosphere
CAS Chemical Abstracts Service (Registry Number)
cm^2 Square Centimetres
CO_2 Carbon Dioxide
COD Chemical Oxygen Demand
deg C (°C) Degrees Celcius
EPA (New Zealand) Environmental Protection Authority of New Zealand
deg F (°F) Degrees Farenheit
g Grams
g/cm^3 Grams per Cubic Centimetre
g/l Grams per Litre
HSNO Hazardous Substance and New Organism
IDLH Immediately Dangerous to Life and Health
immiscible Liquids are insoluable in each other.
inHg Inch of Mercury
inH2O Inch of Water
K Kelvin
kg Kilogram
kg/m^3 Kilograms per Cubic Metre
lb Pound
LC50 LC stands for lethal concentration. LC50 is the concentration of a material in air which causes the death of 50% (one half) of a group of test animals. The material is inhaled over a set period of time, usually 1 or 4 hours.
LD50 LD stands for Lethal Dose. LD50 is the amount of a material, given all at once, which causes the death of 50% (one half) of a group of test animals.
ltr or **L** Litre
m^3 Cubic Metre
mbar Millibar
mg Milligram
mg/24H Milligrams per 24 Hours
mg/kg Milligrams per Kilogram
mg/m^3 Milligrams per Cubic Metre
Misc or **Miscible** Liquids form one homogeneous liquid phase regardless of the amount of either component present.
mm Millimetre
mmH2O Millimetres of Water
mPa.s Millipascals per Second
N/A Not Applicable
NIOSH National Institute for Occupational Safety and Health
NOHSC National Occupational Heath and Safety Commission
OECD Organisation for Economic Co-operation and Development
Oz Ounce
PEL Permissible Exposure Limit

Pa Pascal
ppb Parts per Billion
ppm Parts per Million
ppm/2h Parts per Million per 2 Hours
ppm/6h Parts per Million per 6 Hours
psi Pounds per Square Inch
R Rankine
RCP Reciprocal Calculation Procedure
STEL Short Term Exposure Limit
TLV Threshold Limit Value
tne Tonne
TWA Time Weighted Average
ug/24H Micrograms per 24 Hours
UN United Nations
wt Weight

Attachment 6-2 Vendor WMF Chemicals and EPC

Attachment 6-2
Summary of Exposure Point Concentration Development
(Water Treatment Chemicals)

Product Name	Chemical Name	CAS Number	%	Proper Shipping Name	Supplier	Area	Transport		Onsite Storage		Operation	
							mass/volume	concentration	mass/volume	concentration	mass/volume	concentration
Aluminium Chlorohydrate 50%	Aluminium chlorohydrate Water	12042-91-0 7732-18-5	48-50% 50-52%	Aluminium Chlorohydrate	REDOX	Reverse Osmosis	10000L	50%	20000L	50%	13-17L/hour	50%

L = litres
mg/l = milligrams per litre
L/hr = litre per hour
AVG = average
mg/kg = milograms per kilogram
NA = not applicable

Attachment 6-2
Summary of Exposure Point Concentration Development
(Water Treatment Chemicals)

Product Name	Chemical Name	CAS Number	Annual Usage (ROP volumes based on peak rate of 10ML/d)	Purpose / Function	Fate	Assumed Chemical % For Transportation Release Scenario	Assumed Release Volume for Transportation Release Scenario	Transport Release Surface Water Concentration (mg/l)		
						%	L	100%	25%	5%
Aluminium Chlorohydrate 50%	Aluminium chlorohydrate Water	12042-91-0 7732-18-5	150000L	coagulant	Removed with Actiflo sludge (solid waste)	50% 50%	10000 NA	5000000 5000000	1250000 NA	250000 NA

L = litres
mg/l = milligrams per litre
L/hr = litre per hour
AVG = average
mg/kg = milograms per kilogram
NA = not applicable

Attachment 6-2
Summary of Exposure Point Concentration Development
(Water Treatment Chemicals)

Product Name	Chemical Name	CAS Number	Transport Release Soil Concentration (mg/kg)	Permeate Concentration		COPC concentration in soil from release of permeate	COPC concentration in soil from 20 years of irrigation
			100%	(mg/l)	Permeate notes	(mg/kg)	mg/kg
Aluminium Chlorohydrate 50%	Aluminium chlorohydrate	12042-91-0	5952	NA	This product is not directed to the permeate stream.	NA	NA
	Water	7732-18-5	NA	NA	This product is not directed to the permeate stream.	NA	NA

L = litres
mg/l = milligrams per litre
L/hr = litre per hour
AVG = average
mg/kg = milograms per kilogram
NA = not applicable

Attachment 6-2
Summary of Exposure Point Concentration Development
(Water Treatment Chemicals)

Product Name	Chemical Name	CAS Number	Brine Concentration (mg/l)	Brine Notes
Aluminium Chlorohydrate 50%	Aluminium chlorohydrate	12042-91-0	NA	This product not directed to brine dams.
	Water	7732-18-5	NA	This product not directed to brine dams.

L = litres
mg/l = milligrams per litre
L/hr = litre per hour
AVG = average
mg/kg = milograms per kilogram
NA = not applicable

Attachment 6-3 Risk Assessment Dossier

DIALUMINIUM CHLORIDE PENTAHYDROXIDE

This dossier on dialuminium chloride pentahydroxide does not represent an exhaustive or critical review of all available data. Rather, it presents the most critical studies pertinent to the risk assessment of dialuminium chloride pentahydroxide in water treatment systems. The majority of information presented in this dossier was obtained from the ECHA database that provides information on chemicals that have been registered under the EU REACH (ECHA). Where possible, study quality was evaluated using the Klimisch scoring system (Klimisch et al., 1997).

Screening Assessment Conclusion – Dialuminium chloride pentahydroxide was not identified in chemical databases used by NICNAS as an indicator that the chemical is of concern and is not a PBT substance. Dialuminium chloride pentahydroxide was assessed as a tier 3 chemical for acute toxicity and as a tier 1 chemical for chronic toxicity. Therefore, dialuminium chloride pentahydroxide is classified overall as a ***tier 3*** *chemical and requires a quantitative risk assessment for end uses.*

1. BACKGROUND

Dialuminium chloride pentahydroxide is very soluble in water and will dissociate to form aluminium hydroxide species and chloride ions. Biodegradation is not applicable to dialuminium chloride pentahydroxide. The aluminium hydroxide hydrolysis products will adsorb to colloidal matter. Dialuminium chloride pentahydroxide is not expected to bioaccumulate in aquatic organisms. Dialuminium chloride pentahydroxide has low acute toxicity by the oral and dermal routes. It is non-irritating to the skin and slightly irritating to the eyes. It is not a skin sensitizer. No systemic, reproductive, or developmental toxicity was seen in rats at oral doses up to 1,000 mg/kg-day aluminium hydroxychloride (a structurally similar compound) in a combined repeated dose toxicity and reproductive/developmental toxicity screening (OECD 422) study. Dialuminium chloride pentahydroxide is not genotoxic. The Australian drinking water guideline (ADWG) values for aluminium (acid-soluble) is 0.2 mg/L based on aesthetics. ADWG has concluded that there is insufficient data to set a guidance value based on health considerations. The ANZECC water quality guideline (2000) used acute and chronic laboratory toxicity data for the derivation of trigger values for aluminium, which are 55 µg/L at pH >6.5 and 0.8 µg/L at pH of <6.5.

2. CHEMICAL NAME AND IDENTIFICATION

Chemical Name (IUPAC): Dialuminium chloride pentahydroxide

CAS RN: 12042-91-0

Molecular formula: $Al_2ClH_5O_5$; general formula $Al(OH)_x(Cl)_{(3-x)}$ with x between 2.3 and 2.6

Molecular weight: 174.45

Synonyms: Dialuminium chloride pentahydroxide; dialuminium chloride pentahydroxide; aluminium chlorohydroxide; aluminium hydroxychloride dehydrate; aluminium chloride hydroxide, dihydrate

3. PHYSICO-CHEMICAL PROPERTIES

Table 1: Overview of the Physico-chemical Properties of Dialuminium Chloride Pentahydroxide

Property	Value	Klimisch score	Reference
Physical state at 20ºC and 101.3 kPa	Solid; fine flakes	1	ECHA
Melting Point	No melting point below 400ºC could be determined.	1	ECHA
Boiling Point	No boiling point below 400ºC could be determined.	1	ECHA
Density	1.95 g/cm^3 @ 20ºC	1	ECHA
Partition Coefficient (log K_{ow})	-	-	-
Water Solubility	>1,000 g/L @ 20ºC (sample pH was 3.3)	1	ECHA
Auto flammability	Not auto flammable.	1	ECHA

Polyaluminium coagulants, which have been developed for water treatment applications, have the general formula $(Al_n(OH)_mCl_{(3n-m)})_x$. The length of the polymerised chain, molecular weight, and the number of ionic charges is determined by the degree of polymerization. The polyaluminium coagulants include polyaluminium chloride (n=2; m=3), dialuminium chloride pentahydroxide (n=2; m=5), and polydialuminium chloride pentahydroxide (similar to dialuminium chloride pentahydroxide) (Gebbie, 2001).

On hydrolysis, various mono- and polymeric species are formed, with an important cation being $Al_{13}O_4(OH)_{24}^{7+}$. A less predominant species is $Al_8(OH)_{20}^{4+}$.

Depending on the pH, the following reaction takes place (Gebbie, 2006):

$$Al_2(OH)_5Cl \rightarrow Al_2(OH)_5^+ + Cl^- + H_2O \rightarrow 2Al(OH)_3 + H^+ + Cl^-$$

This reaction will typically take place at a water pH of 5.8 to 7.5. Within this pH, colour and the colloidal matter are removed by adsorption onto/within the metal hydroxide hydrolysis products that are formed (Gebbie, 2006).

4. DOMESTIC AND INTERNATIONAL REGULATORY INFORMATION

A review of international and national environmental regulatory information was undertaken. This chemical is listed on the Australian Inventory of Chemical Substances – AICS (Inventory). No conditions for its use were identified. No specific environmental regulatory controls or concerns were identified within Australia and internationally for dialuminium chloride pentahydroxide.

Table 2 Existing International Controls

Convention, Protocol or other international control	Listed Yes or No?
Montreal Protocol	No
Synthetic Greenhouse Gases (SGG)	No

Convention, Protocol or other international control	Listed Yes or No?
Rotterdam Convention	No
Stockholm Convention	No
REACH (Substances of Very High Concern)	No
United States Endocrine Disrupter Screening Program	No
European Commission Endocrine Disruptors Strategy	No

5. ENVIRONMENTAL FATE SUMMARY

A. Summary

Dialuminium chloride pentahydroxide is very soluble in water and will dissociate to form aluminium hydroxide species and chloride ions. Biodegradation is not applicable to dialuminium chloride pentahydroxide. The aluminium hydroxide hydrolysis products will adsorb to colloidal matter. Dialuminium chloride pentahydroxide is not expected to bioaccumulate in aquatic organisms.

B. Biodegradation

Biodegradation is not applicable to dialuminium chloride pentahydroxide.

C. Bioaccumulation

Fish accumulate aluminium in and on the gill, and it has been suggested that the rate of transfer of aluminium into the body is either slow or negligible under natural environmental conditions (Spry and Wiener, 1991). The initial uptake of aluminium by fish occurs mainly on the gill mucous layer (Wilkinson and Campbell, 1993); both mucus and bound aluminium may be rapidly eliminated following exposure. Roy (1999) calculated the BCFs in fish to range from 400 to 1,365.

The BCF for *Daphnia magna* varied from 10,000 at pH 6.5 to 0 at pH 4.5, based on the results of Havas (1985). Most of the metal appears to be adsorbed to external surfaces and is not internalised (Havas, 1985; Frick and Hermann, 1990).

The accumulation of aluminium by the algae *Chlorella pyrenoidosa* increased with the concentration of inorganic monomeric aluminium (Parent and Campbell, 1994). A comparison of assays performed at different pH values but the same concentration of aluminium showed suppression of that aluminium accumulation at low pH.

6. HUMAN HEALTH HAZARD ASSESSMENT

A. Summary

Dialuminium chloride pentahydroxide has low acute toxicity by the oral and dermal routes. It is non-irritating to the skin and slightly irritating to the eyes. It is not a skin sensitizer. No systemic, reproductive, or developmental toxicity was seen in rats at oral doses up to 1,000 mg/kg-day aluminium hydroxychloride (a structurally similar compound) in a combined repeated dose toxicity and reproductive/developmental toxicity screening (OECD 422) study. Dialuminium chloride pentahydroxide is not genotoxic.

B. Acute Toxicity

No oral acute toxicity studies are available for dialuminium chloride pentahydroxide. The oral LD_{50} of aluminium hydroxychloride in rats is >2,000 mg/kg (ECHA) [Kl. score = 2].

The dermal LD_{50} of dialuminium chloride pentahydroxide in rats is >2,000 mg/kg (ECHA) [Kl. score = 2].

C. Irritation

No skin irritation studies area available for dialuminium chloride pentahydroxide. Application of 0.5 mL of aluminum hydroxychloride to the skin of rabbits for 4 hours under semi-occlusive conditions was not irritating. The mean of the 24, 48 and 72 hour scores were zero for both erythema and edema (ECHA). [Kl. score = 1]

Dialuminium chloride pentahydroxide was slightly irritating to the eyes of rabbits. The mean of the 24, 48, and 72-hour conjunctival redness scores was 1.00; all other parameters were zero (ECHA). [Kl. score = 1]

D. Sensitization

Dialuminium chloride pentahydroxide was not a skin sensitizer in a guinea pig maximisation test (ECHA) [Kl. score = 1].

E. Repeated Dose Toxicity

<u>Oral</u>

No studies are available on dialuminium chloride pentahydroxide.

Aluminium chloride, basic (aluminium hydroxychloride) was tested in a combined repeated dose toxicity and reproductive/developmental screening toxicity (OECD 422) study. Male and female Wistar rats were dosed by oral gavage with 0, 40, 200, or 1,000 mg/kg aluminium chloride, basic; these doses correspond to 0, 3.6, 18, or 90 mg/kg-day aluminium. There were no effects in the females at any dose level. In males, there were effects indicative of stomach irritation at the high-dose; no other effects were noted. The NOAEL for systemic effects in this study is 1,000 mg/kg-day, the highest dose tested. The NOAEL for localized effects (site-of-contact) is 200 mg/kg-day (ECHA). [Kl. score = 2]

<u>Inhalation</u>

No adequate studies were located.

<u>Dermal</u>

No studies are available.

F. Genotoxicity

In Vitro Studies

Dialuminium chloride pentahydroxide was not mutagenic to *S. typhimurium* strains TA98, TA100, TA1535, TA1537 and *E. coli* strain WP2*uvr*A in the absence or presence of metabolic activation (ECHA). [Kl. score = 1]

The *in vitro* genotoxicity studies on the structurally similar compound aluminium hydroxychloride is shown below in table 2.

Table 3: *In Vitro* Genotoxicity Studies on Aluminium Hydroxychloride

Test System	Results*		Klimisch Score	Reference
	-S9	+S9		
Bacterial reverse mutation (S. typhimurium and E. coli strains)	-	-	1	ECHA
Mammalian cell gene mutation (mouse lymphoma L5178Y cells)	-	-	1	ECHA
Micronucleus (peripheral human lymphocytes)	-	-	1	ECHA

*+, positive; -, negative

In Vivo Studies

Male and female NMRI mice were given an oral gavage dose of 0 or 2,000 mg/kg dialuminium chloride pentahydroxide on two consecutive days. There were no increases in the frequency of micronucleated polychromatic erythrocytes in the bone marrow of the treated mice compared to the controls (ECHA). [Kl. score = 1]

G. Carcinogenicity

No studies are available.

H. Reproductive/Developmental Toxicity

No studies are available for dialuminium chloride pentahydroxide.

Aluminium chloride, basic (aluminium hydroxychloride) was tested in a combined repeated dose toxicity and reproductive/developmental screening toxicity (OECD 422) study. Male and female Wistar rats were dosed by oral gavage with 0, 40, 200, or 1,000 mg/kg aluminium chloride, basic; these doses correspond to 0, 3.6, 18, or 90 mg/kg-day aluminium. There was no reproductive or developmental toxicity at any dose level. The NOAELs for reproductive and developmental toxicity is 1,000 mg/kg-day, the highest dose tested (ECHA). [Kl. score = 1]

I. DERIVATION OF TOXICOLOGICAL REFERENCE AND DRINKING WATER GUIDANCE VALUES

Toxicological reference values were not derived for dialuminium chloride pentahydroxide.

The ADWG value for aluminium (acid-soluble) is 0.2 mg/L based on aesthetics. ADWG has concluded that there is insufficient data to set a guidance value based on health considerations (ADWG, 2011).

The ADWG value for chloride is 250 mg/L based on aesthetics (ADWG, 2011).

J. HUMAN HEALTH HAZARD ASSESSMENT OF PHYSICO-CHEMICAL PROPERTIES

Dialuminium chloride pentahydroxide does not exhibit the following physico-chemical properties:

- Explosivity
- Flammability
- Oxidizing potential

7. ENVIRONMENTAL EFFECTS SUMMARY

A. Summary

In the aquatic environment, aluminium compound toxicity is intimately related to ambient pH; changes in ambient acidity may affect aluminium compound solubility, dissolved aluminium compound speciation, and organism sensitivity to aluminium compounds. Toxicity testing on a similar aluminium salt compound identified a low toxicity concern for terrestrial invertebrates.

B. Aquatic Toxicity

Acute Studies on Aluminium Polychlorohydrate

Table 4 lists the results of acute aquatic toxicity studies conducted on aluminium salts.

Table 4 Acute Aquatic Toxicity Studies on Aluminium Salts

Test Species	Endpoint	Results (mg/L)	Klimisch Score	Reference
Zebrafish *(Danio rerio)*	96-hr LC_{10}	142 nominal (as Dis Al 0.58)	2	ECHA
Zebrafish	96-hr LC_{50}	186 nominal (as Dis Al 1.39)	2	ECHA
Zebrafish	96-hr EC_{50}	>0.357* as Dis Al	1	ECHA
Water Flea *(Daphnia magna)*	48-hr EC_{50}	98 nominal (as Dis Al <0.1)**	2	ECHA
Water Flea	48-hr EC_{50}	38*** nominal (as Dis Al 1.26)	2	ECHA
Pseudokidrchneriella subcapitata	72-hr EC_{50} growth rate	14 nominal (as Dis Al 0.24)	1	ECHA

*NOEC was >1,000 mg/L. pH of the test media was maintained at 7.5.
**Toxicity is driven by other causes than dissolved aluminium
*** Value for dialuminium chloride pentahydroxide.

The pH significantly alters the speciation and therefore bioavailability of the aluminium such that acutely toxic concentrations occur below a pH of 6 but that above 6 the bioavailable concentration necessary to achieve immobilisation in an acute study cannot be achieved (ECHA).

Data used by ANZECC for Aluminium water quality guideline

In developing a water quality guideline for aluminium (ANZECC 2000), ANZECC separated the screened freshwater toxicity data into those conducted at pH >6.5 and those at pH <6.5. These data are summarised below (it should be noted that only the acute toxicity data was used to derive a water quality guideline):

Freshwater pH >6.5:

Fish

The 48-96 hour LC_{50} values for 5 species were 600 to 106,000 µg/L (the lowest value was for *Salmo salar*). The chronic 8- to 28-day NOEC equivalents[1] from seven species were 34-7,100 µg/L. The lowest measured chronic value was an 8-day LC_{50} for *Micropterus* species of 170 µg/L.

Amphibian

The 96-hour LC_{50} values for *Bufo americanus* were 860-1,660 µg/L. The chronic 8-day LC_{50} for *Bufo americanus* was 2,280 µg/L.

Crustacean

The 48-hour LC_{50} values for one species were 2,300-36,900 µg/L. The chronic 7- to 28-day NOECs were 136-1,720 µg/L.

Algae

The 96-hour EC_{50} values were 460-570 µg/L based on population growth. The NOECs for two species were 800-2,000 µg/L.

Freshwater pH<6.5 (all between pH 4.5 and 6.0):

Fish

The 24-96-hour LC_{50} values for two species were 15-4,200 µg/L (the lowest value was for *Salmo trutta*). The 21- to 42-day LC_{50} values were 15-105 µg/L.

Amphibian

The 96- to 120-day LC_{50} values were 540-2,670 µg/L; the absolute range was 400-5,200 µg/L.

Algae

The NOEC from one species was 2,000 µg/L based on growth.

[1]Chronic toxicity values were a mixture of LC/EC_{50} LOEC, MATC, and NOEC values; where stated, these were converted to NOEC equivalents.

C. Terrestrial Toxicity

A study equivalent to the earthworm acute toxicity (OECD TG 207) test was conducted on sulfuric acid, aluminium salt (3:2), octadecahydrate (CAS No. 7784-31-8). The 14-day LC_{50} to earthworm *Eisenia andre*i was 316 mg/kg soil dry weight (van Gestel and Hoogerwerf, 2001; ECHA). [Kl. score = 2]

D. Calculation of PNEC

PNEC water

The ANZECC water quality guideline (2000) used acute and chronic laboratory toxicity data for the derivation of trigger values for aluminium. The guideline for freshwater is: *"A freshwater moderate reliability trigger value of 55 µg/L for aluminium at pH >6.5 using the statistical distribution method (Burr distribution as modified by SCIRO, Section 8.3.3.3) with 95% protection and an ACR of 8.2.*

"A freshwater low-reliability trigger value of 0.8 µg/L was derived for aluminium at pH of <6.5 using an AF of 20 (essential element) on the low pH trout figure."

"The low-reliability figures should only be used as indicative interim working levels."

PNEC sediment

No experimental toxicity data on sediment organisms are available. K_{ow} and K_{oc} parameters do not readily apply to inorganics, such as dialuminium chloride pentahydroxide. Thus, the equilibrium partitioning method cannot be used to calculate the $PNEC_{sed}$. Based on its properties, no adsorption of dialuminium chloride pentahydroxide to sediment is to be expected, and the assessment of this compartment will be covered by the aquatic assessment.

PNEC soil

No experimental toxicity data on soil organisms are available. The environmental distribution of dialuminium chloride pentahydroxide is dominated by its water solubility. Sorption of dialuminium chloride pentahydroxide should probably be regarded as a reversible situation, *i.e.*, the substance is not tightly nor permanently bound. K_{oc} and K_{ow} parameters do not readily apply to inorganics, such as dialuminium chloride pentahydroxide. Thus, the equilibrium partitioning methods cannot be used to calculate the $PNEC_{soil}$. Based on its properties, dialuminium chloride pentahydroxide is not expected to significantly adsorb to soil, and the assessment of this compartment will be covered by the aquatic assessment.

8. CATEGORISATION AND OTHER CHARACTERISTICS OF CONCERN

A. PBT Categorisation

The methodology for the Persistent, Bioaccumulative and Toxic (PBT) substances assessment is based on the Australian and EU Reach Criteria methodology (DEWHA, 2009; ECHA, 2008).

Dialuminium chloride pentahydroxide is an inorganic compound that dissociates in water to form chloride ions and various species of aluminium hydroxide hydrolysis. Biodegradation is not applicable to dialuminium chloride pentahydroxide. Both chloride ions and aluminium hydroxide ionic species can be found naturally in the environment. For the purposes of this PBT assessment, the persistent criteria are not considered applicable to this inorganic compound.

Fish accumulate aluminium in and on the gill, and it has been suggested that the rate of transfer of aluminium into the body is either slow or negligible under natural environmental conditions. Chloride ions are essential to all living organisms, and their intracellular, and extracellular concentrations are actively regulated. Thus, dialuminium chloride pentahydroxide and its dissociated ions are not expected to meet the criteria for bioaccumulation.

The lowest chronic NOEC value in fish for aluminium is <0.1 mg/L; thus, the dissolved aluminium from dialuminium chloride pentahydroxide meets the screening criteria for toxicity.

The overall conclusion is that dialuminium chloride pentahydroxide is not a PBT substance.

B. Other Characteristics of Concern

No other characteristics of concern were identified for dialuminium chloride pentahydroxide.

9. SCREENING ASSESSMENT

Chemical Name	CAS No.	Overall PBT Assessment [1]	Chemical Databases of Concern Assessment Step		Persistence Assessment Step		Bioaccumulative Assessment Step	Toxicity Assessment Step			Risk Assessment Actions Required[3]
			Listed as a COC on relevant databases?	Identified as Polymer of Low Concern	P criteria fulfilled?	Other P Concerns	B criteria fulfilled?	T criteria fulfilled?	Acute Toxicity [2]	Chronic Toxicity[2]	
Dialuminium Chloride Pentahydroxide	12042-91-0	Not a PBT	No	No	NA		No	Yes	3	1	3

Footnotes:

1 - PBT Assessment based on PBT Framework.

2 - Acute and chronic aquatic toxicity evaluated consistent with assessment criteria (see Framework).

3 - Tier 3 - Quantitative Risk Assessment: Complete PBT, qualitative and quantitative assessment of risk.

Notes:

NA = Not Applicable

PBT = Persistent, Bioaccumulative and Toxic

B = bioaccumulative

P = persistent

T = toxic

10. REFERENCES, ABBREVIATIONS AND ACRONYMS

A. References

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B. Abbreviations and Acronyms

°C	degrees Celsius
ADWG	Australian Drinking Water Guidelines
DEWHA	Department of the Environment, Water, Heritage and the Arts
EC	effective concentration
ECHA	European Chemicals Agency
EU	European Union
GHS	Globally Harmonised System of Classification and Labelling of Chemicals
HHRA	enHealth Human Risk Assessment
IUPAC	International Union of Pure and Applied Chemistry
Kl	Klimisch scoring system
LOAEL	lowest observed adverse effect level
mg/kg	milligrams per kilogram
mg/L	milligrammes per litre
mg/m^3	milligrammes per cubic metre
MW	molecular weight
NICNAS	The National Industrial Chemicals Notification and Assessment Scheme
NOAEC	No Observed Adverse Effect Concentration
NOAEL	no observed adverse effect level
NOEC	no observed effective concentration
OECD	Organisation for Economic Co-operation and Development
PBT	Persistent, Bioaccumulative and Toxic
PNEC	Predicted No Effect Concentration

ppm	parts per million
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
RfD	Reference Dose
SDS	Material Safety Data Sheet
SMILES	simplified molecular-input line-entry system
TGD	Technical Guidance Document
USEPA	United States Environmental Protection Agency
UVCB Materials	Unknown or Variable Composition, Complex Reaction Products and Biological
WHO	World Health Organisation
µm	micrometre

Appendix 8 – Exposure Pathways

	Lifecycle Primary Source	Potential Drillling and Completion Chemical Exposure - Activities						
	Modes of Exposure	Blending & Storage of Products	Drilling Operations	Storage & Recycling of Fluids and Cuttings	Land Application/Beneficial Reuse of Muds and Cuttings	Irrigation Beneficial Reuse	Stockwater Beneficial Reuse	Dust Supression, Construction and Operational Benefical Reuse
Affected Media/Environment	Stored Fluids / Produced Water	Yes	Yes	Yes	Yes	Yes	Yes	No
	Soils	No	No	No	Yes	Yes	No	Yes
	Surface Water	No	No	No	Yes	Yes	No	Yes
	Groundwater	No	Yes	No	No	No	No	No
Stored Fluids / Produced Water								
Human Receptors	Worker	NA	NA	NA	NA	NA	NA	-
Ecological Receptors	Terrestrial flora	IC	IC	IC	I/LP	IC	IC	-
	Terrestrial fauna	I/LP	IC	I/LP	C	C	C	-
	Aquatic flora	IC	IC	IC	I/LP	IC	IC	-
	Aquatic fauna	IC	IC	IC	I/LP	IC	IC	-
Soils								
Human Receptors	Worker	-	-	-	NA	NA	-	NA
	Agricultural Worker or Resident	-	-	-	C	C	-	NA
Ecological Receptors	Terrestrial flora	-	-	-	I/LP	C	-	I/LP
	Terrestrial fauna	-	-	-	C	C	-	I/LP
	Aquatic flora	-	-	-	I/LP	IC	-	IC
	Aquatic fauna	-	-	-	I/LP	IC	-	IC
Surface Water								
Human Receptors	Worker	-	-	-	NA	NA	-	NA
	Agricultural Worker or Resident	-	-	-	NA	C b	-	NA
Ecological Receptors	Terrestrial flora	-	-	-	IC	C b	-	IC
	Terrestrial fauna	-	-	-	IC	C b	-	IC
	Aquatic flora	-	-	-	I/LP	I/LP	-	I/LP
	Aquatic fauna	-	-	-	I/LP	I/LP	-	I/LP
Groundwater								
Human Receptors	Worker	-	NA	-	-	-	-	-
	Agricultural Worker or Resident	-	C	-	-	-	-	-
Ecological Receptors	Terrestrial flora	-	IC	-	-	-	-	-
	Terrestrial fauna	-	C a	-	-	-	-	-
	Aquatic flora	-	IC	-	-	-	-	-
	Aquatic fauna	-	IC	-	-	-	-	-

NOTE	
C	Complete exposure pathway
IC	Incomplete exposure pathway
I/LP	Insignificant / Low Probability Exposure Pathway
NA	Not a Matters of National Environmental Significance (MNES)
a	Livestock only
b	Surface ponding resulting from application of irrigation

	Lifecycle Primary Source	Potential Hydraulic Fracturing Chemcial Exposure - Activites				
	Modes of Exposure	Blending & Storage of Products	Hydraulic Fracturing Operations	Irrigation Beneficial Reuse	Stockwater Beneficial Reuse	Dust Supression, Construction and Operational Benefical Reuse
Affected Media/Environment	Stored Fluids / Produced Water	Yes	Yes	Yes	Yes	No
	Soils	No	No	Yes	No	Yes
	Surface Water	No	No	Yes	No	Yes
	Groundwater	No	No	No	No	No
Stored Fluids / Produced Water						
Human Receptors	Worker	NA	NA	NA	NA	-
Ecological Receptors	Terrestrial flora	IC	IC	IC	IC	-
	Terrestrial fauna	I/LP	I/LP	C	C	-
	Aquatic flora	IC	IC	IC	IC	-
	Aquatic fauna	IC	IC	IC	IC	-
Soils						
Human Receptors	Worker	-	-	NA	-	NA
	Agricultural Worker or Resident	-	-	C	-	NA
Ecological Receptors	Terrestrial flora	-	-	C	-	I/LP
	Terrestrial fauna	-	-	C	-	I/LP
	Aquatic flora	-	-	IC	-	IC
	Aquatic fauna	-	-	IC	-	IC
Surface Water						
Human Receptors	Worker	-	-	NA	-	NA
	Agricultural Worker or Resident	-	-	C b	-	NA
Ecological Receptors	Terrestrial flora	-	-	C b	-	IC
	Terrestrial fauna	-	-	C b	-	IC
	Aquatic flora	-	-	I/LP	-	I/LP
	Aquatic fauna	-	-	I/LP	-	I/LP
Groundwater						
Human Receptors	Worker	-	-	-	-	-
	Agricultural Worker or Resident	-	-	-	-	-
Ecological Receptors	Terrestrial flora	-	-	-	-	-
	Terrestrial fauna	-	-	-	-	-
	Aquatic flora	-	-	-	-	-
	Aquatic fauna	-	-	-	-	-

NOTE	
C	Complete exposure pathway
IC	Incomplete exposure pathway
I/LP	Insignificant / Low Probability Exposure Pathway
a	Livestock only
b	Surface ponding resulting from application of irrigation

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Appendix 9 – Summary of Best Practice Methodologies

Best Practice Risk Assessment Methodology – Chemical Additives

The approval defines "best practice risk assessment methodology" as follows:

- A chemical risk assessment in accordance with best practice national or international standards and guidelines may be based on the following:
  - United States Environmental Protection Agency (USEPA) (2014). EPA-Expo-Box (A Toolbox for Exposure Assessors), available at http://www.epa.gov/expobox
  - Organisation for Economic Co-operation and Development (OECD) (2014). The OECD Environmental Risk Assessment Toolkit: Tools for Environmental Risk Assessment and Management, available at https://www.oecd.org/env/ehs/risk-assessment/environmental-risk-assessment-toolkit.htm
  - The most recently published and approved guideline recommended by the Minister
- In addition, the chemical risk assessment must be based following best practice guidance:
  - Department of the Environment and Energy (DoEE) (2017). Exposure Draft: Risk Assessment Guidance Manual: for chemicals associated with coal seam gas extraction (CSG Risk Assessment Guidance Manual). Commonwealth of Australia, available at www.environment.gov.au/water/coal-and-coal-seam-gas/national-assessment-chemicals/consultation-risk-assessment-guidance-manual
  - The National Environment Protection (Assessment of Site Contamination) Measure (NEPM) 1999 as amended 2013; specifically, Volume 5: Schedule B4 Guideline on Site-Specific Health Risk Assessment
  - Environmental health risk assessment: Guidelines for assessing human health risks from environmental hazards, enHealth Subcommittee (enHealth) of the Australian Health Protection Principal Committee, Canberra, Australia, 2012a
  - Australian exposure factor guidance, enHealth Subcommittee (enHealth) of the Australian Health Protection Principal Committee, Canberra, Australia, 2012b

USEPA's EXPOsure toolBOX (EPA-Expo-Box) has been referenced as a framework that should be leveraged in the chemical risk assessment. EPA-Expo-Box was developed by USEPA Office of Research and Development, as a compendium of exposure assessment tools that links to exposure assessment guidance, databases, models, key references and related resources. The toolbox provides a variety of exposure assessment resources organized into six Tool Sets, each containing a series of modules as shown in the table below:

Table 8-1: Document Revision and Approval Requirements

Approach	Media	Routes
• Direct Measurement (Point-of-Contact) • Indirect Estimation (Scenario Evaluation) • Exposure Reconstruction (Biomonitoring and Reverse Dosimetry)	• Air • Water and Sediment • Soil and Dust • Food • Aquatic Biota • Consumer Products	• Inhalation • Ingestion • Dermal
Tiers and Types	**Life Stages and Population**	**Chemical Classes**
• Screening-Level and Refined • Deterministic and Probabilistic • Aggregate and Cumulative	• General Population • Residential Consumer • Occupational Workers • Life stages • Highly Exposed	• Pesticides • Other Organics • Inorganics and Fibres • Nanomaterials

For example, the inhalation module under the route tool set provides the following:

- Method used in the dose-response
- Calculations for exposure concentrations and potential dose
- Estimating media-specific concentrations
- Exposure scenarios and potential receptors
- Exposure factors
- Guidance and references.

OECD Environmental Risk Assessment Toolkit provides access to practical tools on environmental risk assessment of chemicals. It describes the general work-flow of environmental risk assessment and provides examples of risk assessment. The toolkit also provides links to relevant tools developed by OECD and member countries that can be used in each step of the work-flow. The examples provide a roadmap of the process, showing the steps involved in each case and the tools that were used.

The OECD general risk assessment process for environmental risk assessment includes four steps: hazard identification, hazard characterisation, exposure assessment, and risk characterization. summarises the available tools for the risk assessment process.

Table 8-2: Summary of Available Tools for Risk Assessment

Categories		Links to Available Materials	Explanation
Hazard Assessment	Gathering existing information	OECD Existing Chemicals database	OECD-wide agreed hazard assessments elaborated in the OECD Co-operative Chemicals Assessment Programme
		eChemPortal	Global Portal to Information on Chemical Substances
		Manual for the Assessment of Chemicals (Chapter 2)	A set of guidance documents for (initial) risk assessment developed for the OECD Co-operative Chemicals Assessment Programme. See chapter 2 for gathering data
	Evaluating existing information	Manual for the Assessment of Chemicals (Chapter 3)	See chapter 3.1 for determining the quality of existing data
	Generating new data	Test guidelines	Test methods for assessing (hazard) properties of chemicals
		The OECD (Q)SAR Project	Guidance and tools for filling data gaps by non-testing methods.
	Assessing the hazards	Manual for the Assessment of Chemicals (Chapter 4) & (Chapter 5)	Chapter 4 provides guidance assessing the hazards of chemical substances to man and the environment Chapter 5 provides guidance on elaborating a hazard assessment report.
		Series on Testing and Assessment	Guidance documents and reports related to assessment of several inherent effects
Expo sure		Environmental Exposure Assessment Strategies for	An overview of the approaches on environmental exposure assessment used in the late

Categories		Links to Available Materials	Explanation
	General guidance for exposure assessment	Existing Industrial Chemicals in Member Countries	1990s by OECD member countries
		Manual for the Assessment of Chemicals (Chapter 6)	Guidance on reporting exposure information (Section 6.2) and on initial exposure assessment. (Sections 6.3 and 6.4)
	Measuring or estimating releases to the environment	Emission Scenario Documents	Estimating emission of chemicals in specific industry and use categories
		Global Portal to PRTR Information (PRTR net)	A gateway and databases of global information on Pollutant Release and Transfer Registers (PRTRs)
		Resource Centre for PRTR Release Estimation Techniques	
		Centre for PRTR Data	
	Environmental fate and pathways	Test guidelines	Test methods for assessing (hazard) properties of chemicals
		The OECD (Q)SAR Project	Guidance and tools for filling data gaps by non-testing methods.
		Pov and LRTP Screening Tool	A tool for screening overall persistence and long-range transport potential of chemicals
		Guidance Document on the Use of Multimedia Models for Estimating Overall Environmental Persistence and Long-range Transport	Guidance on the models estimating Pov and LRTP
		EPISuite™	The EPI (Estimation Programs Interface) Suite™ is a Windows®-based suite of physical/chemical property and environmental fate estimation programs developed by the USEPA's Office of Pollution Prevention Toxics and Syracuse Research Corporation (SRC).
	Measuring or estimating concentrations in the environment	Report on improving the use of monitoring data	The workshop report on the use of monitoring data in exposure assessment
		Available tools and models for exposure assessment	A list of tools and models developed and used in OECD member countries for different tiers of exposure assessment.
Other Relevant Materials/ Risk Assessment of Specific Chemicals		New Chemical Assessment Comparisons and Implications for Work Sharing	Comparison of risk assessment of new chemicals.
		Policy Dialogue on Exposure Assessment	Comparison of approaches to exposure assessment in OECD member countries
		Pesticide Testing and Assessment	Guidance documents etc. on hazard and exposure assessment

Categories	Links to Available Materials	Explanation
	Biocides	of pesticides and biocides respectively.

The CSG Risk Assessment Guidance Manual (DoEE 2017) references the USEPA and OECD toolboxes in developing their chemical risk assessment framework and their tools to guide best practice for human health and environmental risk assessment. These toolboxes are all based on the principles contained within USEPA's risk assessment guidelines. As a toolbox, not all of the tools are to be utilized, rather only those tools that are appropriate to the chemical, its functional toxicity, and the exposure pathway being used for assessment should be used. As with all risk assessment methods, a hierarchy is applied in the use and assessment of data on exposure point concentrations and toxicity, with direct measurements and toxicity values provided by epidemiological studies providing the least uncertainty in the risk assessment process.

Best Practice Risk Assessment Methodology – Geogenic Chemicals

The assessment of geogenic chemicals recovered during drilling activities or within produced water will be subject to a screening assessment and if required qualitatively assessed against published or derived risk-based criteria depending on their end fate (i.e. use and/or disposal).

For aqueous residual drilling material, potentially applicable criteria may include:

- Human Health:
    - National Water Quality Management Strategy (NRMMC) Australian Drinking Water Guidelines (2017).
    - WHO Drinking-water Quality, Fourth Edition (2017)
    - USEPA Regional Screening Levels (RSLs) for tap water (November 2018 update) (2018).
    - USEPA Maximum Contaminant Levels (MCLs, 2009)
- Environmental and Ecological:
    - Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018)
    - Risk-Based Screening Levels for the Protection of Livestock Exposed to Petroleum Hydrocarbons, Publication Number 4733 (API, 2004)
    - Republic of South Africa (1993) South African Water Quality Guidelines
    - USEPA National Recommended Water Quality Criteria for Priority Pollutants (2009)
    - USEPA Region 3 Biological Technical Assistance Group Freshwater Screening Benchmarks (2011c).

The screening criteria hierarchy utilised the following for solid residual drilling material includes:

- Human Health Environmental and ecological (including phytotoxicity)
    - The National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended 2013 (ASC NEPM)
    - CRC CARE Technical Report 10: Health screening levels for petroleum hydrocarbons in soil and groundwater (Friebel and Nadebaum, 2011, CRC CARE Technical Report no. 10)
    - USEPA May 2016 RSLs (RSL TR = 1.0, THQ = 0.1)
    - Risk-Based Screening Levels for the Protection of Livestock Exposed to Petroleum Hydrocarbons, Publication Number 4733 (API, 2004).

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Appendix 10 – Contingency Response Actions

Contingency Response Actions for Chemicals used in Coal Seam Gas Extraction

Santos Towrie Development

Petroleum Lease (PL) 1059

Introduction

This document provides an overview of management practices in place within Santos to minimise the risk of potential harm to Matters of National Environmental Significant (MNES) from an accidental spill or release of chemicals used in the extraction of Coal Seam Gas.

The potential for harm and any responding actions necessary to manage the risk of harm will also be informed by the outputs of the Chemical Risk Assessment(s) and the Environmental Management Plan.

This document provides a framework for Santos to:

- Inform response to a spill or accidental release;
- Communicate with the appropriate parties in the event of a spill or accidental release;
- Inform environmental management and / or remedial actions necessary; and
- Inform monitoring and reporting

Scope and Response Process Overview

Scope

This document addresses all spills and accidental releases for the chemicals used for the extraction of coal seam gas to the environment. It does not include spills or releases that occur within operational or construction areas or other chemical substances.

Spill or accidental release scenarios could include (but not limited to):

- Transport truck rollover
- Overflow, over topping or failure of storages such ponds and tanks
- Failure of transfer pipelines, hoses or associated connections
- Uncontrolled releases from irrigation areas

Response Process Overview

To align with overarching emergency response actions for the Towrie Development a copy of the standard response procedure for a chemical spill or accidental release is provided as Attachment 1.

To respond to a spill or accidental release and in accordance with Santos escalation procedures, a combination of on-site field resources, regional operations resources and other company resources will be utilised. Contractors will be utilised as needed to implement management and / or remedial actions and monitoring.

Response actions as provided in the following section.

Response Actions

These actions will be executed with the aim to:

- Reduce the threat to human life or injury
- Protect and manage the risk of harm to the environment (including MNES), and
- Preserve infrastructure, product, and equipment.

General Response Actions

1. **Evacuate** (all non-essential personnel at the location)
2. **Eliminate** (sources of ignition, sparks, etc.)
3. **Stop and Coordinate** (stop source of the incident (e.g. spill) and coordinate shut down of relevant equipment, if possible)
4. **Notify** (internal and external notifications)
   (a) All emergency environmental incidents must be reported to the Santos Duty Manager upon discovery, and
   (b) Conduct regulatory or emergency services report, as required
5. **Identify** (material (if unknown) and identify PPE, hazards, and response procedures using SDSs)
6. **Contain / Isolate** (contain released material / incident using emergency response equipment and/or set up perimeter to isolate area)
7. **Stabilise and Neutralise** (neutralise / stabilise spilt material (where relevant), use absorbents to stabilise released materials etc)
8. **Clean up** (remove released materials, spill response materials, and affected clean-up media etc.)
9. **Evaluate** (based on the outcomes of the Chemical Risk Assessment)
10. **Document**
11. **Monitor and Manage and / or Remediate** (as necessary based on the outcomes of step 9 and outcomes of monitoring), and
12. **Report.**

Accidental Releases to Land

Utilising the steps described above, actions associated with a release to land are focused on stopping and containing the release, thereby preventing further migration and the risk of receptor exposure.

Following containment, and based on the outcomes of the Chemical Risk Assessment in relation to the potential risk to MNES, soil will either be:

- Left in-situ – only where there is no risk of adverse impact to MNES (i.e. concentrations are non-hazardous and / or do not persist at hazardous concentrations, and / or there is no exposure path way to MNES
- Excavated and disposed (in accordance with regulatory requirements) and / or remedial action applied to treat the soil
- Sampled and analysed to inform whether residues within soils need to be excavated and disposed, or managed in-situ.

Post excavation or implementation of management actions, validation monitoring (sampling) may be necessary to confirm that that sufficient residue has been removed or, to confirm that management actions have been successful in managing the risk of adverse impact to MNES. Conversely monitoring may demonstrate that an unacceptable risk remains and that further excavation or management actions would be required to manage that risk. Validation monitoring and remedial actions would be repeated until it has been demonstrated that the risk of adverse impact to MNES has been managed.

Accidental Releases to Water

Where releases occur to water the nature of the response actions are focused on containment of the release and then the associated impacted water to the extent feasible. This can involve a range of activities dependent on the nature of the resource involving establishment of temporary earthen dams, containment booms or sorbent booms.

Consistent with the hierarchy described above stopping further migration to water and limiting the extent of migration downstream is the primary focus of initial activities.

Remediation activities will focus on removal of the chemical released and may involve a combination of pumping and removal of impacted water and/or treatment in place (for example aeration for organic volatile compounds).

Communication

Internal Communication

Emergency incidents will initially be notified internally to facilitate resourcing and effective response actions. This may involve co-ordination with emergency services (fire, police, ambulance) as necessary. Further, all emergency environmental incidents will be recorded in the Incident Management System (IMS) as soon as possible.

Regulatory Notifications

Notification will be made to the Department of Agriculture, Water and the Environment in accordance with the relevant approval requirements.

Incident investigation

All incidents will be investigated to determine the casual factors and associated underlying root causes.

Attachment 1

Santos Standard - Chemical Spill Checklist

3.6 Chemical Spills/Gas Release Procedure Activity Checklist

Person at Incident Scene

- Remove yourself and others from danger (DO NOT place yourself in unnecessary danger) ☐
- Raise the alarm and report the nature, location and extent of emergency – (Call "Emergency, Emergency, Emergency" on nominated site radio channel or trigger a manual alarm) ☐
- Immediately try to locate the source of the spill ☐
- If release is from a storage facility, isolate/contain the release (if it is safe to do so) by closing valves, switching off pumps, blocking drains, establishing temporary bunds, use of spill kits, contacting control room etc ☐
- Identify and isolate any potential sources of ignition ☐
- Evacuate areas that may be affected by the spill either directly or through exposure to fumes (**remember your safety is paramount**) ☐
- Go to Emergency Muster Point/Control Room, stay until directed by the Muster Point Warden or Operations Officer ☐
- When evacuating a chemical spill/gas release, DO NOT GO DOWNHILL/DOWNWIND OF THE SOURCE, AS EXPOSURE TO THE FUMES MAY BE LIFE THREATENING ☐
- If evacuating from a release, evacuate uphill and upwind of emergency site - avoid passing through fume affected areas en route to Muster Point ☐
- Provide First Aid to any injured persons if qualified to do so ☐
- Ensure that any contaminated personnel utilise emergency showers and eye washes ☐

Operations Officer

- Initiate alarms to warn site personnel – audible alarms, broadcast on radio, word of mouth ☐
- Ensure site of emergency is evacuated to a safe distance: evacuate all areas that; ☐
  - Are directly affected by the release (impinged/engulfed) ☐
  - May be indirectly affected (eg exposure to toxic fumes/vapour cloud, access restrictions) ☐
- Notify the ERC and provide a detailed SITREP of the situation (details, site location/conditions) ☐
- Arrange for the safe shutdown of equipment/plant in the affected area ☐
- Identify released materials and source appropriate MSDS's; make these available for response personnel as necessary ☐
- In consultation with the Muster Point Warden, determine the suitability of the Primary Emergency Muster Point/Control Room (is it affected by/downwind of release); determine alternate Muster Point as required ☐

- For an offsite spill/release, ensure that the ERC has all information required to carry out appropriate notification of government departments, Police etc
- Relay all environmental information to the ERC and EOC and ensure that appropriate environmental/governmental agencies are notified
- Determine containment/decontamination requirements (in consultation with ERT or specialists – onsite or offsite) and source equipment from offsite as required – confer with EOC
- Continue to provide SITREPS to the ERC and ERT - develop ongoing response strategy in consultation with them
- When developing response strategies, consider;
    - Advice from Environmental Department
    - Physical response constraints (weather, wind direction/strength, release location)
    - Review available MSDSs
    - PPE/response equipment availability
    - Exposures of site personnel (injuries/trapped personnel)
- Ensure that appropriate toxic/chemical exposure monitoring is conducted during response to limit responders exposure to within acceptable levels (refer MSDS's)
- Ensure external emergency services have been contacted
- If spill/release escalates or creates secondary hazards to personnel (eg escalation, exposure to spill/release), consider further/more extensive evacuations (or relocation of evacuated personnel)
- Arrange for barricading of affected area until remediation is complete/atmosphere is clear
- When considering the impacts of the release, take into the account any potential for contamination of site water supplies – provide alternate drinking water supply if required
- Try to minimise the impact of the spill by implementing the three C's rule:
    - CEASE flow of release into the surrounding area
    - CONTAIN the spillage
    - CLEAN-UP spill
- Review the need for any off site expertise or equipment to control/contain the spill/release and communicate requirements to the ERC and EOC
- Establish Control Zones
- Assist with investigation and review of the procedures/actions taken

Appendix 11 – Peer Review Checklists

Note: The following checklists for Tier 3 and Tier 4 will inform and guide the review of a submitted chemical risk assessment for a high risk chemical. It is noted that all listed aspects within the respective checklists may or may not be completed, as this will depend on the level and nature of assessment for each chemical. The checklists do not constrain the Minister in their approval of a chemical risk assessment.

Chemical			
Dossier Review Checklist			**Comments (if applicable)**
Dossier Section	**Check if**		
	Yes	**No**	
All Chemicals (Tier 1, 2, 3 and 4)			
Has the substance been correctly identified?			
Have physical/chemical properties been documented?			
Was the chemical listed on any data bases indicating chemical of concern?			
Environmental Hazard Assessment Complete?			
Aquatic acute toxicity			
Aquatic chronic toxicity			
Terrestrial acute toxicity			
Terrestrial chronic toxicity			
Environmental Fate Assessment Complete?			
Biodegradation			
Environmental distribution			
Bioaccumulation			
PBT Assessment Complete?			
Persistent			
Bioaccumulative			
Toxic			
Categorisation Correct?			
Tier 1			
Tier 2			
Tier 3			
Tier 4			
Additional Requirements for Tier 2, 3 and 4 Chemicals			
Human Health Hazard Assessment Complete?			
Acute toxicity			
Irritation/Corrosion			
Skin			
Eye			
Sensitisation			
Genotoxicity			
in vitro			
in vivo			
Carcinogenicity			
Repeated dose toxicity			
Reproductive toxicity			
Developmental toxicity			
PNEC Development Complete?			
Water			
Soil			
Additional Requirement for Tier 3 and 4 Chemicals			
Has an assessment of cumulative impact(s) been completed?			

Note: The following checklists for Tier 3 and Tier 4 will inform and guide the review of a submitted chemical risk assessment for a high risk chemical. It is noted that all listed aspects within the respective checklists may or may not be completed, as this will depend on the level and nature of assessment for each chemical. The checklists do not constrain the Minister in their approval of a chemical risk assessment.

Chemical			
Qualitative Assessment Review Checklist			**Comments (if applicable)**
Assessment Section	**Check if**		
	Yes	**No**	
All Chemicals (Tier 2, 3 and 4)			
Problem Formulation and Issue Identification			
Bounds of the assessment defined (Tier 2, 3 or 4 components listed)?			
Process and usage information provided for the chemical?			
SDS attached?			
Dossier attached?			
Relevant soil and water guidelines detailed?			
Hazard Assessment			
Physical and chemical properties summarized?			
PBT assessment findings described?			
Human Health Hazard Assessment			
Human toxicity endpoints described?			
Risk-based criteria for qualitatively assessing human health exposure defined?			
Potential receptors and potentially complete exposure pathways identified for assessed uses?			
Potential for exposure assessed in context of site setting and management protocols?			
Key controls limiting potential for exposure detailed?			
Environmental Hazard Assessment			
Aquatic and terrestrial toxicity endpoints described?			
Environmental fate properties which impact potential for toxicity evaluated?			
Risk-based criteria for qualitatively assessing ecological exposure defined?			
Potential receptors and potentially complete exposure pathways identified for assessed uses?			
Potential for exposure assessed in context of site setting and management protocols?			
Key controls limiting potential for exposure detailed?			
Risk Communication and Management			
Key plans and/or systems applicable to the management and mitigation of risks associated with chemical usage identified?			

Note: The following checklists for Tier 3 and Tier 4 will inform and guide the review of a submitted chemical risk assessment for a high risk chemical. It is noted that all listed aspects within the respective checklists may or may not be completed, as this will depend on the level and nature of assessment for each chemical. The checklists do not constrain the Minister in their approval of a chemical risk assessment.

Chemical	
Quantitative Assessment Review Checklist	**Comments (if applicable)**
Assessment Section	
All Chemicals (Tier 3)	
Problem Formulation and Issue Identification	
Bounds of the assessment defined (Tier 3 components listed)?	
Process and usage information provided for the chemical?	
SDS attached?	
Dossier attached?	
Relevant soil and water guidelines detailed?	
Hazard Assessment	
Physical and chemical properties summarized?	
PBT assessment findings described?	
Safety/Uncertainty Factors considered?	
Human Health Hazard Assessment	
Human toxicity endpoints described?	
Risk-based criteria for qualitatively assessing human health exposure defined?	
Potential receptors and potentially complete exposure pathways identified for assessed uses?	
Potential for exposure assessed in context of site setting and management protocols?	
Key controls limiting potential for exposure detailed?	
Environmental Hazard Assessment	
Aquatic and terrestrial toxicity endpoints described?	
Environmental fate properties which impact potential for toxicity evaluated?	
Risk-based criteria for qualitatively assessing ecological exposure defined?	
Potential receptors and potentially complete exposure pathways identified for assessed uses?	
Potential for exposure assessed in context of site setting and management protocols?	
Key controls limiting potential for exposure detailed?	
Exposure Assessment	
Mass balance calculations conducted to identify the amount of the chemical used in the process?	
Exposure point concentrations calculated for each applicable release scenario?	
Risk Characterisation	
Potential risks for complete exposure pathways assessed for MNES and non-MNES receptors?	
Risk ratios developed for potentially complete exposure pathways associated with applicable release scenarios?	
Based on the magnitude and severity of the potential exposure, additional quantitative assessment provided relevant to end use?	
Cumulative impact(s) assessed?	
Uncertainty analysis complete?	
Risk Communication and Management	
Key plans and/or systems applicable to the management and mitigation of risks associated with chemical usage identified?	

Note: The following checklists for Tier 3 and Tier 4 will inform and guide the review of a submitted chemical risk assessment for a high risk chemical. It is noted that all listed aspects within the respective checklists may or may not be completed, as this will depend on the level and nature of assessment for each chemical. The checklists do not constrain the Minister in their approval of a chemical risk assessment.

Chemical	
Quantitative Assessment Review Checklist	**Comments (if applicable)**
Assessment Section	
All Chemicals (Tier 4)	
Problem Formulation and Issue Identification	
Bounds of the assessment defined (Tier 4 components listed)?	
Process and usage information provided for the chemical?	
SDS attached?	
Dossier attached?	
Relevant soil and water guidelines detailed?	
Hazard Assessment	
Physical and chemical properties summarized?	
PBT assessment findings described?	
Chemical substitution discussed?	
Safety/Uncertainty Factors considered?	
Human Health Hazard Assessment	
Human toxicity endpoints described?	
Risk-based criteria for qualitatively assessing human health exposure defined?	
Potential receptors and potentially complete exposure pathways identified for assessed uses?	
Potential for exposure assessed in context of site setting and management protocols?	
Key controls limiting potential for exposure detailed?	
Environmental Hazard Assessment	
Aquatic and terrestrial toxicity endpoints described?	
Environmental fate properties which impact potential for toxicity evaluated?	
Risk-based criteria for qualitatively assessing ecological exposure defined?	
Potential receptors and potentially complete exposure pathways identified for assessed uses?	
Potential for exposure assessed in context of site setting and management protocols?	
Key controls limiting potential for exposure detailed?	
Exposure Assessment	
Mass balance calculations conducted to identify the amount of the chemical used in the process?	
Exposure point concentrations calculated for each applicable release scenario?	
Risk Characterisation	
Potential risks for complete exposure pathways assessed for MNES and non-MNES receptors?	
Risk ratios developed for potentially complete exposure pathways associated with applicable release scenarios?	
Full life cycle quantitative risk assessment conducted, including food chain risk assessment?	
Cumulative impact(s) assessed?	
Uncertainty analysis complete?	
Risk Communication and Management	
Key plans and/or systems applicable to the management and mitigation of risks associated with chemical usage identified?	