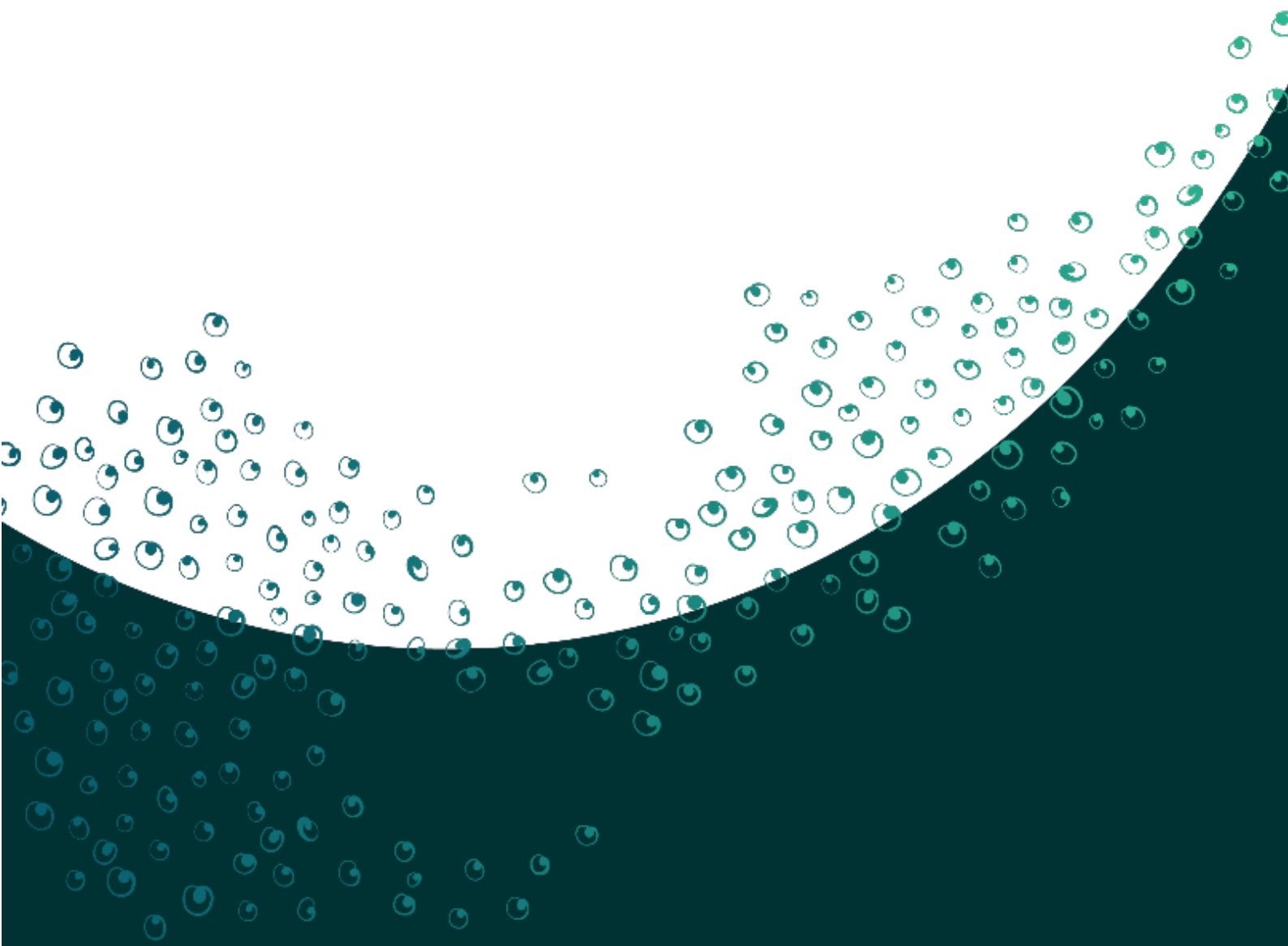

Coal seam gas brine management action plan

2023–2033

Queensland Government

Prepared by: Environmental Services and Regulation, Department of Environment and Science

The Department of Environment and Science acknowledges Aboriginal peoples and Torres Strait Islander peoples as the Traditional Owners and custodians of the land. We recognise their connection to land, sea and community, and pay our respects to Elders past, present and emerging.

The department is committed to respecting, protecting and promoting human rights, and our obligations under the Human Rights Act 2019.

March 2023

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Acknowledgement of Country

The Department of Environment and Science (DES) acknowledges the Country and people of Queensland's First Nations. We pay our respect to Elders, past, present and emerging.

We recognise and value the ongoing contributions of First Nations people and their culture and the opportunities that exist for shared ways of working to protect Queensland's environment.

We acknowledge that:

- Land and water are of spiritual, cultural and economic importance to First Nations people.
- All places in Queensland exist on the traditional country of First Nations people.
- First Nations people's interests, needs and aspirations are integral to the department's core business.

In recognising and respecting thousands of years of environmental stewardship, Queensland's First Nations people and their culture is integral to the department's objective to protect and sustainably manage Queensland's environment and natural, cultural and heritage values. As part of our regulatory approach, we seek to engage and work collaboratively to build a culturally safe work environment that is inclusive of First Nations people's perspectives and values.

DES is committed to working in genuine partnership with Queensland's First Nations people to achieve stronger outcomes for community and for all people. The department's Gurra Gurra Framework 2020–2026 was launched in April 2020. The framework will help us reframe the way we work by holding Country and people at the centre of our business operations and decision-making.

This artwork was developed by the DES Cultural Capability Action Plan working group in conjunction with our graphic designers to represent our Aboriginal and Torres Strait Islander cultural capability.

It features the artwork of Elaine Chambers—a Kuku Yalanji and Koa woman.

The artwork was designed with all elements in mind: water resources, land management, rural lands and coastal areas.

The hands around the main design signify our hands embracing the lands and waterways we care for.

The blue and green background represents the land and waters of Queensland.

Summary

This action plan has been developed in collaboration with industry, community groups and academia to develop a long-term approach for the management of coal seam gas (CSG) brine waste.

CSG brine is generated as a waste stream from the reverse osmosis treatment of CSG water and is currently stored in dedicated storage dams. A number of environmental risks are associated with this interim approach.

At the request of the Queensland Government, the Australian Petroleum Production and Exploration Association (APPEA) prepared a report that summarises some of the brine management options that have been investigated and undertook a feasibility study of the options. This report was peer reviewed by The University of Queensland Centre for Natural Gas (UQ).

The APPEA report recommended crystallisation of brine wastes and salt encapsulation (similar to that of a lined landfill) as the most feasible management approach at this stage. This outcome is supported by UQ with a recommendation to continue investigation into other management options.

Around 5 million tonnes of CSG brine waste (in solid salt form) is expected to be generated as a result of CSG activities over the life of the industry. This volume is significantly less than originally estimated for the industry. It is not anticipated that the need for waste facilities will be required until around 2030.

This action plan has been developed collaboratively by the Department of Environment and Science (the department) and industry, landholder and environmental groups and aims to provide a pathway forward to ensure the effective and efficient management of CSG brine waste. It is recognised that while the most feasible option is currently encapsulation of brine waste, research and investigation of alternative options for brine management must be continued in keeping with circular economy principles within the CSG resources sector.

The key principles for CSG brine management identified within this action plan are to:

- ensure a robust regulatory framework
- promote a circular economy
- invest in research and development
- increase transparency and stakeholder engagement.

These principles are supported by seven actions to be carried out by the the department and industry (represented by APPEA). The actions include:

- regular reporting of brine volumes
- review and analysis of the existing regulatory framework for brine management
- updated departmental guidance on CSG brine management
- investigating options for providing public access to data relating to environmental impacts of brine management
- coordinated approach to the consideration of brine management options
- investing in research and development
- publicly reporting on the application of learnings from research and development.

This action plan will be periodically reviewed to ensure currency taking into account emerging research and development including advancements in technological capability and scientific knowledge.

1.0 Overview of CSG brine management in Queensland

Queensland's abundant natural resources include petroleum and gas in addition to coal and minerals. Petroleum and gas resources are typically categorised by the method of extraction, with conventional resources using traditional methods of drilling and unconventional resources using extensive fields of multiple wells and surface infrastructure. CSG is an unconventional resource and is a natural gas that is found in coal deposits. The industry is currently being developed in the Surat and Bowen basins.

As part of the CSG extraction process, large volumes of groundwater are brought to the surface.

In Queensland, CSG water that meets certain water quality criteria may be used for irrigation and other beneficial uses. Water that does not meet the water quality criteria is typically treated using reverse osmosis (RO) so that it may be reused.

CSG brine is a concentrated saline waste resulting from the RO treatment. This brine is stored in dedicated storage dams on an interim basis. Options for managing the brine in the long term have been researched and investigated by industry and academia over the last 10 years, and the findings used to inform development of this action plan.

1.0 Background information

What is CSG?

CSG is natural gas that is found in coal deposits. CSG is extracted through wells drilled into coal seams. The production involves the initial extraction of water from the coal seams to reduce the pressure and release the gas from the coal. The water in the gas is separated when the CSG is brought to the surface. The water extracted from coal seams in Queensland is generally saline and may be available for a range of uses or require treatment prior to reuse depending on the water quality. Figure 1 provides a simple illustration of the CSG process.

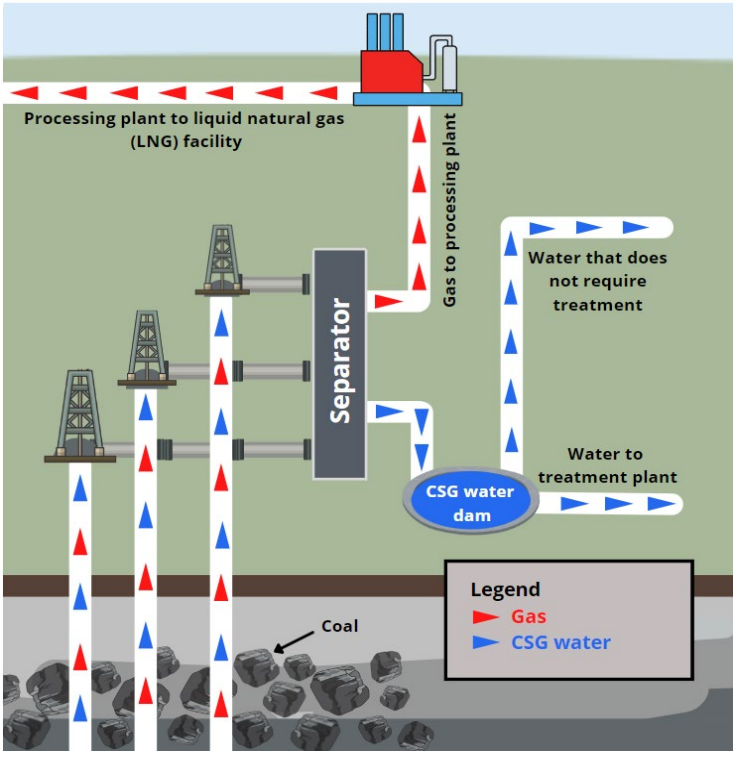

Figure 1 - Coal seam gas process

Reverse osmosis (RO) process

Where CSG water does not meet the required water quality limits for reuse, it is separated for treatment. Typical treatment consists of reverse osmosis (RO) and is illustrated in Figure 2. The RO process applies pressure to pass CSG water through membranes to remove impurities, including salt. Depending on water quality limits, the treated water is either released for a beneficial use or separated for storage in a dedicated dam.

According to information provided by APPEA, more than 90% of water generated from CSG activities in Queensland is made available for a range of beneficial uses such as irrigating crops, watering livestock, commercial use, or added to watercourses[1]. The majority of this water is treated using RO technology.

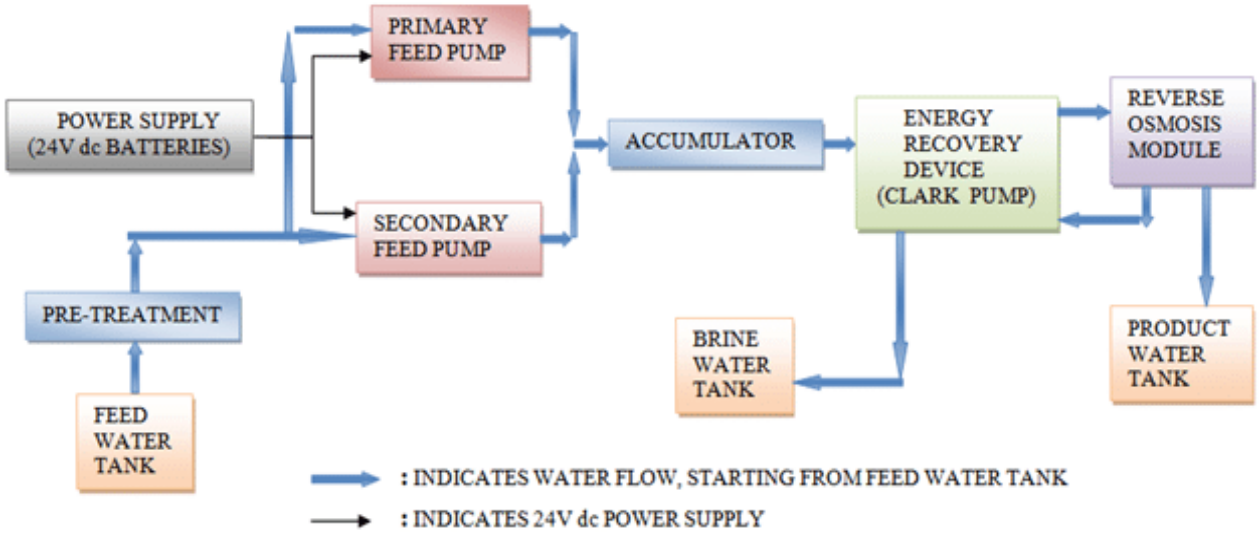

Figure 2 - Process flow diagram of reverse osmosis desalination system (Source: ResearchGate)

What is brine and how much will be produced?

CSG brine is the concentrated saline waste that is produced as a result of treating CSG water using RO technologies. Brine is generally unsuitable for release to the environment and must be appropriately managed in a dedicated CSG brine dam. Treated water that meets the appropriate water quality parameters may be released for a range of beneficial uses (see Figure 3).

The concentration and composition of salts and minerals in the brine depends on the characteristics of the CSG water and the treatment process. The volume and concentrations of total dissolved solids (TDS) in CSG water vary significantly across individual fields. The Department defines brine as saline water with a TDS concentration greater than 40,000 milligrams per litre (mg/L)[2]. This concentration of salt is similar to that of ocean water.

The volume of brine produced by industry is dependent on the volume of water extracted from CSG wells and the concentrations of TDS in the water. The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ 2000) provide evidence and justification for a range of uses dependent on the quality of the water. For example, water with concentrations of TDS up to 3,000 mg/L is considered suitable for cattle stock watering. According to the Surat Cumulative Management Area (CMA) 2021 Underground Water Impact Report (UWIR)[3] approximately 54,000 ML of water is extracted from approximately 8,600 CSG wells in the Surat CMA per year. Concentrations of TDS range from 184 mg/L in the Precipice Sandstone to a range of 1,380-2,442 mg/L in the Walloons Coal Measures.

The volume of salt estimated to be produced has varied over time, with initial industry estimates at up to 15 million tonnes. However, according to APPEA, as actual production and treatment volumes have been assessed, and the estimated volume of salt likely to be generated by industry has reduced to less than a third of the original forecast, to less than 5 million tonnes (see Figure 5). This estimate will continue to be refined as operational data is obtained and assessed.

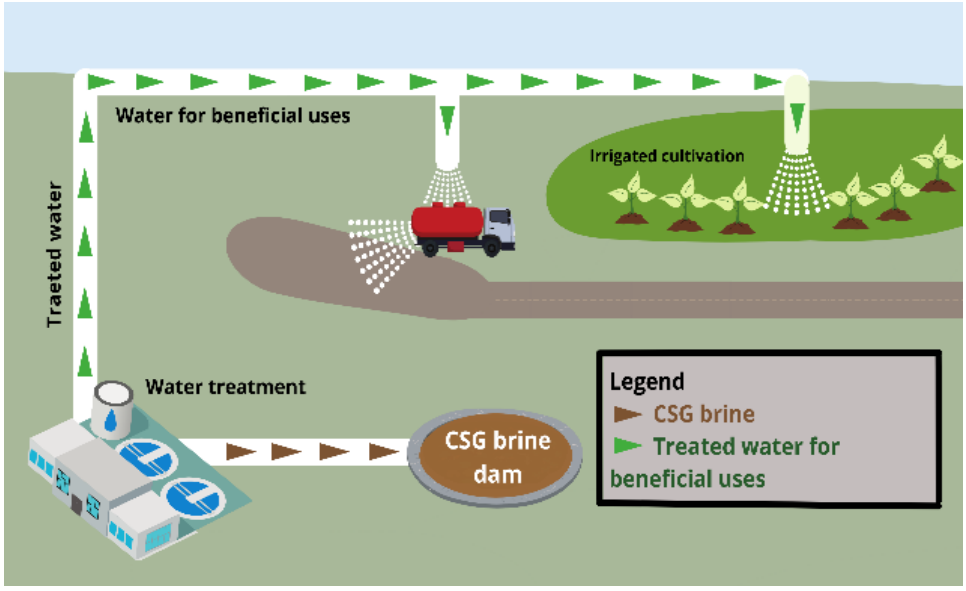

Figure 3 - CSG water treatment, use and storage

Current management of brine

Brine is currently being stored in dedicated storage dams on an interim basis until a long-term disposal strategy is adopted. Generally, storage dams are engineered, constructed, operated and maintained in accordance with the Department's Regulated Structure guidelines[4]. Figure 4 provides an aerial view of a typical regulated dam in the CSG industry. Recent information has identified an innovative above ground tank design for the storage of brine, that is not considered a regulated structure. Information provided to the department by APPEA (Figure 5) indicates there are 36 brine dams located within Queensland with a total estimated storage capacity of 20,811 ML of which 67.24% is currently in use.

Figure 4 – Example of a typical regulated dam in the CSG industry

Figure 5 –Information regarding brine storage and estimated salt volume provided by the CSG industry (as at September 2022)

Environmental risks

Some of the environmental risks associated with storing brine in storage dams include:

- seepage of brine through the dam walls
- overtopping of dams due to excessive rainfall events
- release of brine due to structural failure
- release of brine due to discharge through the leak detection system
- vertical seepage to groundwater
- aerosol salt spray.

These risks are currently managed through environmental management conditions that require monitoring and maintenance of the dams and as part of the overall management of water stored on site.

Public health considerations

According to Queensland Health, a public health risk is something that is likely to be harmful to human health or contribute to disease in humans. Harmful germs and substances may be transmitted from waste, water, air, dead or living animals in the environment. Typically, public health risks are regulated by local governments. However, state, local, and federal authorities may work together to develop standards or rules and conduct inspections to reduce, control, or prevent risks to public health from a range of contaminants.

CSG processes have been monitored and researched over the years. Concerns have previously been raised by residents regarding the impact of CSG activities on their health. Due to these concerns Queensland Health undertook research and investigations regarding potential health issues to air, water, soil, and noise near Tara in Queensland. Information regarding the investigations is available at Environmental health | Queensland Health.

CSG water (from which brine is generated following treatment) is sometimes associated with compounds of benzene, toluene, ethyl-benzene and xylene (BTEX). While BTEX chemicals can be man-made, these compounds can also occur naturally in underground water sources. The use of BTEX in fraccing processes is regulated in Queensland and the addition of these chemicals to fraccing fluid is banned. Information regarding BTEX chemicals and fraccing in Queensland is available at BTEX Chemicals | Department of Environment and Science. Public health guidelines for concentrations of BTEX chemicals in drinking water are identified in the Australian Drinking Water Guidelines (Australian Government, NHMRC).

In naturally occurring water sources in Queensland, BTEX concentrations must not exceed environmental and human health standards, and in ambient and occupational air settings in Queensland the Environmental Protection (Air) Policy 2019 specifies concentrations to ensure protection of human and environmental health; however, no concentrations for salt have been identified.

1.1. Long-term brine management options

The Queensland Government as the environmental regulator has over the last decade considered possible options for the long-term management of brine within the CSG industry. In addition to consulting with industry, the Queensland Government has also engaged with non-industry stakeholders that could potentially be impacted.

In working towards a solution, the government asked APPEA, the peak body for Australia's oil and gas industry, to develop a report to identify industry-wide solutions for the long-term management of brine generated from CSG activities.

The University of Queensland Centre for Natural Gas (UQ) was subsequently engaged by the department to undertake a peer review of the APPEA Report and provide advice, conclusions, and recommendations.

Several potential options for managing brine were investigated, including the following:

- selective salt recovery (reuse)
- ocean outfall (release)
- salt encapsulation (disposal)
- brine injection (disposal).

Each of these options have been considered on their merits regarding environmental, economic, and social outcomes. Details of the key findings and recommendations are provided below.

Australian Petroleum Production and Exploration Association (APPEA) Report

In late 2017, the Queensland Government asked APPEA to prepare a report on a whole-of-industry feasibility study regarding the long-term management of saline wastewater produced by CSG activities in Queensland. In December 2018, APPEA provided a report to the department titled 'Queensland Gas: end-to-end water use, supply and management' (APPEA Report)[1]. The APPEA report provides an overview of several feasibility studies that have been undertaken by industry operators individually or in collaboration with other industry operators that relate to the identification of a long-term strategy for the management of brine generated from CSG operations. The feasibility of brine management options was assessed against a range of criteria including environmental, economic, safety, technical, regulatory and social factors.

The report summarises the findings of the following options examined by the studies:

- selective salt recovery
- brine injection
- ocean outfall
- salt encapsulation.

Option 1: Selective salt recovery (reuse)

Selective salt recovery uses technologies to produce salt products from brine for potential beneficial reuse. The selective salt recovery process commences after stored brine has been further concentrated by solar or other mechanical means. The concentrated brine is then moved via pipeline to a selective salt recovery facility to crystallise the brine into salts. Testing of the process identified crystallisation produced a number of products, such as table salt (sodium chloride) and soda ash (sodium carbonate).

The APPEA report concluded that while this solution is technically feasible there were a number of issues that preclude this approach being adopted industry wide. These are outlined in the table below:

Issue	Reason
Energy use	Selective salt recovery is a highly energy intensive process that requires more energy than any of the other alternatives that were considered.
Chemical use	Selective salt recovery relies upon the use of several chemicals in its operation, thereby increasing safety risks for plant operations and transport of these chemicals to the selective salt recovery facility.
Waste generation	Supply of brine to a centralised processing facility through pipelines requires a pre-treatment process to be used. This pre-treatment process generates additional solid and liquid waste streams that require management and/or disposal.
Noise generation	The mechanical vapour recompression process results in significant noise generation that would require specific attenuation.
Transportation concerns	The transportation of salt products over long distances from the CSG fields to developed transportation hubs (road, rail, ship) increases the risk of a range of transport accidents, that may result in uncontrolled releases and associated environmental impacts.
Certainty	Selective salt recovery does not provide a level of certainty for the industry due to reliance on a single selective salt recovery facility and the proprietary nature of the technology used in the facility meaning that it could be difficult to locate a new operator if necessary.
Market concerns	Selective salt recovery from CSG industry would be entering the existing market for salt and competing with existing suppliers in a loss-making scenario which could result in significant negative impacts for the salt market in Australia and around the world.

Option 2: Brine injection (disposal)

Injection wells are a well-established process which can be used for the disposal of brine. The process involves the placement of brine underground into suitable geological formations. To avoid the movement of brine to other aquifers, the brine would be injected into formations between impermeable layers of rock.

The feasibility of a whole of industry solution based on brine injection into geological formations is dependent on locating a suitable geologically isolated formation which contains sufficient capacity. The potential for environmental harm would also need to be managed through targeting a geological formation that either: does not contain groundwater; or if groundwater is present the brine to be injected is of a similar or better quality then the groundwater in the formation.

The APPEA report concluded that no suitable geologic formation has been identified that could be considered appropriate for injection by the gas industry. Therefore, brine injection was assessed by industry as being not feasible.

Option 3: Ocean outfall (release)

The disposal of brine via ocean outfall would involve the construction of a pipeline that connects the CSG industry's brine dams to a coastal outfall for discharge. This option would not only consist of the construction of a main transfer pipeline to the coast of several hundred kilometres, but also include the construction of a number of infield pipelines of an additional several hundred kilometres in total to connect to the main transfer pipeline.

The APPEA report concluded that while this solution is technically feasible there were a number of issues that limit the viability of this approach being considered. These are outlined in the table below:

Issue	Reason
Route	The potential pipeline route could traverse over a thousand properties, including highly developed urban areas on the coast at the eastern end of the pipeline.
Land disturbance	The construction activities would involve significant land disturbance.
Costs	Elevated costs for specifically engineered pipeline infrastructure to ensure containment and minimisation of corrosion over the lifetime of the gas industry. While suitable pipeline materials are available the costs of the pipeline would be a significant increase compared with the costs of a similar potable water or water pipeline.
Water quality	The ocean outfall would be required to operate over a wide range of salinity concentrations and compositions while being capable of achieving the necessary diffusion of brine within a mixing zone which does not cause a negative impact.

Option 4: Salt encapsulation (disposal)

Salt encapsulation is a term used for the disposal of salt via placement in a landfill facility that has been specifically sited, designed, constructed and operated for the salt waste.

The process of salt encapsulation involves the conversion of brine as a liquid to a mixed salt as a solid, using a crystalliser prior to placement in a dedicated cell for disposal. The salt placed in the landfill would be contained by a multi-layered liner system designed and constructed by an appropriately qualified person to specific standards for the identified location and identified waste. A liner would be designed by a suitably qualified person and installed prior to the deposition of salt and generally consist of a leachate collection system and a multi-layered liner system.

After landfill capacity has been reached, a multi-layer capping system would be installed to form a seal on the landfill to prevent water infiltration. During the operational life of the landfill, deposited waste would be covered with a suitable cover material to limit rainwater infiltration.

Figure 6 provides a graphical representation of a typical landfill that could accept a range of waste (including salt), that includes a representative liner and leachate system prior to the placement of waste, followed by the construction of an appropriate capping system. The representation is based on typical landfill standards across Australia. For further guidance regarding landfill siting and design in Queensland, please visit the department's website: www.des.qld.gov.au.

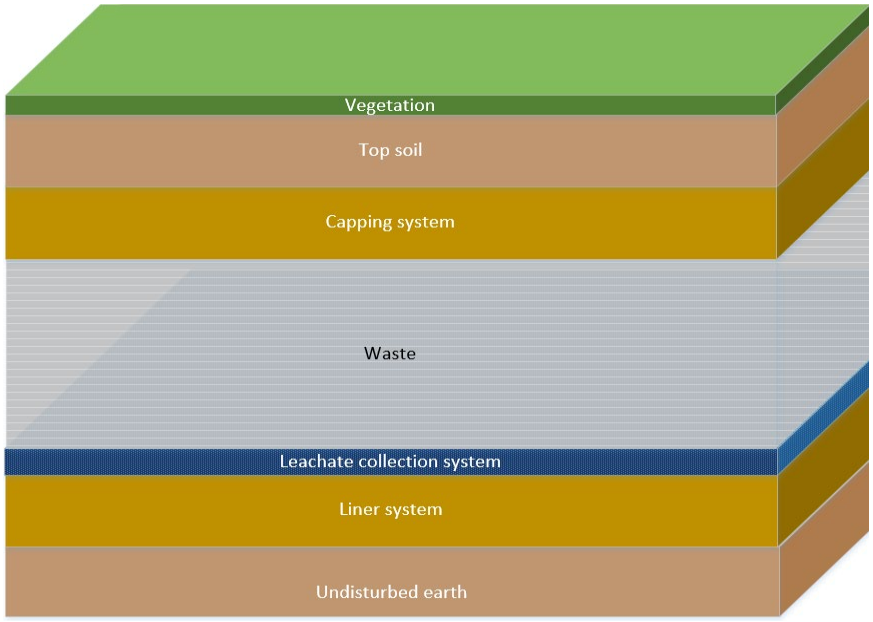

Figure 6 - Capping and liner system for a landfill that could accept waste material such as salt

Recommendation

The APPEA report concluded that while initial preliminary studies identified selective salt recovery as the most suitable option for brine management, further investigation identified that the most viable brine management option is salt encapsulation.

The University of Queensland Report

In 2019, the department engaged The University of Queensland (UQ) Centre for Natural Gas to conduct an independent peer review of the conclusions of the APPEA report. UQ was asked to determine if all practical options for brine management had been considered and comment on the feasibility of the identified options and conclusions. Additional advice was also sought on whether there were other practical options warranting further investigation. In February 2020, UQ provided the Independent review: Brine and salt management Queensland Gas: end-to-end water use, supply and management)[5] (UQ report).

The UQ report concluded that industry has reviewed all reasonable brine disposal options available at the time. While some of the investigations were dated, no new options have emerged in the intervening years to make the original investigations irrelevant or provided new avenues for investigation. The information provided supports the industry conclusion that salt encapsulation is the most technically viable brine management option. This conclusion is based on this option being a proven technology with well-established and effective regulatory processes to manage key environmental risks.

The UQ report stated in its recommendations that it is prudent for government and industry to plan on the basis that crystallisation of brine and construction and operation of salt encapsulation facilities provide, at least in the medium term (10–15 years), the best approach for the management of brine. The review made the following recommendations:

1. The requirements of the environmental assessment process toward permitting salt encapsulation facilities should be determined rapidly to ensure that all technical information can be provided to meet regulatory requirements and the necessary public consultation and education processes can be managed effectively.
2. APPEA and the companies should place a high priority on stakeholder engagement and consultation to build the level of community acceptance required for salt encapsulation facilities. The level to which this is achieved for the first salt encapsulation facilities will affect future proposals and the ongoing social licence of the industry.
3. The department should determine the residual risk management requirements that will apply to the salt encapsulation facilities. This regulatory mechanism is critical in ensuring the long-term physical integrity of the sites and addressing community concerns regarding the management of the facilities beyond the lifetime of the CSG industry.
4. A public reporting process be developed to provide access to all monitoring data and demonstrate that the salt encapsulation facilities are complying with all regulatory requirements and that the physical integrity of the site is maintained.
5. The department should conduct five-yearly reviews of brine/salt production management to:
    a. confirm that industry planning for management and disposal options is at an appropriate scale, given the likelihood of production estimates continuing to change
    b. review the latest research and determine if there are any relevant emerging technologies.
6. The CSG industry should continue to invest in research that will:
    a. minimise the medium and long-term risks of salt encapsulation facilities
    b. reduce energy intensity and operational costs of brine management and salt disposal options
    c. investigate any emerging technologies that are identified through their own efforts or in future reviews.

The conclusions and recommendations above have been taken on board in the development of the actions provided in section 3.0.

1.2. Regulatory framework

The Queensland Government has a rigorous framework in place for the regulation of resource and prescribed activities. This regulatory framework is comprised by a range of legislation and associated regulations, policies, and guidance materials which impose a number of requirements and restrictions on an operator when undertaking an activity. Below is a summary the relevant regulatory framework as it applies to CSG brine management, either as a resource activity or a prescribed activity, in Queensland. Approvals obtained under the *Environmental Protection Act 1994* (EP Act) do not remove the need to obtain any additional approvals or comply with other relevant legislative requirements under other state and/or Commonwealth legislation, for example the *Regional Planning Interests Act 2014*.

Environmental Protection Act 1994

The object of the EP Act is to protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends.

The EP Act sets the regulatory framework for assessing and authorising the carrying out of environmentally relevant activities (ERAs). ERAs include agricultural activities, resource activities, and other activities prescribed by regulation (prescribed ERAs).

The Environmental Protection Regulation 2019 (EP Regulation) then prescribes a number of ERAs in Schedule 2. Of relevance to the management of CSG brine is waste disposal (ERA 60), which consists of operating a facility for disposing of regulated waste and/or or general waste.

Regulated waste is defined in the EP Regulation and includes non-toxic salts. Schedule 9 of the EP Regulation identifies 'non-toxic salts, including, for example, 'saline effluent' as a category 2 regulated waste. Brine and salt produced during CSG production is therefore captured under this definition.

The authorising instrument under the EP Act for both prescribed and resource ERA's is an Environmental Authority (EA). The specific assessment criteria are tailored to each ERA type and application/assessment process. However, the general approach taken to assessing EA applications under the EP Act for both resource and prescribed activities involves consideration of the following:

1. *Environmental values* Identifying the potential environmental values affected.
2. *Environmental impacts* Assessing the risk of adversely impacting the relevant environmental values (in the short and long term).
3. *Mitigation measures* Considering what controls could be implemented to minimise these risks and whether they are sufficient.
4. *Licence conditioning* If mitigation measures are sufficient, imposing conditions on the EA requiring the operator that address operation of the activity, rehabilitation, financial obligations and post-closure activities.

Land access and siting aspects are generally considered as part of separate assessment processes. For CSG resource activities this occurs in the tenure application process under the *Petroleum and Gas (Production and Safety) Act 2004* (P&G Act) and for prescribed activities, a development approval application process under the *Planning Act* 2016.

Environmental authorities for resource and prescribed activities

Resource activities

A resource activity is a geothermal, greenhouse gas (GHG) storage, mining or petroleum activity. Where a resource activity includes activities that meet the criteria for a prescribed ERA, they may be authorised as part of the resource activity. These activities are considered ancillary activities, provided they are undertaken as part of the resource activity.

Salt encapsulation, carried out as part of the petroleum activity, would be considered waste disposal (ERA 60) and could be authorised as an ancillary activity. However, receiving and disposing of salt from off-tenure would not be undertaken as part of the petroleum activity and would not be considered ancillary.

Under the P&G Act framework, associated water generated from CSG activities is considered a waste and provides that it may be used for any purpose determined by the tenure holder, including disposal and/or transfer to another tenure (including a tenure not held by the tenure holder).

The application and assessment process for EAs for resource activities that include or add an ancillary activity (e.g. waste disposal) is undertaken entirely via the process outlined within the EP Act. The EP Act and subordinate legislation provides the regulatory requirements and criteria an application for a resource activity EA must be assessed against.

Details on the rehabilitation requirements and financial obligations that may be required for resource ERAs are detailed in the below section '*rehabilitation requirements and financial obligations'*.

Prescribed activities

If salt encapsulation is being carried out off-tenure, it will be a prescribed ERA and require an EA. It may also require a development approval for a material change of use (MCU) under the *Planning Act 2016* (Planning Act) under certain circumstances.

For the salt encapsulation approach to brine management identified in the APPEA and UQ reports, ERA60 'Waste Disposal' is the most likely ERA to be conducted.

Environmentally Relevant Activity (ERA) 60 description
(1) Waste disposal (the relevant activity) consists of only 1 of the following – (a) operating a facility for disposing of- (i) only regulated waste; or (ii) regulated waste and any, or any combination, of the following – (A) general waste; (B) limited regulated waste; (C) if the facility is in a scheduled area – no more than 5t of untreated clinical waste in a year; (b) operating a facility for disposing of – (i) only general waste; or (ii) general waste and either, or a combination, of the following – (A) a quantity of limited regulated waste that is no more than 10% of the total amount of waste received at the facility in a year; (B) if the facility is in a scheduled area – no more than 5t of untreated clinical waste; (c) operating a facility for disposing of only inert waste; (d) maintaining a decommissioned waste disposal facility. (2) The relevant activity does not include using clean earth as fill.

Under most circumstances, off tenure activities will require both an EA under the EP Act and a development approval (DA) under the *Planning Act 2016*.

The EP Act and subordinate legislation provides the regulatory requirements and criteria for an application for a prescribed ERA to be assessed against. The land use assessment aspect of the application will be undertaken as part of the assessment is regulated under the *Planning Act 2016* framework as applicable (see below for additional information regarding the Planning Act).

As part of the assessment process the administering authority may impose conditions on the EA that the proponent will be required to adhere to. As such, an EA for prescribed ERAs may contain a number of conditions relevant to managing the risk of environmental harm. Details on the rehabilitation requirements and financial obligations that may be required for prescribed activities are detailed in the below section '*rehabilitation requirements and financial obligations'*.

Waste (salt) disposal approvals—resource activity vs prescribed activity

The application pathway for authorising waste disposal depends on the location of the proposed disposal site and the proposed operation/management of the facility (see Figure 7).

Both application pathways allow for the administering authority to impose a range of conditions regarding environmental harm, environmental values, restrictions, prohibitions, rehabilitation requirements, and financial

obligations.

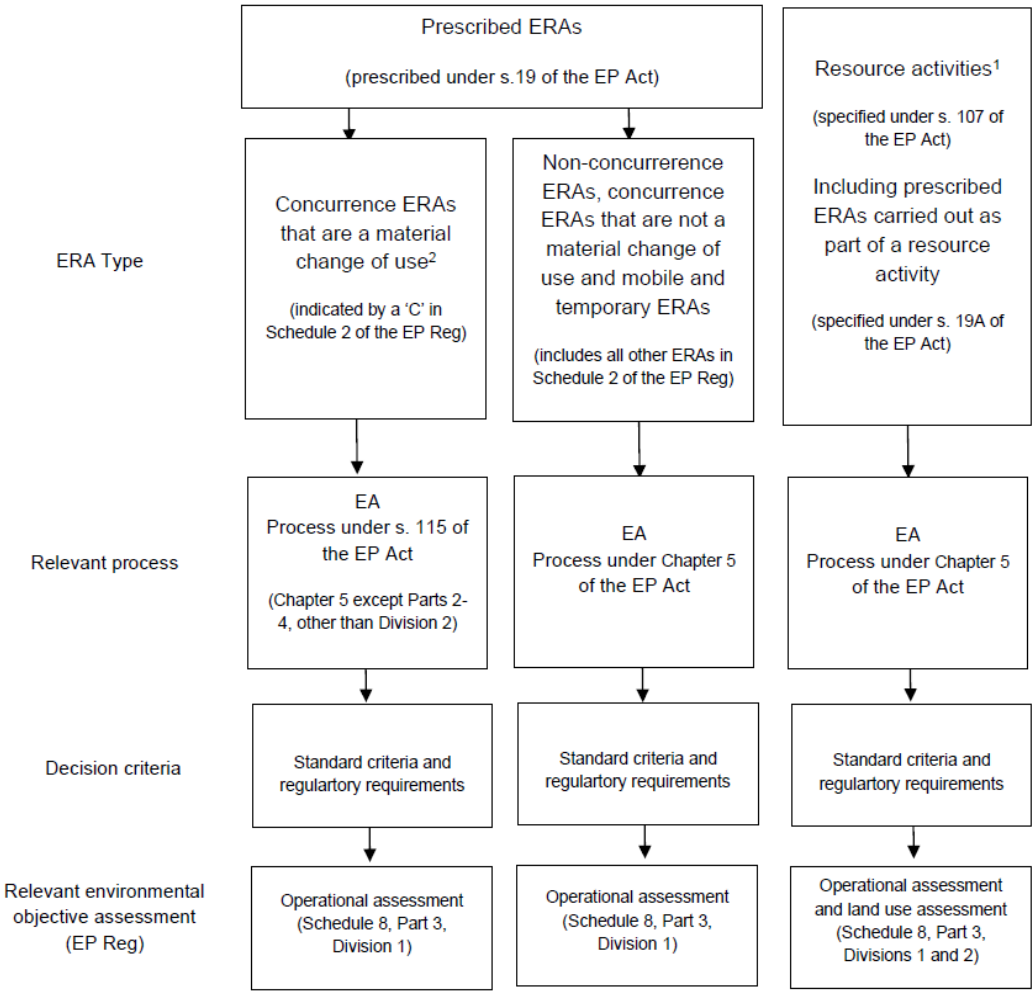

Figure 7 - ERA types, assessment process and criteria, and relevant sections of the environmental objective assessment

[1] A resource tenure is also required for a resource activity, but the resource tenure process is not linked to the EA process.
[2]A DA is required under *Planning Act 2016* where there is a material changed of use. This is an additional process that is not shown in this diagram.

Rehabilitation requirements and financial obligations

For activities involving land disturbance, provisions in the *Environmental Protection Act 1994* typically require EAs to include conditions regarding the rehabilitation of disturbed land and financial obligations to minimise the likelihood of a site becoming a financial burden to the state.

EA holders, for both prescribed and resource activities, are generally required to rehabilitate the land disturbed from the activity to a safe, stable, non-polluting state that is able to support a sustainable post activity land use. For example, a CSG activity may be required to rehabilitate well pads, dams, and tracks, etc to a state that would allow the landowner to use the land for cropping or a similar previous (or proposed) or future use.

Resource activity operators are required to provide estimated rehabilitation costs (ERC) to the government in the event they are unable to meet the rehabilitation requirements of their EA. These funds are held by the Financial Provisioning Scheme Manager in Queensland Treasury to ensure rehabilitation obligations for the resource site are met.

Following completion of a resource activity, if a risk assessment undertaken at the surrender of the EA identifies an elevated financial risk to the State due to the potential rehabilitation failure or monitoring and maintenance requirements, the operator may be required to make a payment (residual risk payment) to the State to manage the

identified risks into perpetuity.

For prescribed ERA's, the department can require financial assurance (FA) from the operator to be held in the event that they are unable to meet the rehabilitation requirements of their EA. Residual risk payments are generally not required for prescribed ERAs.

The financial obligation requirements for ERC, FA and residual risk framework are summarised below in Table 1.

Table 1 – Summary of the ERC, FA and residual risk frameworks

Resource Activity (CSG including waste disposal)	
Operational phase	**Surrender phase**
Estimated Rehabilitation Cost (ERC)	**Residual Risk (RR)**
• Calculated using calculators developed by the Department	• Calculated using methodology set by the Department
• Held by Scheme Manager in Queensland Treasury	• Held by Scheme Manager in Queensland Treasury
• Provides funds to undertake rehabilitation activities if the resource activity is unable to meet its rehabilitation obligations	• Provides funds to undertake maintenance and monitoring activities or rehabilitation activities as required after surrender has been approved by the Department.
• Includes a range of items such as dams, vegetation, infrastructure sheds, offices, salt crystallisation, and water treatment plant	• Includes a range of site features such as voids, waste rock emplacements, waste facilities, and bores/wells

Prescribed Activity (Waste Disposal)	
Operational phase	**Surrender phase**
Financial Assurance (FA)	**None required**
• Calculated using calculators developed by the Department	• Waste has stabilised such that it no longer presents a risk to the environment.
• Held by Department of Environment and Science	• Location of landfill to be noted on Title or relevant planning layer
• Provides funds to undertake rehabilitation activities if the prescribed activity is unable to meet its rehabilitation obligations	• Landfill to be identified on Queensland Government Environmental Management Register / Contaminated Land Register as appropriate
• Includes a range of items such as dams, vegetation, and infrastructure (sheds, offices, salt crystallisation, and water treatment plant)	

Coal Seam Gas Water Management Policy 2012

The objective of the Department's Coal Seam Gas Water Management Policy 2012 is to encourage the beneficial use of CSG water in a way that protects the environment and maximises its productive use as a valuable resource.

The objective is achieved when CSG water and saline waste is managed consistently with the prioritisation hierarchies and management criteria outlined in the policy.

The prioritisation hierarchy for managing and using CSG water is:

Priority 1 CSG water is used for a purpose that is beneficial to one or more of the following: the environment, existing or new water users, and existing or new water-dependent industries

Priority 2 After feasible beneficial use options have been considered, treating and disposing CSG water in a way that firstly avoids, and then minimises and mitigates, impacts on environmental values

The prioritisation hierarchy for managing saline waste is:

Priority 1 Brine or salt residues are treated to create useable products wherever feasible.

Priority 2 After assessing the feasibility of treating the brine or solid salt residues to create useable and saleable products, disposing of the brine and salt residues in accordance with strict standards that protect the environment.

The 2010 version of the Coal Seam Gas Water Management Policy required treatment of CSG water prior to disposal or beneficial use. This resulted in the widespread adoption of RO water treatment by the CSG industry. In accordance with Queensland's waste and resource management hierarchy, to reduce waste from CSG activities, the Coal Seam Gas Water Management Policy 2012 does not mandate treatment of produced water.

State Development and Public Works Organisation Act 1971

The *State Development and Public Works Organisation Act 1971* (the SDPWO Act) provides the framework for State planning and development through a coordinated system of public works organisation, for environmental coordination, and for related purposes.

The SDPWO Act provides for proposed development such as a petroleum activity to be considered as a significant project, that may require the development and submittal of an environmental impact statement (EIS). Review of the EIS by the Coordinator-General (CG) under the SDPWO Act provide the project proponents with a report that includes a number of conditions the CG considers relevant. Under the EP Act, EA conditions may not be inconsistent with conditions proposed by the CG.

Planning Act 2016

The *Planning Act 2016* provides the framework for land use assessments for prescribed ERAs. The Planning Act contains the relevant framework, provisions and planning instruments for local governments to make local planning schemes that require applicants to consider the suitability of adjacent land uses.

The Queensland Government identifies land use matters that are of state significance by developing State interest planning policies, regional plans and other State planning instruments that must be adopted during the development of local planning schemes.

The ERA component of any DA will be assessed against the state development assessment provisions. The DA will contain conditions relating to the use of the land, such as infrastructure siting.

Where a DA application includes the ERA trigger, the development application and EA application will be assessed at the same time.

Waste Reduction and Recycling Act 2011

The objects of the *Waste Reduction and Recycling Act 2011* (WRR Act) are:

(a) to promote waste avoidance and reduction, and resource recovery and efficiency actions;
(b) to reduce the consumption of natural resources and minimise the disposal of waste by encouraging waste avoidance and the recovery, re-use and recycling of waste;
(c) to minimise the overall impact of waste generation and disposal;
(d) to ensure a shared responsibility between government, business and industry and the community in waste management and resource recovery;
(e) to support and implement national frameworks, objectives and priorities for waste management and resource recovery.

The WRR Act includes two measures that are relevant to the management of salt generated from CSG activities: the end of waste (EOW) framework and the waste levy.

EOW framework

The EOW framework is set out in Chapter 8 of the WRR Act and provides the process by which the chief executive decides when and how waste stops being waste and becomes a resource.

The department has developed two EOW codes that are relevant to the reuse of CSG Water:

- The EOW Code for Associated Water allows associated water (or CSG Water) to be used or provided for a number of beneficial uses (including aquaculture, coal washing, dust suppression, construction, landscaping, industrial operations, stock and domestic use) provided it meets the relevant water quality standards.
- The EOW Code for Irrigation of Associated Water allows for associated water (or CSG Water) to be used or provided for irrigation provided it meets the relevant water quality standards.

An EOW code does not exist for CSG brine waste. However, the framework provides an opportunity to support circular economy and provide for innovative approaches to use salt waste for beneficial purposes.

A person may however be eligible to apply for an EOW approval should a suitable reuse opportunity be identified for brine and which is supported by evidence demonstrating a potential market/demand for the resource. EOW approvals are issued on a trial basis to a single holder for the purpose of conducting the trial. The EOW approval would only be issued only for the length of time required to undertake the trial. The Department would then consider the findings of the trial (e.g. benefits, sustainability, environmental impacts and environmental best practice) prior to deciding whether an EOW code should be developed for that waste type.

Waste levy

The waste levy framework is set out in Chapter 3 of the WRR Act and provides for a levy (the waste levy) to be charged for the disposal of wastes in Queensland. All waste being disposed will incur the waste levy unless the waste is both generated and disposed of in the non-levy zone; or the waste is exempt from the waste levy.

On-tenure disposal

Under the WRR Act, a waste disposal site is a waste facility that is required to hold an EA for waste disposal and the waste delivered to the facility sometimes includes waste that is disposed of to landfill at the facility.

However, a waste facility does not include a facility that is lawfully operated for the sole purpose of disposing waste generated by one or more resource activities provided:

- the waste is or was generated only by, and its generation is or was ancillary to, the operation of 1 or more of the resource activities
- the facility is operated by or for an entity carrying out 1 or more of the resource activities
- the facility is authorised under the same environmental authority as 1 of the resource activities.

Note: The details above are a summary only and resource activity operators will need to review the legislation to determine if the relevant exemption applies to their specific circumstances.

Off-tenure disposal

Waste salt taken to a landfill off-tenure for disposal will be subject to the waste levy unless the waste salt is both generated and disposed of in a non-levy zone.

In Queensland, CSG activities are generally located in local government areas within the levy zone, such as: Maranoa, Western Downs, Banana and Central Highlands council areas (see Levy zone map for full details). The levy zone covers 39 out of Queensland's 77 local government areas.

See About the levy | Queensland Government (www.qld.gov.au) for further information regarding the waste levy.

Regional Planning Interests Act 2014

The *Regional Planning Interests Act 2014* is administered by the Department of State Development Infrastructure Local Government and Planning (DSDILGP). The legislation requires new or amended resource activities that are to be undertaken in an Area of Regional Interest (ARI) to obtain a regional interests development approval (RIDA) prior to undertaking the activity.

For example: If an operator of an authorised petroleum activity for CSG in an ARI wanted to include waste disposal as an ancillary activity through an amendment to their EA, they would also be required to obtain a RIDA. The legislation requires an application be assessed by the assessing agency for the relevant ARI. If the relevant ARI were in a priority agricultural area (PAA), the application would be assessed by the Department of Agriculture and Fisheries (DAF), which would provide recommendations to DSDILGP regarding conditions that could be included on the RIDA.

2.0 Key principles for CSG brine management

Management of brine requires the consideration of a range of elements including water management, waste management, water quality, site characteristics, environmental impacts, economic consideration, and safety. To achieve the best outcomes for the environment, industry and the community regarding the management of brine, the following four key principles (see Figure 9) are to be used to guide future actions for the long-term management of brine:

Figure 9 - Key principles for CSG brine waste management

2.1 Ensuring a robust regulatory framework

CSG activities are regulated under several acts, regulations, policies and guidance that operators must comply with to conduct the activity in Queensland.

The framework for CSG activities is generally administered by:

- Department of Environment and Science
- Department of Resources
- Department of Regional Development, Manufacturing and Water.

Under certain circumstances, CSG activities may also be regulated by the Department of State Development Infrastructure, Local Government, and Planning and the Department of Agriculture and Fisheries.

There is opportunity to undertake a gap analysis of the existing framework to determine whether any action is necessary to strengthen the framework by providing greater clarity around the Queensland Government's expectations about applications and ensuring greater consistency in decision-making.

2.2 Promoting a circular economy

A circular economy is a production and consumption model that seeks to maintain resources at their highest value use for as long as possible. In contrast to the traditional 'take, make and dispose' model, the circular model aims to extend the lifecycle of materials whereby at the end of each service life, materials are recovered and regenerated into new products. The Queensland Government supports transition to a circular economy which is reflected in waste management principles such as the waste and resource management hierarchy.

The Queensland waste and resource management hierarchy (shown in Figure 10) guides the order of preference for managing waste. As a first priority, waste should be avoided, after which options for reuse and recycling should be explored. The recovery options for fuel and energy, or disposal should be reserved for residual waste that is unsuitable for higher order options.

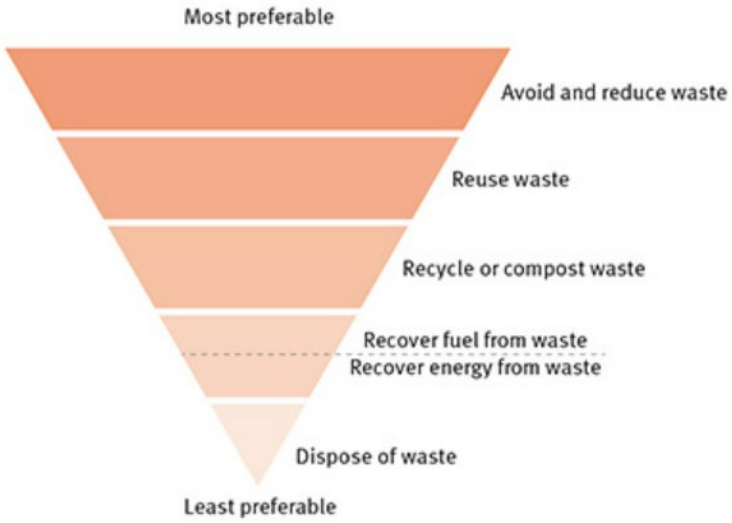

Figure 10 - Waste management hierarchy

CSG brine waste is to be managed in a way that is consistent with the waste management hierarchy and assists in promoting a circular economy.

The Queensland Government's Waste Management and Resource Recovery Strategy identifies three strategic priorities to help drive a fundamental shift in the way waste is managed in Queensland:

- reducing the impact of waste on the environment and communities
- transitioning towards a circular economy for waste
- building economic opportunity.

Long-term approaches for the management of CSG brine must align with these priorities as much as possible.

The development of an approach to the management of CSG waste using a more circular model rather than a linear model to reduce, reuse, and recycle products that continue to circulate in the economy for as long as possible is a preferred outcome. At this time a circular model for CSG brine may not be achievable due to a number of environmental, economic, and social circumstances; however, continued research and investigation by industry and academia may identify options that support a more circular waste management model for CSG waste generally, and/or CSG brine specifically in the future.

2.3 Investing in research and development

Long-term approaches for the management of CSG brine must include a commitment to continued investment into on-going research and investigation into alternative options that:

- minimise the medium and long-term risks of salt encapsulation
- reduce energy intensity and operational costs of brine management and salt disposal options
- investigate any emerging technologies.

Ongoing research and development should primarily focus on technologies and methods to reduce the volume of brine produced, then carbon neutral reuse opportunities.

2.4 Increasing transparency and stakeholder engagement

Long-term approaches for the management of CSG brine must include a commitment to continued engagement with landholders and regional communities to support sustainable coexistence. The regulatory framework provides for community involvement through public notification processes. Landholders and community groups should also be engaged in relation to research and development outcomes and future opportunities for re-use.

Transparency and data sharing will be encouraged as much as possible.

3.0 Actions

This action plan acknowledges that salt encapsulation (i.e., crystallisation of brine into a solid and placement into a purpose-built disposal facility) is the most feasible option for long-term CSG brine waste management at this stage. This option presents less environmental risk than the current practice of storing liquid brine in dedicated storage dams. However, there is an expectation that industry will continue to explore opportunities to create a more circular economy to reduce, manage and reuse CSG brine.

Any proposed salt encapsulation facilities will be subject to a rigorous assessment process under the relevant legislation, including consideration for land rehabilitation, long-term management measures, and financial obligations. The environmental risks of salt encapsulation must be appropriately identified and managed.

The following actions support the key principles identified for CSG brine waste management, including the continued investigation of long-term solutions. The table below indicates timeframes by which these actions are to be completed and the party responsible for undertaking the action.

Action	Item	Timeframe	Responsibility
1	Establish a process for the ongoing regular reporting of brine and salt volumes stored on resource sites.	2023	DES and Industry
2	Investigate options for providing public access to data and information relating to any potential impacts of salt disposal facilities (e.g., groundwater monitoring data), focussing on utilising existing avenues where appropriate (e.g. Open Data Portal, Public register).	2023-2024	DES and Industry
3	Review existing regulatory guidance material to identify: a) the requirements of the environmental assessment process for permitting salt encapsulation facilities b) where industry, landholders and the Department would benefit from further information/guidance c) options for improving regulatory consistency. Guidance to be considered includes for example: landfill siting and design, calculation and application of financial obligations (Estimated Rehabilitation Cost and Financial Assurance), and rehabilitation requirements.	2023-2024	DES

Action	Item	Timeframe	Responsibility
4	Update department guidance materials regarding waste disposal considering the outcomes of the review from Action 3. This may include, for example, updating existing landfill siting and design guidance and determining relevant conditions for waste disposal.	2024-2025	DES
5	Where salt disposal options are being considered, undertake actions to ensure a strategic co-ordinated effort across industry that aims to: a) minimise the footprint of disposal facilities and potential for environmental impacts b) identify principles and criteria for determining suitable facility locations that consider agricultural land and environmental constraints (community engagement to be undertaken where appropriate).	Ongoing	Industry
6	Invest in research and development (R&D) that focuses on: a) reducing brine volumes produced b) reuse opportunities for brine and salt c) reducing energy intensity and operational costs of brine management and salt disposal options d) minimising the medium and long-term risks of salt encapsulation facilities.	Ongoing	Industry
7	Publicly report on: a) R&D priorities for the next 5 years b) the progress of R&D over the previous 5 years c) any beneficial application of learnings from R&D to industry operations.	5 yearly – first report commencing in 2024	Industry

4.0 Monitoring and review

This action plan will be in effect for 10 years from commencement. The department will continue to work with stakeholders to monitor the progress and development of CSG brine management practices, noting that adaptive management may be required that considers advancements in technological capability and scientific knowledge.

In addition to undertaking the actions identified within this action plan, the department will conduct periodic reviews of this action plan to:

- ensure currency over the 10-year timeframe
- monitor that identified actions are undertaken and progressed in a timely manner
- ensure that alternative actions and/or timeframes are considered, developed and implemented in a transparent manner
- ensure that stakeholders are provided with timely updates and consultation opportunities as appropriate
- monitor to ensure that outcomes of the actions are being achieved.

5.0 Glossary

Brine—water with a total dissolved solids concentration greater than 40,000 milligrams per litre.

Coal seam gas—is natural gas found in coal deposits that is held in place by water pressure. To produce the coal seam gas, water is extracted to reduce the water pressure to allow the gas to be captured.

Crystallisation—the process of removing liquid from a substance to create a solid. Liquid may be removed through a range of methods, with heat typically being applied to remove water. For example, crystallising brine to form salt.

Dam—a land-based structure or a void that contains, diverts or controls flowable substances, and includes any substances that are thereby contained, diverted or controlled by that land-based structure or void and associated works. For the purpose of this action plan, a dam may also be referred to as a regulated structure, storage pond, or similar.

Salt—for the purposes of this action plan**,** a general term to describe the solid form of total dissolved solids in brine from treated coal seam gas water.

Total dissolved solids (TDS)—a measure of the dissolved combined content of all inorganic and organic substances present in a liquid in molecular, ionized, or micro-granular (colloidal sol) suspended form. For coal seam gas, TDS concentrations are also referred to as salt.

6.0 References

[1] Australian Petroleum Production and Exploration Association (APPEA) December 2018 - “Queensland Gas: end-to-end water use, supply and management” P. 33 (https://environment.des.qld.gov.au/__data/assets/pdf_file/0016/240316/appea-end-to-end-water-management-report.pdf)

[2] Department of Environment and Science (Queensland Government) - Coal Seam Gas Water Management Policy 2012 (https://environment.des.qld.gov.au/__data/assets/pdf_file/0034/89386/rs-po-csg-water-management-policy.pdf)

[3] Office of Groundwater Impact Assessment (Queensland Government) - Underground Water Impact Report 2021 for the Surat Cumulative Management Area December 2021 (Underground water impact report (UWIR) for the Surat CMA | Business Queensland)

[4] Department of Environment and Science (Queensland Government) - Structures which are dams or levees constructed as part of environmentally relevant activities Coal Seam Gas Water Management Policy 2012 Structures which are dams or levees constructed as part of environmentally relevant activities ESR/2016/1934 (des.qld.gov.au)

[5] University of Queensland (Centre for Natural Gas) February 2020 - Independent review: Brine and salt management (Section 6, Queensland Gas: end-to-end water use, supply and management) (UQ Report).