7 GAS FIELD COMPONENT OPERATIONS

7.1 DESCRIPTION OF THE CSG RESOURCE

Coal seam gas (CSG) is a natural gas formed deep under ground over geological time through the heating, compression and deposition of organic debris, or plant matter. Over time the gas becomes trapped in coal seams by water, typically several hundred metres below the surface. Removing the water changes the pressure and allows the gas to flow.

CSG is composed mostly of methane and contains little or no amounts of other hydrocarbon gases such as ethane, propane and butane. Also, it contains only small amounts of carbon dioxide and nitrogen. As such, it is considered a “cleaner” gas that requires relatively little treatment before being used in industry and households.

QGC has developed a model to highlight areas in the north-east Surat Basin of southern Queensland that present the best prospects for CSG extraction. This model has identified the Walloon Fairway as the area offering the greatest probability of success.

The CSG resource for the Queensland Curtis LNG (QCLNG) Project is stored within stratigraphical layers known collectively as the Walloon Sub Group (WSG).

The WSG is divided into two coal intervals:

- Juandah Coal Measures (CM)
- Taroom Coal Measures.

There are seven coal seams in the Juandah CM and three coal seams in the Taroom CM. The net coal thickness in the WSG averages 30 m, with an average of 22 m in the Juandah CM and 8 m in the Taroom CM. *Figure 2.7.1* shows that stratigraphy of the WSG.

The WSG:

- lies at a typical depth of between 100 m and 800 m below the ground surface
- has an average net coal thickness of 30 m
- has an average gas content of 5 m3/t coal
- has an average gas saturation of 80 per cent.

The typical gas composition, as determined from testing at existing QGC wells is presented in *Table 2.7.1*. With approximately 97 per cent methane, and only traces of nitrogen, carbon dioxide and ethane, this CSG represents a clean, easily processed feed gas for the LNG Facility. However, the CSG resource is typically accompanied by large volumes of water which require management.

Figure 2.7.1 Walloon Sub Group Stratigraphy

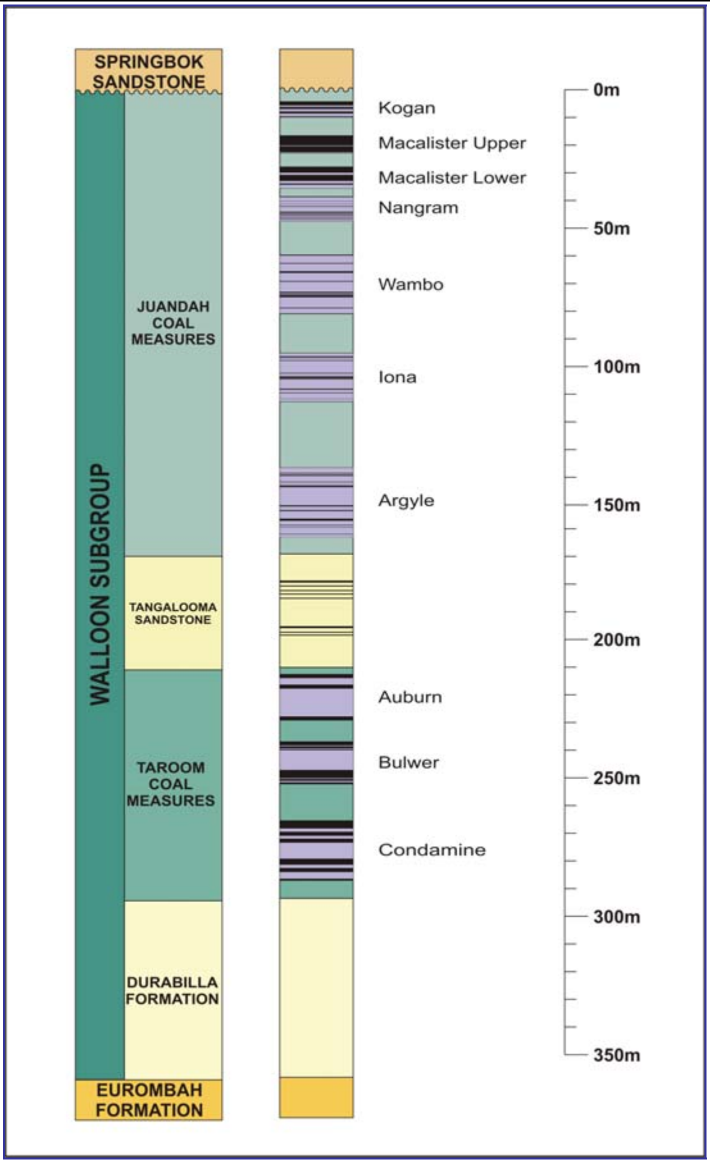


Table 2.7.1 Average CSG Composition at the Wellhead

Composition	MOL %
Nitrogen	2.3
Carbon dioxide	0.2
Methane	97.5
Ethane	0.01

7.2 OVERVIEW OF OPERATIONS

The Gas Field Component of the QCLNG Project encompasses the expansion of QGC's existing CSG operations in the Surat Basin to provide supply for existing and future domestic gas markets.

As outlined in *Chapter 3*, the Project is anticipated to have a design life of at least 20 years. Over this timeframe the Gas Field expansion comprises development of:

- approximately 6,000 gas production wells over the life of the project with initially 1,000 to 1,500 wells across the Gas Field by mid-2014. The remaining wells will be phased in over the life of the project (20 to 30 years) to replace declining wells
- associated surface equipment, such as wellhead separators, wellhead pumps, telemetry devices and metering stations
- gas-gathering systems
- gas processing and compression infrastructure
- field infrastructure such as access tracks, warehouses, camps (both construction and operations), office and telecommunications
- water-gathering and water management infrastructure, such as ponds and water treatment facilities.

The Gas Field Component also includes the management of Associated Water, which is water produced in the CSG extraction process on the production tenements. Options for beneficial use of Associated Water and potential infrastructure requirements are discussed in this Environmental Impact Statement (EIS) – see *Section 7.9* and *Volume 3, Chapter 11.*

Design, location and operation of gas-gathering, transportation and processing infrastructure aim to minimise any environmental and social impacts.

Variability in production rates across a field development is the primary constraint to forecasting precise locations for field infrastructure, gas- and water-gathering systems, gas processing, and compression infrastructure. A flexible approach to well location and design will allow QGC to manage actual production rates across its acreage.

The basis for the Project design is the delivery of 1,360 million standard cubic feet per day (mmscfd) of compressed CSG to the LNG Facility via the Export Pipeline and its associated infrastructure for supply to the first two LNG trains.

Central Processing Plants (CPPs), which collect, process and supply gas to the Export Pipeline, require a constant flow of gas from Field Compression Stations (FCSs).

The location of CPPs and FCSs is based on exploration and appraisal results which confirm reserve estimates within a particular area of the Gas Field Component. From this, the construction of FCSs and delivery rates or flows to CPPs can be scheduled to meet the constant flow requirements over the life of the Project.

To accommodate this flexible approach, this EIS has developed a reference case to assess the likely impacts on the receiving environment. This reference case is based on deliverability information and standard FCS and CPP configurations as available in December 2008. The design case is expected to change in line with the field development maturation as a result of ongoing exploration drilling and testing.

The key phases and activities associated with Gas Field Component operation are summarised in *Table 2.7.2*.

Table 2.7.2 Key Phases and Activities

Phase	Infrastructure Item
Operations and maintenance	Wellhead separator and wellhead pump
	Infield gas- and water-gathering lines
	Field Compression Stations (FCS)
	Central Processing Plants (CPP)
	Associated Water infrastructure, including ponds and water treatment
	Gas pipelines between FCS and CPP
	Gas sales stations
	Supporting infrastructure

Construction activities are discussed in *Volume 2, Chapter 11.*

Rehabilitation and decommissioning are discussed in *Volume 2, Chapter 15.*

7.3 WELL OPERATION

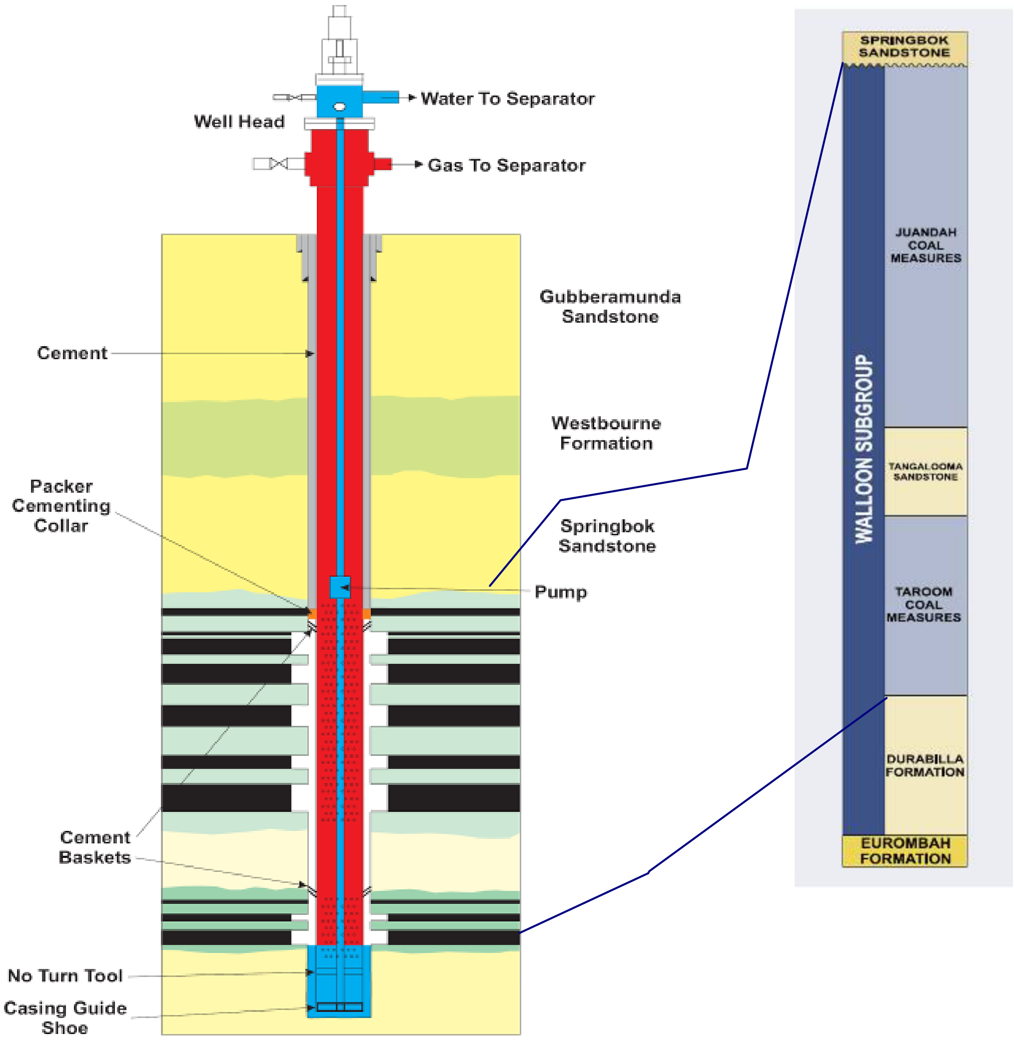
To extract CSG, vertical wells are drilled to a depth between 200 m and 700 m underground to intersect gas-bearing coal seams of the WSG.

Water associated with the coal seam will either flow or be pumped to the surface, thereby lowering the reservoir pressure and allowing the gas to desorb from the coal seam and flow into the well. The CSG may then flow to the surface.

When assistance is required a pump lifts the water from the well through a tubing string. The CSG flows up the annulus between the tubing string and the casing. Once at the wellhead, the CSG and water are recombined in a common pipe that runs to a separator. Once separated from the water, the CSG is piped to FCSs and from there to CPPs. At the FCS and CPP the gas is compressed and eventually fed into an Export Pipeline for transportation to the LNG Facility. During appraisal production testing of wells, the CSG is measured and then sold or flared after separation and measurement.

Figure 2.7.2 shows a typical gas well in relation to the WSG.

Figure 2.7.2 Typical Gas Well



Surface production facilities will typically consist of a well pad fitted out with the wellhead, wellhead hydraulic drive unit, miscellaneous pipe work, valves and fittings, gas/water separator, flare stack and instrumentation. Following progressive rehabilitation, these facilities occupy an area of approximately 5,000 m^2. The surface equipment is fenced to exclude stock access.

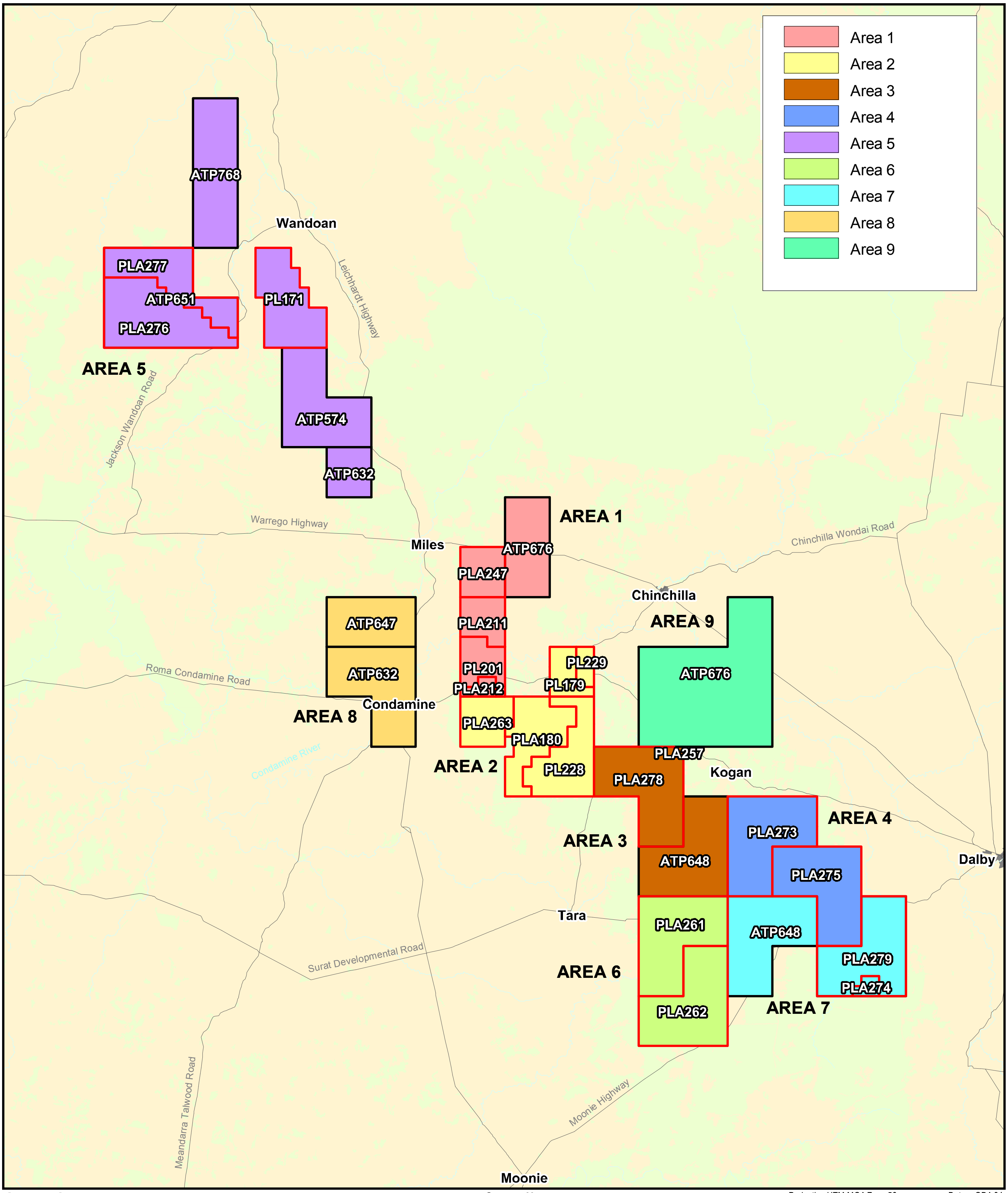
QGC will progressively establish up to 6,000 commercial production wells over the life of the Project. The exact location of these wells will not be known until exploration activities are conducted in each tenement. The design life of a well is in excess of 25 years. Typically, the life of a well is between 15 and 20 years.

Table 2.7.3 shows the estimated number of wells at various stages of the Project life.

Table 2.7.3 Estimated Number of Wells

Year	Cumulative number of wells
2010	400
2013	1,000
2014	1,500
2020	3,600
2030	6,000

The predicted order of CSG extraction over time is shown in *Figure 2.7.3,* commencing in Area 1 and ending in Area 9, although some development will occur simultaneously in all areas. This order of extraction is based on best estimates at the time of compiling the Environmental Impact Statement (EIS) and is subject to change based on field performance and other considerations.



Legend:

Gas Fields - Petroleum Lease/Petroleum Lease Application

Gas Fields - Authority to Prospect

Source Note:

DCDB data copyright State of Queensland (2008)
1:250,000 Topographic Vector copyright Geoscience Australia
Mining Tenement Information copyright State of Queensland
(Dept. Mines and Energy)

Projection UTM MGA Zone 56 Datum GDA 94

0 10 20 30 40

Kilometres

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QUEENSLAND CURTIS LNG A BG Group business	Project: **Queensland Curtis LNG Project**		Title: **Gas Field Order of Extraction**
	Client: **QGC - A BG Group business**		
ERM Environmental Resources Management Australia Pty Ltd	Drawn: Mipela	**Volume** 2 **Figure** 2.7.3	Disclaimer: Maps and Figures contained in this Report may be based on Third Party Data, may not be to scale and are intended as Guides only. ERM does not warrant the accuracy of any such Maps and Figures.
	Approved: CDiP	File No: QC02-T-MA-00029	
	Date: 08.07.09	Revision: A	

Plate 2.7.1 shows a typical well configuration, including from left to right a wellhead, drive head unit for a well that is not free flowing, and separator.

Plate 2.7.1 *Pumping Well: Well Configuration with Wellhead, Drive Head Unit and Separator*

Wells are equipped with instrumentation and telemetry that will transmit information including production and gas flow data to a central control room. The control room's primary function is to manage and balance production against demand for CSG, as well as provide a central point for managing and responding to field-based emergencies. Approximately 10 per cent of wells, representing 50 per cent of production, could be shut down or opened remotely from the control room. Triggers for a shutdown can include potential well leaks and production constraints.

Once the LNG Component of the Project is operational, gas production will ramp up from the current rate of up to 200 terajoules (TJ) of gas per day (for domestic sales) to approximately 707 TJ per day, equivalent to 680 mmscfd. This rate of supply exists for the first LNG train before increasing to approximately 1,415 TJ per day (1,360 mmscfd) for two LNG trains.

The Gas Field Component currently includes granted petroleum leases (PL), petroleum lease applications (PLA) and authorities to prospect (ATP). The planned acceleration of commercial well development requires the grant of all PLA to production licence tenures.

In accordance with existing land access procedures, QGC negotiates with landholders prior to the development of each well, construction of gathering systems and access tracks, and the installation of well site equipment. In these discussions and during the QGC planning process, account is taken of environmentally or culturally sensitive locations, landholder requirements and safety requirements. QGC also secures land access agreements where required.

7.4 WELLHEADS AND SEPARATORS

A wellhead seals casing strings and isolates the underground fluids (gas and water), from the surface. A wellhead is usually installed when the well is completed. Wellheads are typically rated to withstand 2,000 – 3,000 pounds per square inch (PSI), with typical maximum pressures up to 700 PSI. A free-flowing wellhead is likely to experience higher pressures. Wellhead pressures are monitored via telemetry and manually checked by digital pressure gauges.

Plate 2.7.2 shows a typical flowing wellhead configuration.

Plate 2.7.2 Flowing Well: Typical Wellhead Configuration

A two-phase (water/gas) separator fitted to each well separates and channels water and gas into gathering lines. This vessel has a design pressure of 125 PSI and is rated for 5,000 mscf (141,500 m^3) of gas and 5,000 barrels (795m^3) of water per day. QGC will continuously monitor via real-time telemetry gas volume, liquid levels, water flow and the pressure of the separator (*Plate 2.7.3* shows a typical separator).

Plate 2.7.3 Separator (horizontal)

Water produced from the well is routed via high pressure steel lines to the water/gas separator and transported to a gathering system . Gas produced by the well flows under natural pressure via a HDPE pipe-gathering system to an inlet manifold at one of the FCSs.

QGC plans to locate wells approximately 750 m apart to optimise production. The well sites require a firm and level area of approximately 100 m x 100 m (i.e. 1 ha) to accommodate a drilling rig (refer to *Volume 2, Chapter 11*). This pad area places the drill rig at a safe distance from site offices, ancillary drilling equipment and other associated temporary infrastructure. Well-drilling operations are conducted 24 hours a day and take approximately one week to complete. A gas well, separator, one or two sumps for temporary containment of drilling fluid and a flare pit are contained within the immediate working area. Once wellhead infrastructure is established, the pad is progressively rehabilitated and eventually occupies an area of approximately 5,000 m^2.

Due to the variability of the reservoirs, each well performs in a different manner around a generalised normal capacity. Ongoing and active management of the wells is required and is particularly focused on monitoring/maintenance and workover management (refer to *Section 7.5.2* for description).

7.5 WELL MAINTENANCE

7.5.1 Monitoring and Maintenance

Wells are monitored continuously and maintained on a regular basis. Gas and water levels and pressures of the wells are recorded as are the gas and water volumes produced from the well bore. Gas engines, gas-gathering lines, flares, separators and pump drive units in the field are regularly inspected and maintained.

A telemetry system provides real-time monitoring of performance to allow trending for maintenance planning. QGC maintains surplus equipment and materials for the maintenance and repair of equipment at warehouse facilities.

Maintenance of the separator and the associated equipment between the wellhead and gathering system includes:

- flushing the separator to clean out the silt and coal fines
- cleaning coal fines and silt from the strainer
- valve replacement for faulty or worn valves
- meter maintenance
- cleaning of gas/water vents and replacement of worn o-ring seals in these vents
- replacement of faulty or worn separator gauges
- replacement of o-ring fittings
- maintenance or repair of safety valves
- maintenance of hammer union fittings
- changing of orifice plates.

7.5.2 Workover Management

Wells may be worked over to reinstate production as required or to optimise the production from a well. A free-flowing well does not have an artificial lift system such as a pump, which is generally fuelled by the CSG produced from the local well. The aim is to convert the pumping wells to free-flowing wells to minimise workover frequency and optimise gas recovery.

Workovers generally require a workover rig (similar to, but smaller than, a drilling rig) to enable well flushes, pump changes and other necessary work. The procedure allows field operators to enhance well productivity or add new systems or processes to increase productivity.

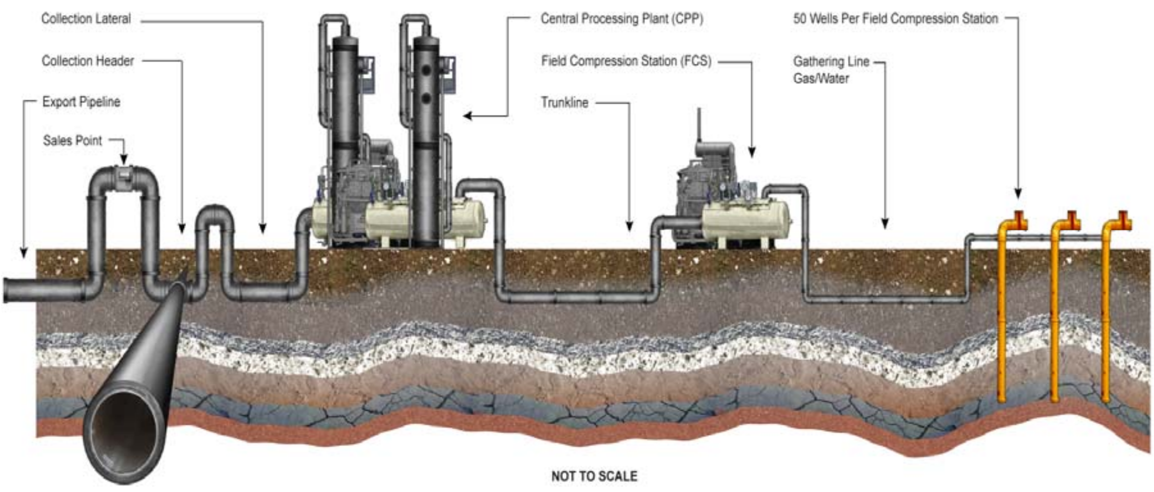
A workover rig consists of a derrick, a workover platform with hydraulic powered tongs, a pump and a blowout preventer (BOP). Workovers are typically carried out on individual wells about once every two years and take approximately three days per well.

7.6 INFIELD GAS- AND WATER-GATHERING LINES AND TRUNK LINES

QGC will install a gas-gathering system constructed from high-density polyethylene (HDPE), fibreglass and steel pipe to connect within the Gas Field Component. *Figure 2.7.4* describes the Gas Field Component infrastructure and gathering systems which connect:

- the completed wells to the FCSs (HDPE)
- the FCSs to the CPPs (steel or fibreglass trunk lines)
- the CPPs to the Collection Header in the Upstream Infrastructure Corridor (steel collection laterals).
- The water-gathering system is constructed of HDPE pipe and installed to transfer water from:
- wells to water storage ponds and treatment facilities
- FCSs and CPPs to oily water ponds
- between water treatment facilities storage ponds and beneficial users.

Figure 2.7.4 Schematic of Infield Components



The infield gas- and water-gathering systems are included within the Gas Field Component of the Project. Other pipelines, as described in *Volume 2, Chapter 8* (Collection Header, Lateral Pipeline and Export Pipeline) are included in the Pipeline Component of the Project.

A 160 mm HDPE line can carry approximately 4 to 5 mmscfd (113,000 to 141,500 m^3 per day) of gas, or about 5,000 barrels (bbl) per day (795 m^3 per day) of water. Flow rates can vary depending on conditions including topography, distance and directional changes. A 315 mm HDPE line can carry approximately 18 to 20 mmscfd (509,000 to 566,000 m^3 per day) of gas or about 45,000 bbl per day (7,154 m^3 per day) of water, depending on conditions.

Anticipated specifications of the various infield gas- and water-gathering pipes are set out in *Table 2.7.4*. These are subject to change as pipeline design is optimised.

Table 2.7.4 Gas Pipeline Specifications

Pipeline Component	Wells to FCS	FCS to CPP	CPP to Collection Header
Applicable standard	QGC Standard Procedure [1]	AS 2885	AS 2885
Cumulative length	~2,500 km	~1,200 km	~100 km
Diameter	160–315 mm	400–600 mm	1,050 mm
Material	HDPE	Class 150 Steel/fibreglass	Class 900 Steel
Construction RoW	15–20 m	30 m	30–40 m
Depth cover	1,000 mm	>900 mm	>900 mm
Corrosion protection	No	For steel only	Yes

1 Based on several Australian Standards

The size of trunk lines may vary depending on the distance between the FCS and the CPP, but predominantly are made from 400 mm to 600 mm pipe. These pipelines are protected from corrosion by coating and cathodic protection. HDPE pipes used in the gathering system predominantly consist of 160 mm, 315 mm and 400 mm pipe. These pipelines have a trace wire installed directly above them to accurately determine their location. Gathering system HDPE pipes have a design life of 50 years.

7.6.1 Gathering Line Maintenance

To prevent undue maintenance of the HDPE gathering system lines, all lines are inspected above ground prior to burial. This includes checking the integrity of welds and pipeline for any structural failures. Once this check is completed, the pipeline is lowered into a trench and buried.

As gathering system lines cover a large area, the possibility of sections of the lines being in low- and high-elevation areas is great. This could lead to gas or water accumulating in sections. In the water-gathering system lines, gas could become trapped in the line. To guard against this, a valve-like device known as a high-point vent (HPV) is installed on high-elevation points. It consists of a float valve which allows gas to escape. In the gas-gathering system lines, water is likely to accumulate in low-lying sections. A water take-off point is installed at these points to remove the water. Known as a low-point drain (LPD), it uses pressure in the line to drive water out when the ball valve on the drain is opened by an operator.

LPDs are drained periodically, with the water either used locally or taken to a storage pond, depending on the salinity and volume. Total Dissolved Solids (TDS) of the LPD water is typically less than 2,000 mg/L. High-point vents are checked periodically for blockages.

Surface structures including manifolds, end-of-line risers and isolation valves are inspected under an integrity management plan.

7.7 FIELD COMPRESSOR STATIONS

The FCSs comprise compression facilities, a vent or flare for pressure management, power generation facilities and a water management system. The exact location of each FCS will be unknown until the gas exploration program confirms the precise areas to be developed, thus requiring compression facilities. QGC expects to distribute FCSs evenly across the tenements, as tenements are progressively explored and gas is extracted.

Final location and design specifications for FCSs have not been completed at the time of compiling this EIS. The following specifications have been used as a reasonable representation of expected design based on current field implementation. The compression equipment at each FCS will comprise eight single-stage screw compressors (e.g. CAT 3512 engines with an Ariel Compressor) with a throughput capacity per compressor of 7-11 TJ per day. Screw compressors will be powered by gas engines, fuelled by a portion of the CSG extracted from adjacent wells. However an option remains to power compressors through electric drive motors. Gas-powered engines have been impact-assessed in the EIS as they represent a worst-case scenario for air and noise emissions. FCSs have equipment for the removal of the free water and compression of the gas to between 1,200 and 1,500 kPa. Screw compressors at a FCS push gas from the CSG wells to reciprocating compressors at the CPP.

Plate 2.7.4 shows the configuration of a section of a FCS with four of eight screw compressors in view.

Plate 2.7.4 Section of a FCS showing Four Screw Compressors

Gas under low pressure (i.e. 200 kPa) from the wells is received at the FCS. This gas contains free water that arises from condensation in the flow lines as well as some carry-over from the wellhead separator.

Flares at the FCS are used in the event that a compressor unit experiences operational difficulties or “upset events”. Flaring is under consideration as an alternative to venting. Flare ignition is unscheduled but events are of short duration and limited frequency.

Power for the supporting infrastructure at the FCS is provided by a gas generator with a diesel generator for backup. The fuel for the gas generator is tapped off from the inlet supply of CSG to the FCS. The generator units are constructed off site and transported to site for installation.

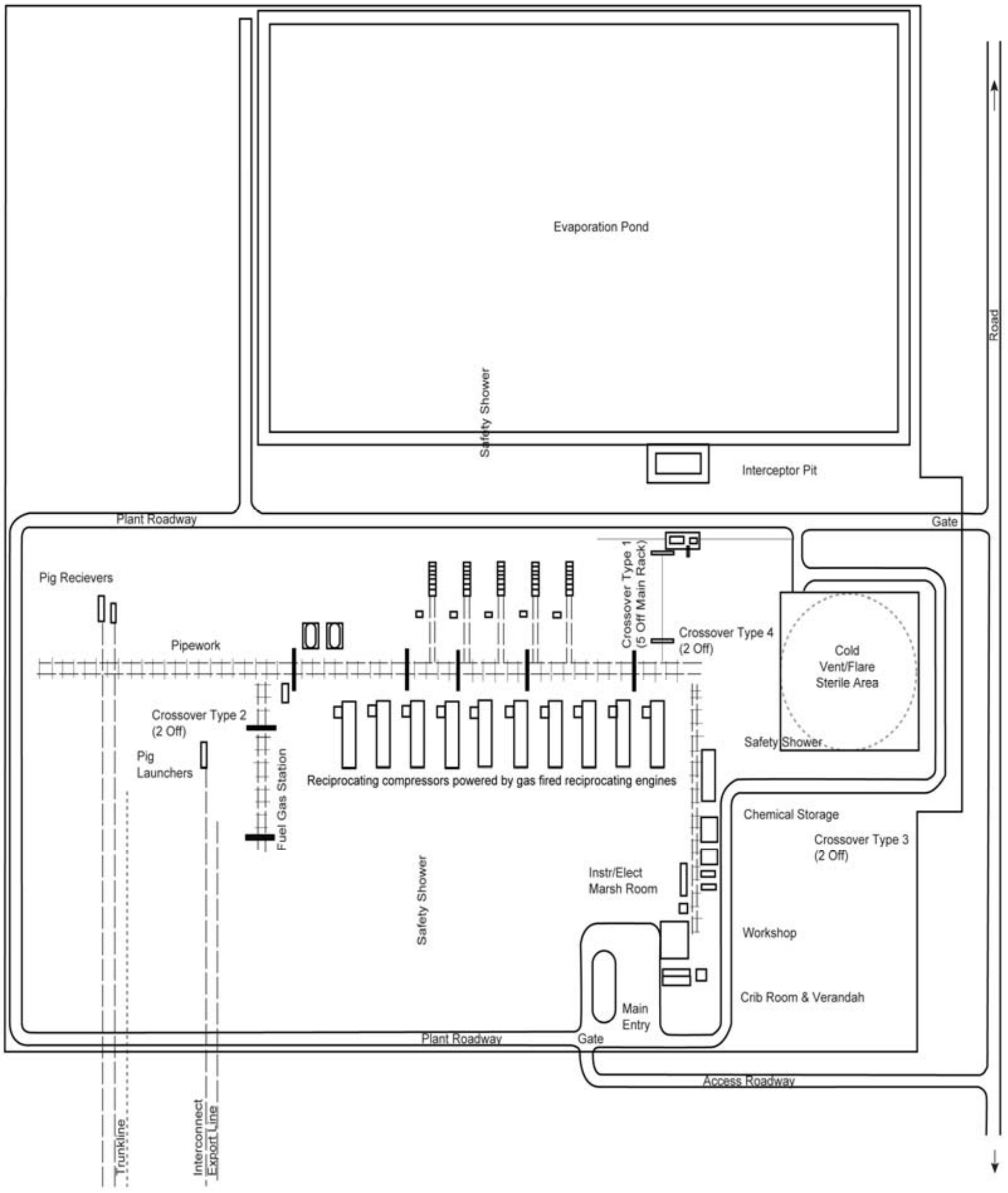
Water from the compression units falls into two categories: water contaminated by compressor oil and non-contaminated water. The oil-contaminated water is collected in a closed drain system and transferred to an oil/water-separation pond on site.

Clean water from the separator is transferred to an onsite interceptor pit and evaporation pond. Waste oil from the process is held in a waste-oil tank for removal by a waste contractor. Non-contaminated water is fed into the Associated Water management system (refer to *Volume 3, Chapter 11*). An onsite water storage pond is required for the management of non-contaminated water.

7.8 CENTRAL PROCESSING PLANTS

The CPPs comprise compression facilities, gas dehydration and regeneration units, a flare, power generation, metering facilities, a water management system and a car park. An example plot plan for a CPP is presented in *Figure 2.7.5*.

Figure 2.7.5 CPP Plot Plan



The EIS reference case has assessed a field development configuration of nine CPPs for the Gas Field Component. The design life of a CPP is 25 years. The location of CPPs will be developed as part of FEED to meet the flow requirements of the LNG Facility. Final design specifications for CPPs have not been completed at the time of compiling this EIS. The following specifications have been used as a reasonable representation of expected design based on current field implementation.

At the CPP the gas is pressurised and dried to its export pressure (~10 megapascals). The CPP uses two-stage reciprocating compressors (CAT 3608 engines with an Ariel Compressor) to pressurise the gas. Each CPP utilises 10 reciprocating compressors with a throughput capacity per compressor of 18 TJ per day.

At the CPP, the gas is dehydrated and compressed for delivery to the high-pressure collection laterals which join the Export Pipeline. Dehydration and regeneration of the gas is via Tri-ethylene Glycol (TEG) units. QGC estimates it requires 45 TEG units (five per CPP). The gas is dehydrated by the absorption of water vapour in the liquid desiccant, TEG. The gas is passed through a column containing TEG and this extracts the water allowing dry gas to pass to the compressor units. The TEG is then regenerated by boiling it using gas-fired tubes. The TEG is circulated using dual electrically-powered pumps.

Plate 2.7.5 shows an aerial view of a CPP and *Plate 2.7.6* shows a side view of a typical CPP, with a reciprocating compressor in the foreground.

Plate 2.7.7 shows a CPP with reciprocating compressors in the background and TEG units in the foreground.

Plate 2.7.5 Aerial View of CPP with Reciprocating Compressors

Plate 2.7.6 Side View of CPP with Reciprocating Compressors

Plate 2.7.7 CPP showing TEG units in the Foreground

Power generation for supporting infrastructure at the CPP site is similar to that at the FCSs. Refer to *Section 7.7*, *Field Compressor Stations*. Electrically powered motors are being considered as an alternative to gas-driven engines however, the EIS has impact-assessed gas-driven engines as they represent a worst-case scenario for air and noise emissions.

Each CPP includes a flare capable of managing 85 TJ per day of flow. Any significant gas vented from the units is directed to the flare. Flaring for emergency shutdowns occurs infrequently (less than five times per year). Flaring for maintenance occurs with each shutdown and start up of units, which occurs weekly and for durations less than one hour (approximately 500 times per year).

Flow from each CPP is metered as part of the process of transferring the gas to market. Metering assists in identifying any losses within the pipeline network.

Water from the process is managed in a similar way as water at the FCSs. An evaporation pond for water from the oily-water system is required. A storage pond for non-contaminated water is also required. Waste management for the CPP is addressed in *Volume 3, Chapter 16.*

Due to the Project-specific design requirements, there is limited or no opportunity for sharing any of the above Gas Field Component infrastructure with other projects proposed for the Surat Basin.

7.9 ASSOCIATED WATER INFRASTRUCTURE

7.9.1 Preface

As part of Front-End Engineering and Design (FEED), QGC is considering options for Associated Water management. An outline of the preferred infrastructure required for Associated Water management is provided below. Associated Water management options are currently at a conceptual phase. These options are analysed more fully in *Volume 3, Chapter 11*, which also provides an overview of environmental and social impacts from Associated Water management options. Detailed environmental and social impact assessments of the conceptual Associated Water management systems have not been conducted. However, should these concepts move to the selection phase, the environmental and social impacts will be identified and mitigation measures presented in the Supplementary EIS.

7.9.2 Introduction

Water associated with CSG extraction will either hydrostatically flow or be pumped out to the surface, thereby lowering the water pressure and allowing the gas to desorb from the coal seam and flow into the well. Current estimates predict the total volume of Associated Water generated over the life of the Project to be approximately 1,200,000 ML. The volume of Associated Water generated is projected to peak at approximately 180 ML per day in 2013/2014, with average production in the order of 160 ML per day between 2015 and 2025. The estimated water volumes may vary by ± 50 per cent. All water management infrastructure will be designed for the duration of expected water production.

From the wellhead, water flows to a gas and water separator, where water flows through a network of gathering pipes and pumps to untreated water collection ponds located in proximity to groups of wells. From collection ponds, water will be pumped to untreated water storage ponds located adjacent to water treatment facilities.

Gas flows via gathering pipes to compressor stations. A minor volume of water (less than 1 per cent of total volumes) will be pumped from the compressor stations to their own smaller evaporation ponds.

The majority of water will require some form of treatment prior to beneficial use. The preferred option is for desalination of a proportion of Associated Water followed by concentration and evaporation of brine produced through the desalination process. The remaining portion of untreated Associated Water may be amended through the addition of gypsum to reduce the sodium adsorption ratio (i.e. to reduce the ratio of sodium to other ions in the water to make it more suitable for uses such as irrigation). Untreated or amended water may be blended with treated water prior to release to a beneficial user. Alternatively, untreated water may be available for beneficial use based on a fit-for-purpose application such as coal washing.

The Gas Field Component has, for the purposes of water management, been divided into three regions, the:

- North West Development Area (NWDA)
- Central Development Area (CDA)
- South East Development Area (SEDA).

Water treatment facility specifications have not been finalised. An indicative water treatment facility consists of a desalination plant, brine processing unit and brine evaporation ponds. There is likely to be one Associated Water treatment facility per region. These will be similar in design and operation and will be located across the tenements near areas of gas and water extraction. Water treatment facilities will be either linked through a central water pipeline, or decentralised with their own storage and treatment facilities depending upon the commercial and resource management limitations of options.

Once treated, water will be transferred to treated water storage ponds. From the treated water storage pond, water will be distributed via a local distribution network to a variety of potential beneficial users of Associated Water.

A range of beneficial use options are described in detail in *Volume 3, Chapter 11*. The options that are most advanced at the time of preparation of this EIS are: irrigation of trees with treated and blended water; supply of untreated and treated water to QGC petroleum activities and various mining and industrial operations.

The principal waste stream from water treatment is saline brine. Saline brine may be further treated through a brine concentration and evaporation process, yielding treated water and crystalline brine (salt). The brine may result in more water being made available for beneficial use, or it may be evaporated from the surface of the brine pond. The salt then crystallises and may become commercially saleable, or where salt has no commercial value, will be disposed of to an appropriately designed waste disposal facility.

7.9.3 *Infrastructure Requirements*

Based on the preferred options listed above, the following water management infrastructure will be developed:

- water-gathering pipelines
- treated and untreated water storage ponds
- desalination facilities
- brine processing and brine waste storage facilities
- quality assurance stations
- pumping stations
- roads
- beneficial user networks, including irrigation systems, pumps and pipeline networks.

Should reinjection be implemented as the preferred option, infrastructure will include water balancing ponds, pipelines and pumps.

The proposed infrastructure required for treatment and distribution of water for irrigation of tree crops is detailed in *Table 2.7.5.* This infrastructure is considered to be substantially similar in nature to other options that may require treatment of Associated Water. Other beneficial use options may require more or less water treatment.

The system proposed for treatment of Associated Water and its subsequent brine waste involves the following processes; pre-treatment, ultra filtration, reverse osmosis, brine concentration and brine evaporation. Water treatment facilities will treat approximately:

- 20 ML per day in the NWDA
- 30 ML per day in the CDA;
- 55 ML per day in the SEDA.

Table 2.7.5 Proposed Water Treatment Infrastructure

NWDA	CDA	SEDA
• 20 ML/day desalination plant • Untreated water collection and storage ponds (2,000 ML) • 2 feed pump stations • Pre-treatment and reverse osmosis treatment plant • Brine concentration plant • Raw water dosing (amendment) and blending system • Brine holding dam (100 ML) • Multi-cell evaporation basin • 2 discharge pump stations • Treated water dam (400 ML)	• 30 ML/day desalination plant • Untreated water collection and storage ponds (2,600 ML) • 5 feed pump stations • Pre-treatment and reverse osmosis treatment plant • Brine concentration plant • Raw water dosing (amendment) and blending system • Brine holding dam (200 ML) • Multi-cell evaporation basin • 4 discharge pump stations • Treated water dam (300 ML) • Salt disposal landfill	• 55 ML/day desalination plant • Untreated water collection and storage ponds (3,950 ML) • 7 feed pump stations • Pre-treatment and reverse osmosis treatment plant • Brine concentration plant • Raw water dosing (amendment) and blending system • Brine holding dam (400 ML) • Multi-cell evaporation basin • 7 discharge pump stations • Treated water dam (1,200 ML) • Salt disposal landfill

In addition, approximately 500 km of water-gathering lines will be required between wells, water treatment facilities, storage ponds and on-tenement beneficial uses. Approximately 25 km of roads will be constructed to enable the operation of the Associated Water management system. These roads are likely to coincide with access roads to gas-processing facilities.

7.9.3.1 Water-gathering Lines

Approximately 500 km of HDPE water-gathering lines will transfer water from:

- wells to untreated water storage ponds
- untreated water storage ponds to water treatment facilities
- water treatment facilities to treated water storage ponds
- all storage ponds, via the water pipeline in the Upstream Infrastructure Corridor (UIC), to other storage ponds or water treatment facilities.

7.9.3.2 Water Storage Ponds

As part of QGC's water management strategy, evaporation ponds will be used in the short term to dispose of Associated Water whilst other disposal options are developed. In the medium to long term, evaporation ponds will be transitioned to water storage ponds for balancing water flows.

There will be three main types of water storage ponds:

- untreated water collection ponds for existing exploration and production wells
- untreated water storage ponds
- treated water storage ponds.

Untreated Water Collection Ponds

Untreated water collection ponds will be located in proximity to groupings of exploration and production wells in each region and will collect Associated Water from these well groups. New ponds will either be constructed for this purpose or gathering systems will connect to existing ponds. The potential water volumes to be stored in exploration ponds and purpose built production ponds are described in *Table 2.7.6*.

Table 2.7.6 Untreated Water Collection Ponds

Field Area	Purpose Built Ponds (ML)	Future Exploration Ponds (ML)	Specifications	Pond Area (ha)
NWDA	2 x 200	7 x 200	Lined[1] pond ~ 5 m deep x 300 m x 135 m	9 x 4 = 36
CDA	3 x 200	10 x 200	Lined pond ~ 5 m deep x 300 m x 135 m	13 x 4 = 52
SEDA	4 x 200	13 x 200	Lined pond ~ 5 m deep x 300 m x 135 m	17 x 4 = 68
TOTAL	1,800	6,000		156

Note: 1. The pond lining could be clay, compacted clay or HDPE, as appropriate, and will be determined following site investigations

Untreated Water Storage Ponds

Untreated water storage ponds will be located in proximity to water treatment facilities. These ponds will be used to store and balance untreated water flows prior to treatment. The potential water volumes to be stored in these ponds and the pond specifications are described in *Table 2.7.7.*

Table 2.7.7 Untreated Water Storage Ponds

Field Area	Purpose Built Ponds (ML)	Existing Licensed Ponds (ML)	Specifications	Pond Area (ha), excluding existing ponds
NWDA	1 x 200	-	Lined pond[1] ~ 5 m deep x 300 m x 135 m	1 x 4 = 4
CDA	-	Multiple to a total of 500 ML	Lined pond ~ 5 m deep x 300 m x 135 m	0
SEDA	1 x 550	-	Lined pond ~ 5 m deep x 500 m x 220 m	1 x 11 = 11
TOTAL	750	500		15

Note: 1. The pond lining could be clay, compacted clay or HDPE, as appropriate, and will be determined following site investigations

Treated Water Storage Ponds

Treated water storage ponds will be located in proximity to water treatment facilities. These ponds will be required to store and balance water flows from water treatment facilities for beneficial user networks. Treated water storage ponds will either comprise purpose-built ponds or existing ponds that QGC is licensed to operate for existing operations. The potential water volumes to be stored in these ponds and the pond specifications are described in *Table 2.7.8.*

Table 2.7.8 Treated Water Storage Ponds

Field Area	Purpose Built Ponds (ML)	Existing Ponds (ML)	Specifications	Pond Area (ha), excluding existing ponds
NWDA	2 x 200	-	Lined pond[1] ~ 4.5 m deep x 250 m x 180 m	2 x 4.5 = 9
CDA	1 x 300	Multiple to a total of 500 ML	Lined pond ~ 4.5 m deep x 350 m x 190 m	1 x 7 = 7
SEDA	3 x 400	-	Lined pond ~ 4.5 m deep x 400 m x 225 m	3 x 9 = 27
TOTAL	1,900	500		43

Note: 1. The pond lining could be clay, compacted clay or HDPE, as appropriate, and will be determined following site investigations

The volumes and areas of the above ponds are preliminary estimates only. Capacities will change as further refinement of water management infrastructure occurs.

The total volume and area of all ponds proposed for operations, other than ponds already licensed, is approximately 10,450 ML and 214 ha respectively. QGC has, or is in the process of obtaining, approximately 550 ha of licensed, existing ponds. These ponds are licensed for operations outside of the framework of this EIS.

Across the three regions approximately:

- 8,550 ML of new storage will be required for untreated water
- 700 ML of new storage will be required for brine (refer to *Table 2.7.9*)
- 1,900 ML of new storage will be required for treated water.

Ponds will be designed to store approximately thirty days worth of untreated and treated Associated Water.

Ponds will be maintained and operated according to regulations, environmental authority conditions and QGC's internal systems of pond control. These systems of control have been developed for operation of existing storage ponds.

7.9.3.3 *Desalination Facilities*

Options for desalination are discussed in detail in *Volume 3, Chapter 11*.

Due to the short timeframe in which to establish the initial water treatment technologies, and the importance of these plants operating successfully, only well-proven technologies will be contemplated in the initial years of operation. In later years, with experience gained from the initial treatment plants and more time for trials and development, other emerging technologies can be pursued. It is for these reasons that reverse osmosis (RO) technology is likely to be utilised in the first instance as a means of managing Associated Water treatment.

The RO process is sensitive to the feed-water quality. Hence the correct pre-treatment process is essential to promote the membrane lifespan and increase the process efficiency.

The system proposed for treatment of Associated Water and its subsequent brine waste involves the following processes; pre-treatment, ultra filtration, RO, brine concentration and brine evaporation.

The pre-treatment process will be based on feed-water quality and RO pilot studies performed in the past. Ongoing trials are proposed to optimise the pre-treatment system. Ultra filtration (UF) membranes have been widely accepted in the CSG industry as part of the pre-treatment to protect the RO membranes from physical and biological fouling.

The selection of water treatment technology will be scaled and optimised for the Project. QGC will reassess water treatment technologies throughout the life of the Project to ensure the most robust, efficient and proven technologies are used. Ion exchange is being considered as a potential pre-treatment technology.

The RO process is likely to yield a recovery rate of 90 per cent treated water to 10 per cent saline brine. At peak Associated Water production, approximately 10 ML per day of brine will be produced.

The multi-stage RO is included in the core treatment step, but is often also considered as a brine treatment step in that it significantly reduces the brine disposal volume.

7.9.3.4 *Brine Processing and Waste Disposal Facilities*

Options for treatment and disposal of brine are discussed in detail in *Volume 3, Chapter 11*. The preferred option is for brine processing facilities that treat the saline brine through a combination of brine concentration and evaporation. Exposed, multi-cell solar evaporation ponds are proposed to enhance the evaporation rate and reduce the operational period of the brine disposal site. Brine processing will yield approximately 1 per cent of the initial water volume (10 per cent of the brine stream) as crystallised brine (salt) and about 9 per cent (90 per cent of the brine stream) of the initial water volume as treated or evaporated water. The potential water volumes to be stored in brine ponds and the pond specifications are described in *Table 2.7.9.*

Table 2.7.9 Brine Ponds

Field Area	Brine Ponds (ML)	Specifications	Pond Area (ha)
Northern Region	1 x 100	Dual HDPE-lined Pond ~3.5 m deep x 250 m x 125 m	1 x 3 = 3
Central Region	1 x 200	Dual HDPE-lined Pond ~3.5 m deep x 300 m x 190 m	1 x 6 = 6
Southeast Region	2 x 200	2 x Dual HDPE-lined Pond ~3.5 m deep x 300 m x 190 m	2 x 6 = 12
TOTAL	700		21

The volumes and areas of the above ponds are preliminary estimates only. Capacities may change as further refinement of brine processing infrastructure occurs.

Each cell would be partially filled with concentrated brine and left to evaporate over time. Performance of the system may be improved by pumping brine between cells. When the water has been evaporated, the remaining solid salt product will be removed and deposited in an engineered landfill. It is likely that two salt landfill sites will be required. These would nominally be located at the water treatment facilities in the CDA and the SEDA.

7.9.3.5 Combined Water Treatment Facilities

Typical chemicals which form part of the treatment process include:

- coagulant, e.g. ferric chloride
- disinfectant, e.g. sodium hypochlorite
- bio fouling inhibitor, e.g. sodium hypochlorite, aqueous ammonia
- pH adjustment, e.g. sulfuric acid, sodium hydroxide
- scale inhibitor.

Water treatment chemicals will be stored in appropriately designed and bunded storage tanks. All tanks holding reagents and dosing systems will have a bunded wall to prevent ingress of stormwater and to control spillage. For each bunded area a sump pump will be required. Concrete slabs will be raised from the ground in accordance with best civil practices and/or will be bunded to protect them from potential flooding. Appropriate drainage shall be provided for the facilities.

Each water treatment facility will be composed of multiple modular water treatment units that can be customised for variable water quality and quantity. These systems may have additional systems for particular waste stream treatment, such as high iron, aluminium or silicon content that is specific to that facility.

Each water treatment facility will have a footprint of approximately 4 ha. All water treatment facilities will have purpose-designed administration quarters that are self-contained with crib room, water storage, ablutions, first aid and laboratory facilities, maintenance workshop, and communications systems.

The source of power for water treatment facilities has not been decided, but could be either gas-powered generators or a connection to the electricity network. These options will be assessed in the Supplementary EIS or a separate impact assessment.

7.9.3.6 Quality Assurance Stations (QAS)

QAS will be located within the water treatment facilities. Each QAS will be equipped to monitor the quality and quantity of treated water supplied for beneficial use. Water quality output will be recorded to ensure the QAS controls all input streams in a manner that is optimised for constant use within the equipment design life.

All major control systems will control the facilities on site and have a continuous linkup with a central control system that can override all site systems. If the linkage from the main project site system fails, the treatment plant control systems will be able to operate in isolation. Remote monitoring equipment will monitor water quality and quantity, vibration, pressures and tank levels at all times. Monitoring is critical for systems such as tank levels, where the effects of a unit failing may result in environmental spillage. Where there is a likelihood of a failure, all systems will default to closed or fail-safe mode.

When major maintenance routines are required that result in a significant downtime, a modular water treatment system will be set up in advance and the storage pond levels will be reduced to allow for water build-up without spillage.

7.9.3.7 Pumping Stations

Approximately 27 pumping stations of between 400 kW and 800 kW per pump will be required to transfer water between water management infrastructure, 24 hours a day, seven days a week. If treated Associated Water is used for irrigation, further pumping stations will be required. Pumping stations will be capable of pumping approximately 3 to 4 ML per day per pump. Wherever possible, all motors and pumps will be located undercover.

The potential impact of pumping stations will be assessed in the Supplementary EIS.

7.9.3.8 Roads

Roads will be maintained to allow all-weather access to water management infrastructure. Car parking will be provided on site to allow for the maximum expected number of site personnel.

7.9.3.9 Beneficial User Networks

Distribution networks will be specifically designed to supply beneficial use options. Distribution networks will consist of prefabricated packages to be delivered, installed and maintained by a contracted vendor. In the case of irrigation networks, these will potentially comprise:

- an irrigation transfer station and approximately 15 km of pipeline per region
- 10,450 ha plantation with surface drip irrigation systems
- 700 ML of water-balancing storages
- 12 irrigation filtration systems
- soil- and climate- monitoring systems
- irrigation pump stations.

Supply of water for QGC petroleum activities and to industrial users will require the construction and operation of water pipelines.

7.10 INFRASTRUCTURE REQUIREMENTS

7.10.1 Material Requirements

Material requirements are described in *Volume 2, Chapter 11* (Gas Field Construction) as the majority of materials are required during construction. During operations, there will be limited requirements for materials such as gravel, fill, sand, road base and clay.

7.10.2 Storage Requirements

Materials storage requirements are discussed in *Volume 2, Chapter 11.*

Due to the wide distribution of operations, there is limited to no opportunity for sharing storage infrastructure with other projects proposed for the Surat Basin.

Facility consumables are either stored at warehouses or small quantities at the facility location. The following items with approximate volumes will be stored in bunded chemical storage areas at warehouses:

- 40 kL coolant
- 40 kL TEG
- 70 kL compressor oil
- 0.7 kL hydraulic oil
- 0.7 kL air compressor oil
- 0.7 kL TEG pump oil.

Spare facility parts and other consumables are stored in a lockable section at warehouses, where an inventory will be kept and routinely supplemented.

Each FCS will have about 10,000 L of compressor oil on site. At least 3,000 L of diesel and 20,000 L of compressor oil will be stored at each of the CPPs.

Those wells which are not free-flowing require the use of diesel pumps. Diesel fuel will be stored at these locations in 1,000 L or 2,000 L portable bunded tanks which are refuelled on a routine basis.

7.10.3 Site Security

All QGC's Gas Field Component assets are subject to a detailed security risk assessment conducted by suitably qualified professionals. This will be reviewed by the global head of security of BG Group, QGC's parent company, with recommendations implemented and audited as part of the Health, Safety, Security and Environment (HSSE) audit plan.

Access to the general area will be via existing roads and tracks wherever practicable. Access to infrastructure will be limited to authorised personnel.

7.10.4 Accommodation

Table 2.7.10 identifies the estimated workforce numbers required for operating the Gas Field Component.

Table 2.7.10 Workforce for Operations

Activity	Number of personnel	Nature of accommodation
Exploration and survey	50	Temporary camp
Well drilling	200	Temporary camp
Gas and water gathering including well establishment and gathering lines	350	Temporary camp
Maintenance/workover of infrastructure	50	Permanent camp
Support staff – onsite offices, warehouses and camp	100	Permanent camp
Water treatment/evaporation pond maintenance	50	Permanent camp
Total	**800**	

Approximately 800 personnel will require accommodation after the initial construction phase from 2010 to 2013. Approximately 15% of these will be locally housed and will not require camp accommodation. This percentage is expected to increase over time, as local employment increases. Approximately 600 personnel are required for ongoing well exploration, drilling and establishment which will be conducted on an ongoing basis for the life of the Project; and therefore will have construction and operation elements. Temporary camp requirements for these crews are addressed in *Volume 2, Chapter 11*.

QGC will place approximately 200 people at existing permanent camps of 100 people per camp. Permanent camps are located on QGC-owned land and centrally located within QGC's tenures. QGC does not plan to use local tourist and residential accommodation as part of its accommodation strategy.

A typical permanent camp site will occupy around 5 ha of land and include air-conditioned, demountable units with the following/similar features:

- 25 accommodation buildings (sleeves) housing four ensuite rooms per building, where one sleeve is approximately 14 m x 3 m
- ensuites with a toilet and shower and hand basins in each room
- rooms equipped with a bed, wardrobe, table and small fridge
- messing units with three sleeves for the kitchen and two sleeves for refrigeration, at least three sleeves for the dining room and a wet mess with recreation lounge
- a gym with four sleeves
- two central ablution blocks, with one sleeve per ablution block, around the camp for use by camp occupants
- two laundries at a minimum with about six to eight washers and driers in each
- an equipped recreational room with about three sleeves
- offices
- training/meeting room
- first aid room.

The majority of accommodation will consist of single units with the workforce operating on a schedule of 21 days on and seven days off. A fly-in, fly-out service between Brisbane and Gas Field Component operations is currently under investigation.

Gas-powered or diesel generators will supply the campsite with power.

Disposal of camp waste, including solid and liquid wastes, is described in *Section 7.10.10* of the chapter. Solid and Liquid Waste Management is addressed in detail in *Volume 3, Chapter 16.*

Shallow aquifer bore water will provide water for the camps, including potable water.

7.10.5 Transport Requirements and Infrastructure

The main transport requirements during operations are:

- transport of personnel between locations within the Gas Field Component, predominantly in 4WD vehicles or by bus, for maintenance, monitoring and administration purposes
- transport of infrastructure for wellheads and gathering lines.

Road transportation on public roads is described in *Volume 3, Chapter 14*. Road requirements for operations are significantly less than that for construction purposes.

7.10.6 Energy/Electricity Requirements

Energy is required for the following purposes:

- reciprocating engines to power screw compressors at the FCSs
- reciprocating engines to power reciprocating compressors at the CPPs
- ancillary power requirements at CPPs, including TEG units
- ancillary power requirements at FCSs
- telemetry systems
- wellhead pumps
- camp sites
- water treatment infrastructure
- water pumps
- field offices.

Table 2.7.11 details the source of power for infrastructure, consumption in megawatts (MW) during a period of peak operation and, where applicable, terajoules of CSG combusted by the power source. Power sources are commissioned once the infrastructure for which they provide energy is commissioned. The infrastructure items listed below will be constructed between 2011 and 2013.

Table 2.7.11 Power Requirements

Power requirement	MW	Source	CSG consumed per annum
Screw compressors	216 x 0.75 MW = 162 MW	CSG from own wells	7,753 TJ (201 million m^3)
Reciprocating compressors	90 x 1.75 MW = 158 MW	CSG from own wells	11,059 TJ (287 million m^3)
Ancillary power – CPP	9 x 240 kW = 2 MW	CSG from own wells	112 TJ (3 million m^3)
Ancillary power – FCS	27 x 80 kW = 2 MW	CSG from own wells	112 TJ (3 million m^3)
Wellhead pumps	2 MW	CSG from own wells	112 TJ (3 million m^3)
Water treatment infrastructure	9 MW	CSG from own wells	504TJ (13 million m^3)
Water pumps	14 MW	CSG from own wells	784TJ (20 million m^3)
Camp sites	5 x 360 kW = 2 MW	CSG from own wells	112 TJ (3 million m^3)
Field Offices	3 x 290 kW = 1 MW	CSG from own wells	66 TJ (1.5 million m^3)
Telemetry systems	1 MW	CSG/solar	66 TJ (1.5 million m^3)
Total	**353 MW**		**20,680 TJ (536 million m^3)**

Of the total of 20,680 TJ, an estimated 19,300 TJ of CSG is required to fuel the compressors for peak operational periods. The entire Gas Field Component will require 353 MW of power during operations. Gas-powered engines, which supply the majority of power, represent the most convenient energy source on site given they can draw upon the CSG extracted. The EIS Reference Case does not include proposed use of electricity from the grid. However, options analysis for electric-driven compression and water treatment is ongoing.

Isolated telemetry systems may use solar power as is used selectively in current QGC operations. Potential energy conservation measures are described in *Volume 7, Chapter 4.*

7.10.7 Telecommunications

Requirements for communications infrastructure to support the Project (including the Gas Field Component) will be considered for the following phases:

- Phase One: development/construction
- Phase Two: production/operations.

Phase One requirements are generally focused on current available telecommunications items such as:

- mobile (wireless) communications (e.g. mobile phones, two-way radios)
- temporary office facilities that provide network and internet connectivity

- remote or well-site telemetry with low bandwidth requirements.

Phase Two requirements are generally the same as Phase One requirements. However, installation is permanent and fully supported. Phase Two requirements include:

- mobile (wireless) communications (e.g. mobile phones, two-way radios)
- permanent office facilities that provide network and internet connectivity
- remote/well-site telemetry with higher bandwidth requirements.

Mobile communication (phone and radio) coverage generally requires surveying before a particular technology is selected for specific development areas. The Gas Field Component is likely to have areas with little or no third -party coverage. For this reason, QGC will install microwave, radio and/or repeater towers to obtain the necessary coverage.

During Phase One it is likely that temporary (trailer-mounted) towers will be erected to service development and mobile construction areas. As the development phase ends and the operational phase commences, QGC will install permanent towers, in consultation with the relevant authorities and landholders, in areas identified as the most cost-effective and as having the lowest environmental impact.

QGC is open to negotiating with third-party telecommunications providers over access to QGC infrastructure, specifically towers, which could potentially be used for improving communications coverage for local communities.

In addition to the above, the following activities are proposed:

- Fibre optic cables could be installed with pipelines between Gas Field Component facilities to service data and voice requirements between facilities.
- Satellite (fixed-base stations) communications may be employed to service data and voice requirements for remote facilities that cannot be connected, or are not cost-effective to connect, to existing infrastructure using fibre.
- Secure wireless communications between wellheads and Gas Field Component facilities will be used.
- Permanent telecommunications sites will be selected to service the life of the Project. These will be maintained with a view to indefinite use. At the completion of the Project, QGC will discuss removal or relocation with interested parties such as the landholder or a third-party telecommunications provider which may be offered ownership at significantly reduced cost, if a long-term beneficial use is identified.

7.10.8 Water Supply and Management

The operation of the Gas Field Component will require approximately 1,000 m^3 of water per day over the operational life of the Project for:

- potable water supplies at camps
- dust suppression
- wash-down facilities
- emergency services.

QGC is seeking approval to use untreated Associated Water with total dissolved solids (TDS) of less than 4,000 mg/L for dust suppression, civil construction and plant/equipment washdown. It is generally expected that operational water requirements will be met through the use of treated and untreated Associated Water. However, should Associated Water be unavailable due to geographical or timing issues, groundwater may be sourced for requirements.

Camps will consume and treat approximately 200 L of water per person per day. Management of liquid waste streams is described in *Section 7.10.10.3*, Liquid Waste Disposal Facilities.

Table 2.7.12 summarises the water quantity and quality requirements, as well as the source of supply, treatment and storage requirements.

7.10.9 Stormwater

It is an offence to pollute waters under the *Environmental Protection Act 1994* (Qld) Section 493(c). QGC will develop a Stormwater Management Plan to ensure no stormwater is contaminated on QGC sites.

Stormwater management for the Gas Field Component includes:

- daily monitoring of weather forecasts during construction to enable adequate planning measures to be in place each day
- installation of sediment fences to prevent soil transport into watercourses
- installation of berms to direct flow away from the construction Right-of-Way (RoW) and onto stable ground
- provision of breaks in vegetation and soil stockpiles to minimise impacts on overland flows.

Table 2.7.12 Indicative Water Requirements for the Gas Field (Operations)

Activities, processes and facilities requiring water	Water quantity requirement (kL)	Water quality requirements	Source of water	Additional treatment requirements	Onsite water storage facilities
Operation Phase					
Washdown facilities	Mean daily: 55 kL/day Annual total: 20,000	TDS < 4000	Associated Water	Treatment by RO or other methods	Ponds
Dust suppression	Mean daily: 750 kL/day Annual total: 273,750	TDS < 4000	Associated Water	Treatment by RO or other methods	Ponds
Accommodation camps	Mean daily: 0.2 kL/person per day Annual total: 60,000	Australia and New Zealand Environment and Conservation Council (ANZECC) water guidelines for potable water	Associated Water/Groundwater	Treatment by RO or other methods	Ponds
Fire fighting and other emergency services	Annual total: when required	TDS < 2000	Associated Water	Treatment by RO or other methods	Ponds
Operation Phase Total	*Mean daily: 1,000 kL/day* *Annual total: 365,000*				

7.10.9.1 All Hardstand Areas

Diversion channels will be installed around all hardstand areas (all infrastructure) to prevent stormwater flowing through site infrastructure. These diversion channels will direct water around infrastructure to undisturbed areas where water can dissipate.

7.10.9.2 Ponds

Diversion channels will be installed around all water storage ponds. These diversion channels serve dual purposes by incorporating the pond spillway and management of stormwater into one.

Diversion channels protect the pond embankment from water collecting around the pond toe and destabilising the banks. The diversion channels direct water around the toe and channel it away to a stable area to dissipate.

7.10.9.3 Compressor Stations

During operations, stormwater management occurs on all compressor stations (CPPs and FCSs) through the use of berms and bunding to segregate the site. Water collected in this zone flows into a compressor drainage sump pit which feeds into a lined interceptor pit. These diversion channels serve a dual purpose by collecting overflow from the interceptor pit in the event of a significant rainfall event.

7.10.9.4 Additional Areas

A bund or impervious wall will surround all areas that could potentially lead to contamination. Wastes from the contaminated area will be directed into a collection pit and grating will contain loose solids. Collected waste will be disposed of using licensed waste contractors.

7.10.10 Solid and Liquid Waste Management

7.10.10.1 Waste Inventory

Table 2.7.13 provides an inventory of waste generated by the Project and the volume and chapter of the EIS in which the waste and its potential impacts are described, and mitigation and management measures for the waste stream are addressed.

Table 2.7.13 Waste Inventory and Relevant EIS Chapter

Type	Chapter
Tyres	Vol 3, Ch 16
Associated Water	Vol 3, Ch 11
Saline brine/salt	Vol 3, Ch 11
Drilling fluids	Vol 3, Ch 16
Liquid waste from human waste storage facilities or waste treatment, including pump-out waste and sewage	Vol 3, Ch 16
Oils, lubricants, fuels, engine coolant, spent TEG, surfactants, acids and alkalis	Vol 3, Ch 16
Batteries, gasket adhesives, cutting lubricants, paint, cleaning agents and water treatment chemicals	Vol 3, Ch 16
Wastes from food preparation at camp sites	Vol 3, Ch 16
Recyclables – glass, aluminium cans, plastic bottles, welding rods, scrap metal and off-cuts, scrap HDPE, paper, printer cartridges, packaging material and cardboard	Vol 3, Ch 16
Soils (topsoil, fill materials)	Vol 3, Ch 16
Drained and crushed oil filters, oil-soaked rags, oil absorbent materials	Vol 3, Ch 16
General rubbish (e.g. used containers and drums, synthetic material fibres)	Vol 3, Ch 16
Oily water/sludge, chemical sludge, spent activated carbon	Vol 3, Ch 16
Concrete waste	Vol 3, Ch 16
Green and timber waste	Vol 3, Ch 16
Air emissions – NOx, CO, VOCs, dust, etc	Vol 3, Ch 12
Greenhouse gas emissions	Vol 7

7.10.10.2 Solid Waste Disposal Facilities

QGC will dispose of solid waste generated on site at a suitably licensed facility off site. Where practicable, waste will be transported to a waste transfer station located at QGC's Windibri property. The transfer station will accommodate various waste streams including concrete, timber, vegetation, treated timber, wire and other scrap metal, tyres, clean fill and contaminated soil. The transfer station will act as a temporary storage for these wastes.

The transfer station is designed to prevent contamination of the site with drainage management incorporated into the site design. Contaminated soil will be held in concrete bunded cells and may be reused following remediation on site.

Operating a waste transfer station designed to receive 30 m^3 or more of waste on any day is defined as Environmentally Relevant Activity (ERA) 62 under the EP Regulations.

All wastes placed and removed from this site will be recorded (including trackable and non-trackable wastes).

Warehouses will have an oily wastes facility (used oils, oily rags etc) and containers for recycling. The camps will also have containers for storing cardboard for recycling. Camps, warehouses and offices will have facilities to store aluminium, plastic and glass until transferred to the appropriate receiving facility.

7.10.10.3 Liquid Waste Disposal Facilities

The majority of liquid waste generated at the Gas Field Component is Associated Water. Management of Associated Water is addressed in *Volume 3, Chapter 11.*

Discharge into existing sewerage systems from accommodation camps is not possible given their remote location. Each camp will have a treatment system capable of treating the maximum amount of effluent generated from the camp kitchen and accommodation, likely to be 50 kL to 75 kL per day, or a maximum of 240 kL per day over the Gas Field Component at the various camps.

Raw sewage will be gravity-fed into a pump well and balance tank(s). It will then flow through treatment units composed of a number of components including:

- a primary tank which undertakes sedimentation, digestion and storage of solid matter
- a balance tank for flow equalisation
- an aeration tank to reduce organic matter
- a clarifier for further removal of residual suspended solids
- a final effluent tank for disinfection and storage of treated water
- a filter feed tank, gravity-fed from the final effluent tank
- an ultra-filtration membrane
- chlorine dosing
- a final treated effluent tank with wet-weather storage before discharge to an irrigation area.

Once sewage is treated to Class A standard, it can be used for irrigation, reused for dust suppression and other low contact uses. A 250-person temporary camp will require approximately 2.8 ha of irrigation area. The effluent disposal system will consist of a fenced, appropriately-vegetated area, where treated effluent will be irrigated above ground. Sludge from wastewater treatment facilities will be removed as required, but typically consists of approximately 10 kL to 15 kL per camp every one to two months.

Plant maintenance will result in about 18 kL per week of waste oil generated across the Gas Field Component. This will be stored at the oily waste storage tanks at the warehouses and facilities. Approximately 1.2 kL to 2.4 kL per month of waste TEG will be collected in drums and collected by a third party. Roughly 40.8 kL per year of waste coolant will be generated, which will be recycled by a third party.

7.10.11 Noise Emissions

The main noise sources are the reciprocating and screw compressors and power-generation gas turbines. Predicted noise emissions at the Gas Field Component and mitigation measures are described in detail and assessed in *Volume 3, Chapter 13*.

7.10.12 Air Emissions

Reciprocating and screw compressors are the main sources of air emissions. Emissions include oxides of nitrogen, carbon monoxide and hydrocarbons. Predicted air emissions at the Gas Field Component and mitigation measures are described in detail and assessed in *Volume 3*, *Chapter 12*.

7.11 PROJECT ALTERNATIVES

7.11.1 Infrastructure Location and Configuration Factors

Within QGC's tenures there are a number of factors affecting the configuration alternatives, final location and timing of Project infrastructure. The factors involved in the review of alternatives and selection of construction location and configuration are detailed below.

Wells

Well locations are flexible in their individual placement and are guided by several factors:

- access to land
- field development priorities – both yield and capacity of CSG
- health and safety
- environmental constraints
- environmentally sensitive locations
- landholder requirements
- proximity to other infrastructure
- synergies with existing infrastructure

- surrounding well performance.

These factors determine the manner and timing of a particular well's development for production.

Order of Extraction

The field development plan which determines the graticular blocks from which gas is extracted, is based on:

- results from appraisal wells
- projected well interference distance (i.e. a minimum 750 m spacing between wells)
- balance of flow rate and loading on compression units
- availability of Associated Water management facilities in proximity to the field.

Field Infrastructure

The location of field infrastructure and configuration, such as compressor stations, is determined by:

- the technology used, so that gas-flow rates can be adjusted
- wellhead pressure modelling of wellhead flows and gathering system constraints
- delivery of Associated Water from wellhead separators
- the optimum distance for delivery of “wet” gas to field compression
- environmental constraints and proximity to sensitive receptors
- use of field compression versus nodes to central processing
- the stability/susceptibility of infrastructure to natural events such as flooding
- access to suitable land with sufficient safety buffers, visual separation distances and low gradient.

7.11.1.2 Process for Selection of Preferred Option

Technical and Commercial

Infrastructure will be located to maximise gas production and processing rates, in a manner that is both cost effective and flexible.

Social and Environmental

Site selection processes are intended to avoid impact on sensitive receptors; mitigate impact on sensitive receptors where avoidance is not possible and where mitigation cannot provide adequate management, a process of negotiation with affected landholders is proposed. As described in this EIS, all measures will be taken to minimise the impact from the proposed location and configuration of Project infrastructure on communities and the environment in the Surat Basin.

Land Use Factors

The Gas Field Component contains approximately 56,800 ha of cropping land for primary production. This represents approximately 12 per cent of the land held under petroleum tenure by QGC. QGC will conduct activities within this land. Negotiation for compensation with landholders who lose productive agricultural land will be undertaken.

There should be limited long-term impacts on pastoral land from Gas Field Component development activities.

Gas Field Component development will result in the clearing of an estimated 4,624 ha of bushland (approximately 3 per cent of that currently present). Mitigation measures are presented in *Volume 3, Chapter 7*.

Rural residential land comprises 21,679 ha (approximately 5 per cent) of the Gas Field. Mitigation measures are presented in *Volume 3, Chapter 5.*

The Gas Field Component does not overlap areas of industrial development and would not impose serious constraints to future industrial development in the area of the tenements. Certain mining lease applications overlap with petroleum lease tenures held by QGC. These are presented in *Volume 2, Chapter 4*.

7.11.2 Alternative Project Technologies and Methods

7.11.2.1 Well design

The standard well design is for one well to be drilled per wellhead, spaced approximately 750 m apart.

Hydraulic Fracturing

Hydraulic fracturing is used to enhance the production rate and recovery of petroleum from a reservoir. The process involves pumping a blended fluid mixture, comprising chemicals and water, into the well bore at sufficiently high rates to allow a fracture to propagate. A propping agent is added to the fluid mixture to enable the created fracture to remain open after the well is pumped and the pressure released.

This highly conductive fracture allows the flow of oil and/or gas from the reservoir. Once the process is completed the fluid chemically breaks down and is flowed back out of the well. Hydraulic fracturing is a standard petroleum industry practice and has been used extensively throughout the world since 1947. QGC may use this method in areas where production stimulation is required.

Directional Drilling

Directional drilling is comprised of the drilling of slanted or horizontal wells as opposed to vertical wells. Typically, horizontal wells begin either slanted or vertical and are horizontal through the target zone. This is different to slanted wells which are purely drilled on an angle. The directional drilling process can be incorporated for a number of reasons including:

- enhancement of petroleum production and recovery due to a greater length of wellbore connection to the reservoir
- production of a reservoir where vertical access is difficult
- minimisation of surface area disturbance.

In recent years the number of directional wells throughout the world has increased significantly. QGC may use this method in areas where access is limited or surface disturbance restrictions constrain conventional methods.

7.11.2.2 Field Infrastructure configuration

The principal Gas Field Component infrastructure is compressors which facilitate the transfer of CSG in pipelines. There are a number of options for the type of compressor selected and the configuration of selected compressors.

Table 2.7.14 provides details of the range of options for compressor configuration for both FCSs and CPPs.

Table 2.7.14 Compressor Configuration

Option	CPP	FCS	Driver	Total rotating units
EIS Reference Case	9 x 10 reciprocating compressors	27 x 8 screw compressors	Gas engine	306 units
A	9 x 9 reciprocating compressors	0 screw compressors	Electric motor – distributed or centralised	81 units
B	9 x 10 reciprocating compressors	27 x 8 screw compressors	Electric motor – grid supply	306 units
C	2 x 2 + 1 x 3 centrifugal compressors 1 x 2 reciprocating compressors	27 x 8 screw compressors (various configurations)	Gas engine/ gas turbine /electric motor – grid supply	225 units

The selection process will consider the following criteria:

- net present value of each option, including capital and operating expenditure
- operability and maintenance requirements
- availability and deliverability
- flexibility of compressors to adapt to changing flow rates
- technical experience of QGC with construction and operation of existing compressors
- carbon footprint
- plot footprint and total suitable land availability
- environmental constraints such as noise and air emissions.

Following a review of the options against the selection criteria, Option A was considered too inflexible for field development and did not proceed into the next design phase. Options B and C are both capable of delivering the required flow rate to the LNG Facility. An assessment of these options is continuing, particularly focused on the implication of power infrastructure and the flexibility of larger centrifugal compressors.

The environmental impacts of the Reference Case described in this EIS represent a worst-case scenario for environmental impacts. Final configuration will not be optimised until the FEED phase.

7.11.2.3 Gathering systems

The standard gathering system is HDPE piping between wellheads and compressor stations. No alternatives are considered viable.

Trunk lines between FCSs and CPPs may be steel or fibreglass. Selection depends on cost and safety factors as the environmental impacts are similar.

7.11.2.4 Reason for Selection of Preferred Option

Technical

Gas Field Component infrastructure will be selected on the basis on being efficient and effective to operate. The selected option will need to provide flexibility to meet various wellhead pressures, safety requirements and operating experience. Optimisation of the infrastructure selection is ongoing.

Commercial

Gas-powered engines were considered preferable as the supply of gas for fuel can be achieved conveniently and at low cost due to the QGC's experience with gas-powered engines. Gas powered engines are the EIS reference case however electric drive engines are currently being evaluated.

Social and Environmental

The impact of alternative technologies will be minimised by site selection processes and the minimisation of emissions, in particular greenhouse gas emissions. As described in this EIS, Gas Field Component infrastructure will be selected to minimise, where possible, impacts on local communities and the environment.

7.11.3 Associated Water Management Options

7.11.3.1 Background

Water associated with the CSG extraction will either hydrostatically flow or be pumped to the surface, thereby lowering the water pressure and allowing the gas to desorb from the coal seam and flow into the well. Approximately 1,200,000 ML of Associated Water will be produced by the Project. In general, Associated Water is saline and has a high sodium absorption ratio. This presents both challenges and opportunities for the management of Associated Water. The volumes and quality of Associated Water are discussed in detail in *Volume 3, Chapter 11*.

7.11.3.2 Options Analysis

QGC is reviewing the following options for beneficial use of Associated Water.

- QGC petroleum activities during construction and operation
- stock and domestic purposes
- tree cropping
- irrigation of crops
- wetland creation
- supply of water to mines
- urban water supply
- supply of water to industries
- reinjection to groundwater aquifers
- aggregation of CSG waters with other deep CSG producers
- surface water discharge
- coastal discharge
- evaporation ponds.

These options are discussed in detail in *Volume 3, Chapter 11*.

The following criteria have been used to provide a preliminary qualitative evaluation of each beneficial use option:

- environmental impacts, encompassing a broad range of impacts on soils; land contamination; waste management; surface water; groundwater; air; noise and biodiversity
- social impacts, including changes in existing land use; disruption to communities; community and individual access to water and perceptions by communities
- technical constraints, which depend on the availability and reliability of technology proposed to manage water for each beneficial use
- economic constraints, encompassing water quality and distribution network requirements
- commercial constraints, encompassing the volume of water that is demanded by the beneficial use and the degree of reliance placed on third parties to whom water may be supplied
- regulatory constraints based on the preferred Associated Water management methods of regulators.

The volume that can be received by a beneficial use is a critical constraint. Options that do not have demand equivalent to the estimated supply have to be supplemented by other options. Further details about the options evaluation criteria are provided in *Volume 3, Chapter 11.*

Table 2.7.15 provides a ranking of the potential impacts from each option and the constraints facing each option. Impacts can be both positive and negative and are ranked as high, medium or low. Constraints are ranked as high, medium or low. The greater the potential impacts and constraints, the less desirable the option. An overall ranking has been assigned to each option.

Table 2.7.15 Ranking of Beneficial Use Options

Criteria Beneficial Use Option	Environmental Impact	Social Impact	Technical Constraints	Economic Constraints	Commercial Constraints	Regulatory Constraints	Impact/ Constraints Ranking
QGC petroleum activities	Medium	Medium	Low	Low	High	Low	Medium
Stock and domestic purposes	Low	Low (+ve)	Low	High	High	Low	Medium/High
Tree cropping	Medium	High	Medium	Medium	Low	Medium	Low/Medium
Cropping	Medium	Medium	Medium	High	High	High	High
Wetlands	High	Medium	High	Low	Medium	High	High
Mine water supply	Low	Low	Low	Low	Medium	Medium	Low
Municipal water supply	Medium	High (+ve)	High	High	High	High	High
Industrial supply	Medium	Low	Medium	Medium	High	Medium	Medium
Reinjection	Low	Low	High	Medium	Low	Low	Low
Coastal discharge	High	High	High	High	Low	High	High
Surface water discharge	High	Low	Medium	Medium	Low	High	Medium
Evaporation ponds	High	High	Low	Low	Medium	High	High

7.11.4 Preferred Beneficial Use Options

Based on the above qualitative impacts and constraints ranking, the preferred set of beneficial use options is:

- tree cropping
- supply of water to mines
- reinjection.

Both tree cropping and reinjection offer the possibility of supplying the majority of Associated Water to the beneficial use. The potential social and environmental impacts of tree cropping will be investigated to determine the magnitude of potential impacts and the mitigation measures required to reduce those impacts.

Reinjection is likely to have low social and environmental impacts, is a preferred option of regulators, but faces high technical and medium economic constraints. Further field trials will be conducted to determine the technical feasibility of reinjection.

Supply of water to mines offers a low environmental and social impact option with low economic and technical constraints, but will only result in the supply of a small percentage of Associated Water produced.

Those options assessed which have a medium ranking for impacts and constraints are:

- QGC petroleum activities
- supply to industry
- surface water discharge.

These options are, or will be, the focus of further investigations by QGC to determine their feasibility.

The major constraint facing use of Associated Water for QGC's petroleum activities is the very limited volume of water that is demanded by this option. However, this option remains attractive as a means to source water for the Gas Field Component activities, with minimal requirements for water from other sources.

Supply to industry is less certain than supply to mines due to commercial and economic constraints, but remains a reasonable option should an industrial supply option emerge.

Surface water discharge may have high environmental impacts, and is not a preferred option of regulators. However, surface water discharge of treated water has the potential to receive all of the Associated Water produced.

Those options assessed which have a high ranking for impacts and constraints are:

- stock and domestic purposes
- cropping
- wetlands
- municipal water supply
- coastal discharge
- evaporation ponds.

These options are not precluded, but QGC will place less emphasis on these as the long-term solutions to water management.

Supply of water for stock and domestic purposes will utilise a very limited volume of water while posing high economic constraints in distributing small volumes of water to multiple users, each with fluctuating demand.

Supply of water for cropping is likely to be constrained by high costs of distributing water to areas suitable for cropping and the fluctuating demand for water as rainfall changes.

Treatment of water through wetlands is an unproven technology at the scale required by QGC and has potential for high environmental impacts.

Municipal water supply, while providing social benefits, faces high economic, commercial and regulatory constraints to supply small volumes of very high quality water across long distances.

Coastal discharge may have high environmental and social impacts, be costly and is unlikely to receive regulatory approval.

Evaporation ponds are favoured as a short-term solution as they are not economically and technically constrained. As a long-term solution they are not preferred due to high environmental and social impacts and are unlikely to receive regulatory approval.

7.11.5 Water Treatment Options

Due to the short timeframe in which to establish the initial water treatment technologies, and the importance of these facilities operating successfully, only well-proven technologies can be contemplated at present. Should water treatment be required, the preferred method for treatment of Associated Water and the brine waste produced during treatment involves:

- pre-treatment, including ultra filtration
- desalination through reverse osmosis
- brine concentration and brine evaporation

Further details about the selection of water treatment options are provided in *Volume 3, Chapter 11*.