Australia Pacific LNG Project

Volume 2: Gas Fields

Chapter 12: Adaptive Associated Water Management

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12.1 Introduction

12.1.1 Purpose

Sustainable resource management and development is a key driver of the Australia Pacific LNG Project (the Project). The appropriate management of associated water is critical to the gas fields' development program, as well as the long-term social, environmental and economic wellbeing of south central Queensland. Australia Pacific LNG is committed to a water management strategy which will encourage commercial and beneficial uses of associated water to deliver sustainable outcomes.

An adaptive associated water management plan (AAWMP) has been developed and is available in Volume 5 Attachment 24. This tool will assist with the long-term management of the associated water produced during the extraction process of coal seam gas (CSG). The plan forms part of the required environmental management plan for the development of the Australia Pacific LNG gas fields and sets out specific measures or goals to be achieved to maximise the beneficial use of associated water.

The plan has been developed with reference to and prepared in accordance with the Operational Policy – Management of water produced in association with petroleum activities (associated water) (Queensland Environmental Protection Agency, December 2007) and the 'Queensland Coal Seam Gas Water Management Policy' (Queensland Department of Infrastructure and Planning, May 2009).

Australia Pacific LNG has developed a strategic approach to associated water management based on its sustainability principles. Of the 12 sustainability principles, the following five are most relevant in relation to management of associated water:

- Minimising adverse environmental impacts and enhancing environmental benefits associated with Australia Pacific LNG's activities, products or services; conserving, protecting, and enhancing where the opportunity exists, the biodiversity values and water resources in its operational areas
- Using resources efficiently, reducing the intensity of materials used and implementing programs for the reduction and re-use of waste
- Engaging regularly, openly and transparently with people and communities affected by Australia Pacific LNG's activities, considering their views in its decision-making and striving for positive social outcomes
- Working cooperatively with communities, governments and other stakeholders to achieve positive social and environmental outcomes, seeking partnership approaches where appropriate
- Identifying, assessing, managing, monitoring and reviewing risks to Australia Pacific LNG's workforce, its property, the environment and the communities affected by its activities.

In the identification of appropriate treatment and re-use options, an approach is being adopted that seeks to maximise the value of water. Project planning will include location, design and operating infrastructure to reduce environmental impacts.

The AAWMP has set up a strategic management framework that is based on a number of key objectives including to:

- Provide a transparent document outlining Australia Pacific LNG's philosophy and approach

- Demonstrate adherence to regulatory policy
- Document the risks and challenges in relation to associated water management
- Provide a strategic management tool that is adaptive to changes in:
  - Quantity and quality of associated water
  - Demand location and volume
  - Technology
  - Environmental receptors/constraints
  - Community concerns, and regulatory requirements
- Allow for continual improvement and the implementation of good practice management of associated water.

The AAWMP is a working document and will be regularly updated as stakeholder negotiations progress, operations expand, water markets mature and technology improves. The document is intended for use in establishing a strategic planning framework that promotes active responses to regulatory change and outcomes of stakeholder engagement. The current version of the document outlines regulatory requirements and existing conditions which set the scene for the initial and further development of associated water management options.

This chapter provides a summary of the AAWMP, particularly in addressing the requirements of Section 2.4.1.1 of the terms of reference for the EIS.

The terminology used in the chapter adopts the following:

- Associated water - untreated water stream associated with the extraction of CSG (also referred to by others as produced water or CSG water)
- Permeate - high quality treated associated water
- Brine - highly saline effluent stream from treatment of associated water.

12.1.2 Associated water management approach

CSG is predominantly methane stored within coal seams by adsorption to the surface of coal particles. In the Walloons coal seams, pressure from the enclosing water keeps the gas adsorbed as a thin film on the surface of the coal. In order to extract the CSG, the water pressure needs to be sufficiently reduced to enable desorption of the gas. This is achieved by transferring the associated water to the surface. Moreover transfer of water can be managed to modify the gas pressure, therefore optimising the rate of gas production.

The amount of associated water produced during the CSG extraction is difficult to predict and varies both with the location and stage of the production cycle. Likewise, the quality of the associated water is highly variable, but it frequently contains elevated quantities of salt and other contaminants.

The quantity, timing and location of water demand are similarly anticipated to fluctuate, both in terms of the life of the Project and seasonal conditions. The AAWMP therefore needs to be adaptive to reflect changing supply and demand conditions, whilst remaining sustainable by addressing social, economic and environmental considerations.

Australia Pacific LNG has adopted an approach to managing associated water considering:

- Environmental impacts
- Distribution complexities
- Supply contract negotiations
- Advancement and implementation of technology
- Project development and production timeframes
- Potential legislative changes
- Operational requirements.

The initial management regime for associated water management, known as the 'Initial Case', is focused on delivery of sustainable management options that can be readily applied using existing technologies and customers.

Australia Pacific LNG will optimise commercial and beneficial water use through a flexible approach including:

- Water that can be readily supplied long-term will be contracted to commercial customers
- Pursuit of opportunities for water to be managed in conjunction with other producers including water aggregation
- Investigation of beneficial uses and alternative water management technologies including aquifer injection.

It is anticipated that the optimisation of beneficial use will occur over time as options are developed. The AAWMP will be subsequently updated and provided to the relevant regulatory agencies as the options are developed and mature. An outline of the solutions for optimising beneficial use is provided in Section 12.5. An indicative program for development of these preferred options is in the order of three to five years. However, Australia Pacific LNG considers that the early and progressive implementation of the adaptive water management approach to be socially, environmentally and economically beneficial.

Section 12.2 details the selection process and the proposed associated infrastructure of the Initial Case.

12.1.3 Legislative and policy framework

Two key government policies have been identified for consideration in relation to associated water management:

- Operational Policy – 'Management of water produced in association with petroleum activities (associated water)' (Queensland Environmental Protection Agency, December 2007)
- 'Queensland Coal Seam Gas Water Management Policy' (Discussion Paper – Queensland Department of Infrastructure and Planning, May 2009).

The former Queensland Environmental Protection Agency released the operational policy for the management and disposal of associated water to promote the beneficial use of associated water in accordance with the Environmental Protection (Waste Management) Policy 2000.

The key objectives of the operational policy are:

a) To provide consistency, certainty and transparency in decision-making about appropriate management strategies for associated water during the pre-design phase of applications for non-code compliant environmental authorities (petroleum activities)

b) To promote where feasible, beneficial use or injection in preference to any other disposal options, for the management of associated water

c) To achieve the best net environmental, social and economic outcomes for the management of associated water whilst providing flexibility in how the outcome is achieved.

The operational policy puts forward a number of preferred management options (injection, direct use without treatment, treated water use) and non-preferred management options (disposal via evaporation ponds, injection after surface storage or into better quality groundwater, discharge to surface waters).

If beneficial use of associated water is proposed, Australia Pacific LNG may be required to apply for a development approval for re-use of a regulated waste, unless covered by a general or specific approval under the Environmental Protection (Waste Management) Regulation 2000. Australia Pacific LNG will have general approval for the beneficial use of a resource if it complies with the conditions of the general approval for the beneficial use of associated water set out in the operational policy or can apply to the Department of Environment and Resource Management (DERM) for specific approval for the beneficial use.

Both production rates and water quality will affect associated water management options. In the instance where water is released into the above ground environment, some form of treatment will be required. Furthermore storage of associated water is restricted by legislation and like conveyance is cost intensive.

Likewise, the CSG water management policy (CSG water is an alternative term for associated water) is being developed to provide guidance on the management and disposal of associated water. Figure 12.1 below provides an overview of the policy framework, as of 20 October 2008.

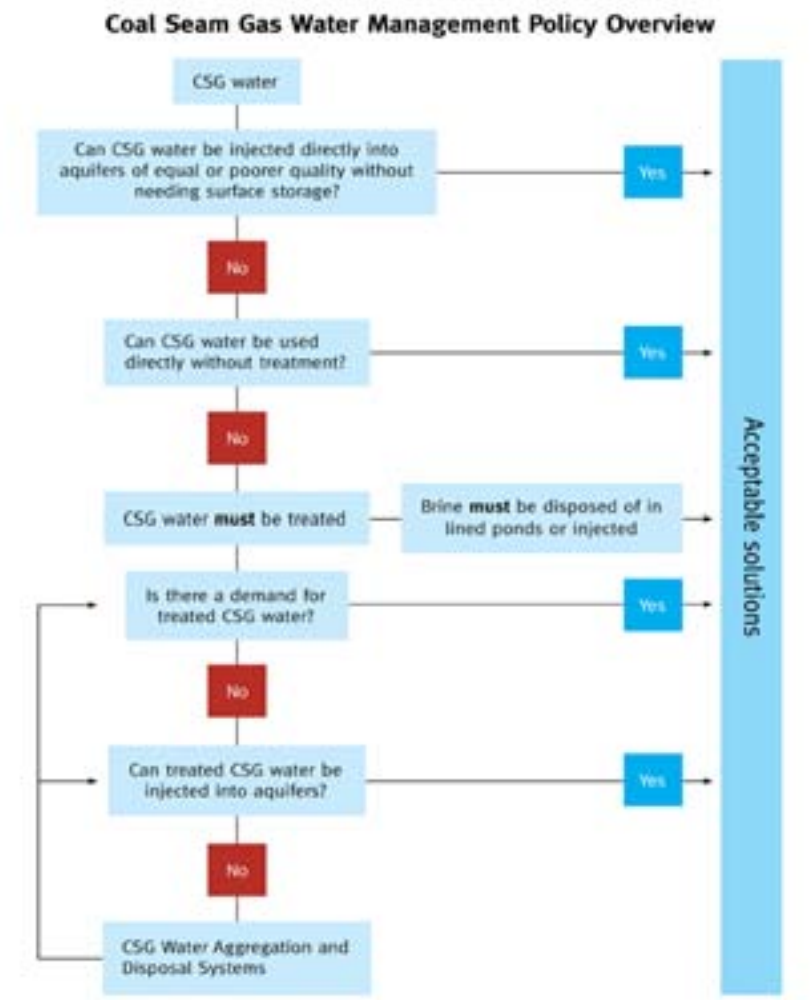

Figure 12.1 Queensland coal seam gas water management policy overview

The policy identifies concerns with the practice of evaporation ponds as a way to deal with the CSG associated water and, in particular, with the long term legacy of the salts stored in the evaporation ponds. Furthermore the policy identifies a significant imbalance between the amount of water that will be generated over the next 30 years by CSG and the demand for this water. Thus, the policy aims to provide clear direction for the treatment and disposal of CSG associated water.

Proposed features of the policy include:

- Discontinuing the use of evaporation ponds as a primary means of disposal and remediation of existing ponds is to occur within three years
- CSG producers to be responsible for treating and disposing of CSG associated water, however if producers do not inject the water (preferred method) or have environmentally acceptable use for the untreated water they must treat the water to standards defined by DERM
- Ponds for storage of brine must be fully lined to DERM standards
- A CSG water management plan will be incorporated into the environmental management plan (the adaptive associated water management plan is equivalent to a CSG water management plan)
- Water which cannot be injected or beneficially used must be aggregated for disposal.

The government is yet to finalise the details surrounding the implementation and operation of its policy related to the disposal and aggregation of associated water, and is in the process of working with industry and other interested parties to establish clear guidelines.

In May 2009, the Queensland Department of Infrastructure and Planning issued a discussion paper titled 'Management of Water Produced from Coal Seam Gas Production'. The intent of the paper is to inform stakeholders of various government criteria concerning the management of CSG and secondly, to seek stakeholder views on a number of specific issues related to these decisions prior to finalising the policy positions.

In response to the discussion paper, Origin Energy and the Australian Petroleum Production & Exploration Association submitted comments on behalf of Australia Pacific LNG.

Furthermore, the Project will need to be in accordance with relevant Queensland legislation, and seek additional approvals (e.g. development approval/s, registration certificate, water licence) to undertake the proposed disposal or beneficial re-use activities. The production of associated water is regulated by the following Queensland legislation:

- *Petroleum and Gas (Production and Safety) Act 2004*
- *Water Act 2000* / *Water Supply (Safety and Reliability) Act 2008*
- *Environmental Protection Act 1994* / Environmental Protection Regulation 2008
- *Sustainable Planning Act 2009*.

Further information on the applicability of the above Acts, policies and guidelines for the management of associated water is provided in Volume 5 Attachment 24.

12.2 Initial Case appraisal and selection

A decision model was developed for the selection of an Initial Case – adaptive associated water management plan. The model has been implemented throughout the development of the adaptive associated water management plan, from well extraction to future water use. The following section primarily focuses on the management options of untreated and treated associated water streams.

A five-step rational decision making model was selected to undertake the option appraisal. Figure 12.2 below, provides an outline of the process, with the five steps categorised to the right of the diagram.

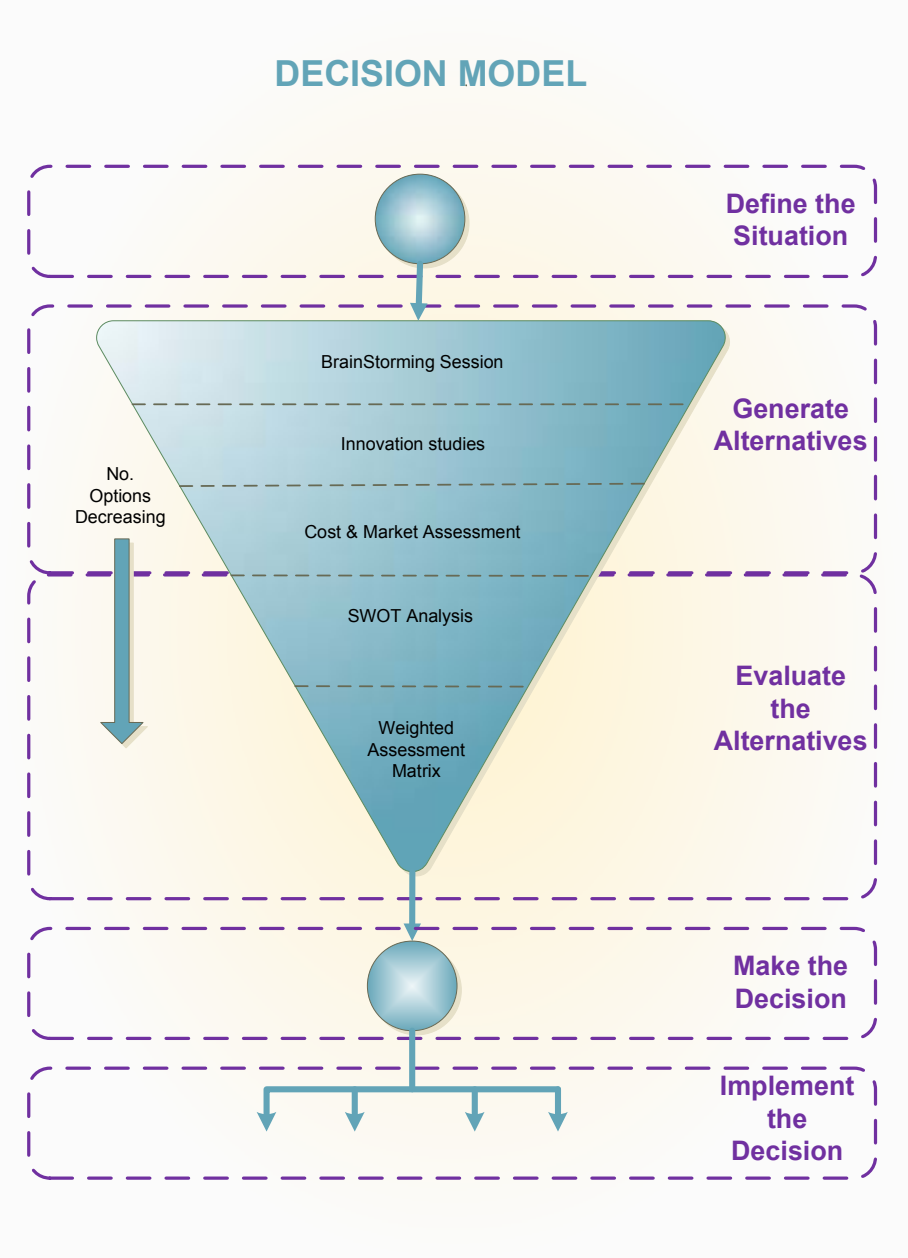

Figure 12.2 Decision model overview

12.2.1 Define the situation

Summary of existing environment

The Australia Pacific LNG gas fields' area is situated in the Surat Basin, a sub-basin, some 280,000km^2 in area, located in the eastern most corner of the Great Artesian Basin (GAB). The GAB is approximately 1.7 million km^2 in size and is the largest groundwater basin in Australia, and one of the largest in the world (Department of the Environment, Water, Heritage and the Arts 2009). The GAB covers approximately 22% of Australia, most of which is arid and semi-arid land. The artesian water supports a range of nationally important natural, socio-economic and cultural values (Great Artesian Basin Consultative Council 2000).

Australia Pacific LNG's gas fields encompass parts of three river catchment areas, the Condamine-Balonne, Fitzroy and Border Rivers drainage basins. The majority of the gas wells are located within the Condamine-Balonne drainage basin. The north-western portion of the development is adjacent to the Dawson River tributaries and the isolated area of Gilbert Gully is situated within the Border Rivers drainage basin. Tributaries within all three catchments generally experience long periods of low to no flow, and are referred to as ephemeral watercourses. The dominant catchment streams, Condamine River and Dawson River, are similarly affected by climatic conditions, reduced to a series of pools and waterholes during dry periods.

The dominant land uses in the Condamine-Balonne drainage basin are dryland cropping, cattle and sheep grazing and to a lesser extent, irrigated cropping, rural residential and urban development. The natural geologic and hydrologic conditions combined with extensive land clearing and inappropriate land management practices, has lead to poor water quality, introduction of weed species, and varying habitat quality and aquatic flora and fauna diversity.

Further details of the existing soil, aquatic ecology, groundwater and surface water environments in the gas fields' area can be found in Volume 2 Chapters 5, 9, 10 and 11 respectively.

Resource profile

The physical nature of the coal seams limits the quantity of the CSG resource for extraction to a localised area around the well. Furthermore, gas flows from CSG wells significantly vary between, and sometimes even through development areas. The number and location of wells to meet the gas demand is dependent on the amount of gas that can be produced from a well associated with the CSG field/reservoir into which the well is drilled.

The associated water production profile is fundamentally a function of gas production management. Although several pilots have operated throughout the Walloons development, a clear understanding of water production and its subsequent quality is only progressively being developed. The capacity and location of water treatment facilities and effluent management systems needs to be able to adapt to changing conditions, therefore developing sustainably.

The water profile developed in response to the EIS investigation provides a maximum production peak of 170ML/d predicted to occur within the first 20 years. Further details of the water production profile are provided in Section 12.3.2.

12.2.2 Generate alternatives

Origin Energy, a joint venture partner in Australia Pacific LNG, operates or is a non-operating partner in several existing coal seam gas production fields in Queensland. Initially water management practice at these fields primarily included the storage of associated water in large evaporation ponds. In 2007, Origin Energy took the pioneering step to treat the associated water at their Spring Gully field via reverse osmosis prior to discharge to a local watercourse. In 2009, Origin committed to a 300ha agricultural venture of Pongamia plants at Spring Gully, in an effort to cease continuous discharge to the watercourse.

Australia Pacific LNG has commissioned numerous studies into emerging technologies and market opportunities for disposal of associated water and potential by-products. Between May and August 2008, extensive consultation with internal and external stakeholders was undertaken to establish a list of water management options. All ideas generated were entered into a central database where each idea was classified into broad categories. A total of 80 water management options were identified.

12.2.3 Evaluate the alternatives

Table 12.1 summarises the 80 options, grouped into seven broad categories, to meet the objectives of the Initial Case. Options from categories two to seven have been considered in the optimisation of beneficial uses. Development of these options is discussed further in Section 12.5 and Volume 5 Attachment 24.

Table 12.1 Seven categories of management options

No.	Category	Description
1	Existing	Five options were identified from existing activities, including evaporation ponds and stream discharge.
2	Industrial	Supply of treated/untreated water to industry, twenty-two options were suggested, of which thirteen were for proposed and existing mines and five were power stations.
3	Potable water supply	Supply of treated water to townships such as: Dalby, Miles, Chinchilla, and Condamine, and into existing distribution networks. Options can be divided into seven urban supply locations and six bulk water supply options.
4	Agriculture	A number of landholders showed interest in accessing water supplies for existing or expansion ventures, whilst a large variety of agricultural ventures, owned and operated by Australia Pacific LNG, were also identified. In total sixteen different options have been identified for agricultural water supply.
5	Injection	As guided by government legislation and Australia Pacific LNG's sustainability principles, injection options have been explored. Eight options in this category have been specified.
6	Other	Eight options that did not fit with any of the above categories have been grouped together. These included innovative technologies such as solar ponds and algae production and large scale options such as construction water and ocean disposal.
7	Salt	Eight options were proposed for salt management, many included the sale of salt, whilst two options were identified for injection and the existing practice of encapsulation was also specified.

A strengths, weaknesses, opportunities and threats (SWOT) analysis and a weighted assessment matrix (WAM) analysis were undertaken by Australia Pacific LNG. Both are common strategic planning tools. The SWOT analysis provided direction and clarification of the options, ensuring all related factors, both positive and negative, were considered. A multi-criteria WAM, was used to rank the options in a preferential sequence. The criteria adopted were as follows:

- **Regulatory approval** - compliance with existing and anticipated future regulation is essential for the award of gas production licensing.
- **Minimal environmental and community impacts** - in the short and long-term, reducing liability and operational risks to the Project
- **Flexible capacity** - to match the scheduled and unscheduled variance in the water profile. Furthermore, management options with constant demands, i.e. limited changes to supply, both annually and seasonally, are preferred.

- **Readily implemented** - limited investigation or negotiation, during a condensed project program
- **Sustainable practice** - for example minimal redundant infrastructure resulting in adaptation to beneficial uses.

A summary of both the SWOT analysis and WAM are presented in Volume 5 Attachment 24.

12.2.4 Implement decision

The preferred Initial Case consists of:

- Australia Pacific LNG owned and operated agricultural use, crops and plantation site selection is to be location based and will be undertaken to maximise sustainable water re-use, whilst equating to actual water production profiles
- The option will be complemented with existing agricultural water supply, where successful negotiations can be reached prior to water production commencement
- Opportunistic discharge of high quality treated water to major watercourses, so as to cause minimum environmental impact, including the proposed discharge pipeline to the Condamine River.

As an interim measure and occasional water surplus management method, Australia Pacific LNG proposes that treated water may also be discharged into local defined watercourses when impacts to stream ecology and flow regime will be minimal.

Although the Initial Case appraisal selected brine to be stored in large evaporation ponds to be encapsulated at the end of the Project, innovative technologies such as crystallisation and brine injection are being trialled. Furthermore, Australia Pacific LNG has committed to progress efforts to find appropriate markets for sale of recovered salt and re-use.

12.3 Associated water treatment

12.3.1 Treatment approach

Australia Pacific LNG proposes that from the water's separation at the well head, the water is conveyed in a low pressure gathering network, and where topographical constraints dictate, will be pumped to a treatment facility.

Investigations into mobile treatment facilities indicated they are inherently unreliable and have high operational costs due to servicing and maintenance. They are also unlikely to meet the high recoveries which can be achieved with an optimised permanent plant. It was hence recommended water treatment facilities be located central to several gas development areas, and be modular, to adapt to the development sequence and associated water production rates.

For the scale of development being considered, a modular 20ML/d facility would be the lowest cost option. These facilities can be further optimised by adopting incremental increases of 5ML/d as required. These facilities also provide cost benefits when centralised within a development field. However, this may require legislative change to occur as piping across tenure boundaries is not permitted.

The capacity and location of water treatment facilities needs to reflect an ability to adapt to changing conditions, promoting sustainable development. Australia Pacific LNG has proposed a treatment

approach appropriate for the beneficial use option and, moreover, is to be selected on a site by site basis therefore reducing unnecessary waste energy and products, and improving efficiency. All treatment processes will be continuously reviewed and optimised.

12.3.2 Projected quality and quantity

Both production rates and water quality will affect associated water re-use and management options. In the instance where water is released into the above ground environment, some form of treatment will be required.

The associated water production profile is fundamentally a function of gas production management. The rate and staging of de-watering and reducing hydrostatic pressure, is adapted to achieve a gas extraction plateau across the field.

Figure 12.3 below provides a summary of the maximum anticipated water profile for the Walloons development, by area.

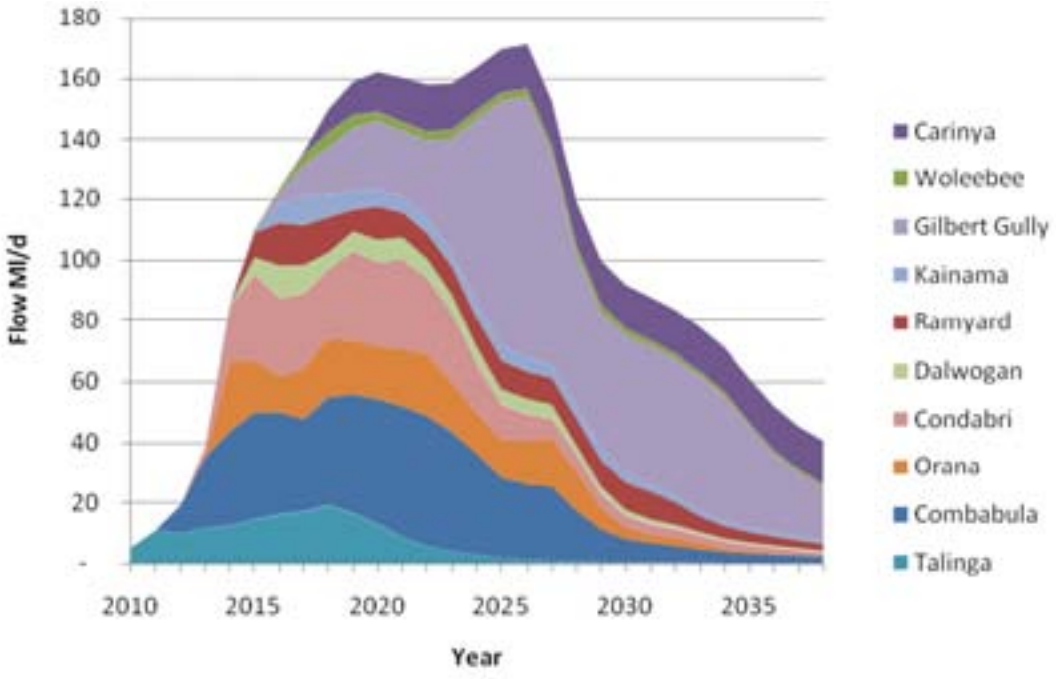

Figure 12.3 Predicted associated water profile for the Walloons development

The water profile developed in response to the EIS investigation is similar to the gas profile in that it indicates a maximum associated water production peak. In this case the peak is around 170 ML/day. This is predicted to occur within the first 20 years. However there still remains a level of uncertainty regarding both the magnitude and timing of this estimate.

Likewise the chemical composition of associated water is uncertain. The quality of associated water is primarily dependent upon the geology of the area in which the well, is located. Consequently, water quality varies across both horizontal and vertical horizons. The associated water's key re-use inhibitors in the Walloon Coal Measures are its saline nature, high sodium absorption ratio (SAR) and high residual alkalinity. Other limiting water quality parameters of concern include fluoride, boron, pH, suspended solids, temperature and dissolved oxygen.

Associated water testing indicates that heavy metals such as mercury and arsenic are of low concentration and hydrocarbons are additionally not of concern.

Table 12.2 provides a summary of key water quality parameters at four fields within the Walloons development area and adjacent Spring Gully gas field (an operating development in the Bowen Basin). As shown in Table 12.2, the variance in quality between fields can be substantial.

Table 12.2 Walloons development and Spring Gully associated water quality

Property	Development Field				
	Combabula	Talinga	Orana	Condabri	Spring Gully
Total dissolved solids (mg/L)	6,534	2,540	2,450	3,693	7,500
pH	8.3	8.7	8.8	8.3	9
Total suspended solids (mg/L)[1]	38	39	9	80	65
Sodium adsorption ratio	115	160	135	138	170
Residual alkalinity (meq/L)	13.6	37.4	30.5	29.0	43.0
Fluoride (mg/L)	0.9	3.9	3.3	1.9	5.9
Boron (mg/L)	0.50	0.72	0.66	0.40	3.1

Notes[1] Solids may be entrained sediments from wells, or of microbiological origin.

12.3.3 Treatment process

Water suitable for river discharge would generally be suitable for irrigation of most crops on most soils. Therefore, the water treatment system adopted would be consistent with that required for river discharge. Australia Pacific LNG has investigated and trialled a range of treatment techniques for the development of the Spring Gully water treatment facility (WTF) and more recently for the Talinga WTF, to achieve watercourse discharge water quality objectives. The treatment process presented below is based on the existing WTFs (i.e. Spring Gully and Talinga) and although treatment, water quality and licence requirements are anticipated to vary with end use, these will principally consist of the same key components in the Initial Case.

The process can be summarised in three stages:

a) Preparation and buffering feed ponds providing a buffer storage, removal of coarse sediment and allowing temperatures to be reduced prior to entering the facility

b) Pre-treatment technologies comprising disc filtration, membrane filtration and ion exchange to remove larger particles and alter parameters to improve desalination processes

c) Desalination using reverse osmosis.

Each primary reverse osmosis unit will produce permeate that meets the discharge quality criteria. An indication of permeate water quality is provided in Table 12.3, which summarises recent monitoring results from Spring Gully WTF discharge.

Table 12.3 Spring Gully permeate water quality results

Parameter	Units	Mean
Electrical conductivity	µS/cm at 25°C	126
pH	std	7.7
Residual alkali (as Na_2CO_3)	mq/L	0.365
Total alkalinity	mg/L	19
Sodium adsorption ratio		4.6
Sodium	mg/L	26
Potassium	mg/L	1.15
Chloride	mg/L	30
Fluoride	mg/L	0.05
Boron	mg/L	0.420
Barium	mg/L	0.011
Strontium	mg/L	0.019
Total nitrogen	mg/L	0.094
Total phosphorus	mg/L	0.043
Ortho phosphorus	mg/L	0.007

Very high recovery desalination is achieved via the secondary reverse osmosis units. Currently, Australia Pacific LNG is trialling the use of secondary reverse osmosis at their Talinga WTF. Optimally the system will reduce brine effluent by half. If the trial is successful, it is proposed to adopt secondary reverse osmosis as a standard component. Additionally, other facilities for further concentration of brine may also be implemented to minimise brine pond area.

The brine pond is a storage area into which the brine reject will be discharged and stored. Ponds will be designed appropriately to safely contain the contaminated waste stream. Table 12.4 provides the Talinga design basis for a brine stream that may be directed to the brine pond.

Table 12.4 Brine pond in-flow water quality design parameters

Property	Units	Range
TDS	mg/L	15,000 to 100,000
pH	std	8 – 9.5
TSS	mg/L	< 20
Temperature	°C	< 35

The design for high salt concentration considers an efficient brine concentration mechanism whilst the large sediment sizes allow for inefficiency in the upstream feed ponds. Furthermore the waste stream is anticipated to contain dilute solutions of acid and alkaline cleaning solutions or flushed chemical spills.

As previously discussed, the facility to deliver the process outlined above is already under construction at Australia Pacific LNG's Talinga operations under an approval separate to this EIS process. It is estimated that approximately 95% of the associated water can be recovered as treated water. A simple system flow diagram of the Talinga WTF, which is similar to the WTFs proposed for the Project, is provided in Figure 12.4.

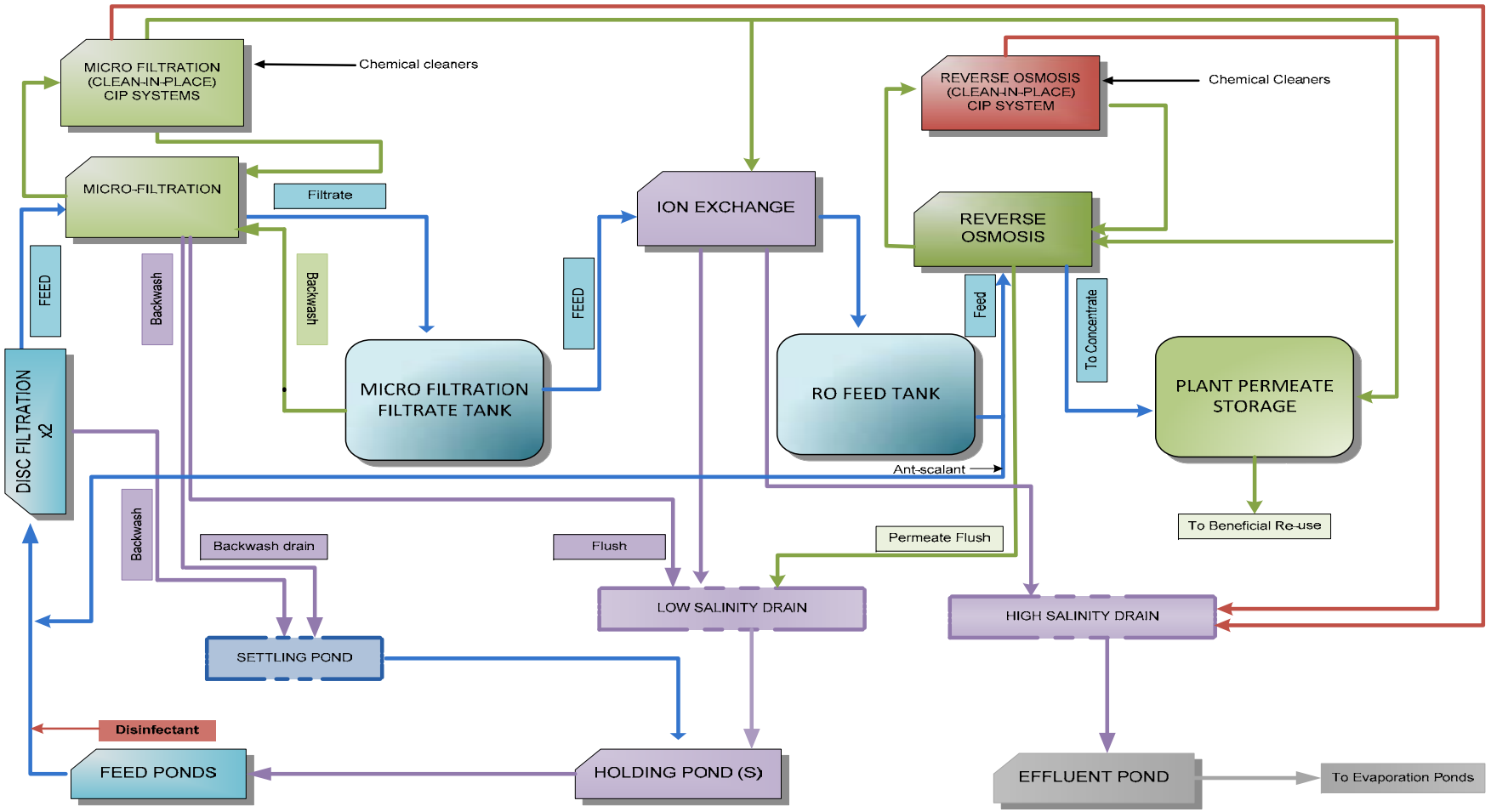

Figure 12.4 Water treatment facility process flow diagram

12.4 Risk assessment

A risk-based evaluation tool has been developed for the EIS which categorises and ranks risks, in terms of potential impact and probability of occurrence. Using the findings from the impact assessments undertaken for the EIS investigation, impacts relating to the management of associated water have been collated and addressed. When applied to associated water this evaluation becomes the basis for assessing and comparing, in a robust decision making framework, the potential impacts of associated water management. The nature of the tool developed for these risk assessments is such that it provides for the ongoing reassessment of risks as further information becomes available.

Details of the risk rankings and proposed controls or mitigation measures are presented in Volume 5 Attachment 24. Further discussion of the relevant risk factors is also presented under the appropriate studies for land and soils (Chapter 5), aquatic ecology (Chapter 9), groundwater (Chapter 10) and surface water (Chapter 11).

12.5 Optimising beneficial use

'Beneficial use' refers to the utilisation of associated water to add value, with Australia Pacific LNG committed to finding the highest value use, including environmental and social benefits, for the water produced on a case by case basis.

Each operating site will be individually examined to scope its unique water profile, available management options, the specific environmental and geological conditions, and potential commercial, community and landowner outcomes. Subsequently, the selected water management option (or options) will be chosen in light of these parameters and in accordance with the commercial constraints and requirements of Australia Pacific LNG.

The Initial water management Case, as described in Section 12.2.4, provides a readily applied and assessed management approach. As uncertainties regarding water quantity and quality diminish and technological advances are made, contractual arrangements can be successfully negotiated to provide a reliable and sustainable supply of water. Implementation of beneficial use options will be in the order of three to five years from the Project start and extend through the peak production period.

12.5.1 Option overview

Beneficial use options are being further investigated for the management of both permeate and brine products. Options identified by Origin and through stakeholder consultation (Section 12.2.2) were reassessed against the following criteria to optimise selection of beneficial use options:

- Opportunity for sustainable beneficial re-use; socially, environmentally and economically
- Reduction of environmental impact
- Regulatory approval
- Achievable implementation in a five year time period.

Options from one salt and six water categories are shortlisted below in Table 12.5.

Table 12.5 Associated water management beneficial use options

No.	Category	Options
1	Existing practices	Includes current practices such as discharge to watercourses. No options were considered to provide significant beneficial re-use opportunities in this category, therefore no further development is proposed.
2	Industrial use	Key opportunities in the industrial sector include both existing and proposed mines and power stations. Initial investigations of other industrial opportunities, primarily Australia Pacific LNG owned and operated, require substantial capital expenditure.
3	Potable water supply	Water supply is often restricted by the high cost of piping and the low volume demand. Australia Pacific LNG plans to investigate a range of high quality water supply networks. Construction, operation and ownership of these networks is yet to be determined. Urban supply to the following townships is also being investigated: Dalby, Miles, Chinchilla, and Tara. Bulk water supply to the Chinchilla weir, the proposed Nathan Dam and the SEQ Water grid also provides opportunities to use existing distribution networks and organisations. Agreements and liabilities in relation to supply remain considerable constraints.
4	Agriculture	Negotiation with landholders of existing agricultural ventures neighbouring key water infrastructure or where associated infrastructure traverses properties will continue to find a mutually beneficial agreement. Conveyance of water to agricultural customers beyond the development area is unlikely to be economically feasible. Australia Pacific LNG will further explore agricultural opportunities, potentially trialling new crops and expanding current plantations. Both of the above sub-options form part of the Initial Case however further optimisation will be undertaken.
5	Injection	Injection options are being further investigated with improved hydrogeological understanding of the area from ongoing feasibility studies and trials.
6	Other	The feasibility of the emerging technologies of algae management and solar ponds has been investigated as alternatives to other salt and associated water management options.
	Salt	Although injection of brine is being actively pursued, there are other key opportunities for re-use in the concentration or crystallisation of brine and the sale of salt products.

12.6 Conclusions

12.6.1 Assessment outcomes

Australia Pacific LNG has established an adaptive approach for the implementation of the AAWMP. The progression from the Initial Case to beneficial use will occur within three to five years of project initiation and involve the evolution of associated water management options.

A number of key milestones/dates have been established to ensure that beneficial use options are implemented during the transitional period. Volume 5 Attachment 24 provides a summary of milestones to be achieved within a high level timeline. Although not all beneficial use options may be implemented, the timeline indicates the path of implementation of each category if considered feasible and suitable during the option appraisal process.

Key challenges in the implementation of opportunities in the industrial, potable water supply and agricultural sectors are the agreement of commercial terms and cost of water supply. Negotiations with a range of end users, including regional councils, mining and power companies are in progress. In order to accelerate contracting water supply, Australia Pacific LNG has already established a working group aimed at achieving commercial agreements with stakeholders.

Australia Pacific LNG continues to work towards additional beneficial use through a number of emerging technical and industrial re-use options, which are currently undergoing research and development. These options are being considered for implementation and include aquifer injection, solar pond power generation, algae production and brine concentration.

Technical feasibility studies completed by Australia Pacific LNG to date have shown that aquifer injection is theoretically possible with potentially significant environmental and social benefits. Studies have focused on injection of associated water, permeate water, and brine concentrate from the treatment process. A number of potential target aquifers have been identified. Australia Pacific LNG intends to advance from theoretical to practical studies as quickly as possible. Further studies and trials are considered essential to reducing any uncertainties in hydraulic properties and chemical compatibility of the potential injection aquifers.

12.6.2 Commitments

Australia Pacific LNG is committed to collaborating with the Queensland Government in support of its 'Blueprint for Queensland's LNG Industry (2009)', and other CSG operators in the region, to develop an agreed approach to regional groundwater monitoring and cumulative effects groundwater modelling.

As part of the ongoing monitoring program, Australia Pacific LNG will conduct further evaluation of the potential for impacts from agricultural and stream discharge and, where necessary, develop appropriate monitoring and control measures to mitigate any residual risks.

When implementing re-use management options, such as agricultural, Australia Pacific LNG will adopt sustainable land management practices, including appropriate irrigation techniques and stormwater and erosion control measures.

Australia Pacific LNG will:

- Treat water to the appropriate quality for disposal or re-use option
- Discharge in a manner that meets environmental flow objectives and mimics pre-development stream flows where practicable

- Minimise the number and size of ponds and line all associated water and brine ponds
- Optimise commercial and beneficial water use through an adaptive approach including:
  - Water which can be reliably supplied long term will be contracted to commercial customers
  - Investigate opportunities for water to be managed in conjunction with other producers including water aggregation
- Consider the use of associated water (either treated or untreated) to meet the forecast water requirements of the Project during field development and operation
- Continue to work with the Western Downs Regional Council to study options to make water available to Miles and the towns near the gas field development
- Participate in studies into the long-term sustainable water supply options and support programs for water conservation within the region
- Offer impacted landholders, near to its water pipeline network, the opportunity to access water on commercial terms or as a compensation offset, subject to availability and relevant approvals
- Actively investigate alternative water management technologies including aquifer injection
- Actively investigate improved water management technologies to address beneficial use of brine.

References

Department of the Environment, Water, Heritage and the Arts 2009, *Great Artesian Basin,* viewed November 2009, <http://www.environment.gov.au/water/locations/gab/index.html>

Great Artesian Basin Consultative Council 2000, *Great Artesian Basin Strategic Management Plan*, Great Artesian Basin Consultative Council, Canberra.