Natural gas from coal seams 3

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3 Natural gas from coal seams

This section provides a description of the formation and production of natural gas from coal seams, along with a general outline of industry practice for the development of gas fields.

3.1 Coal and gas formation

Coal is a sedimentary rock formed from ancient vegetation, which is transformed over millions of years by the combined effects of microbial action, pressure and heat. It is layered between other sedimentary rocks and is found in seams ranging from less than a millimetre in thickness to many metres.

As coal is being formed, large quantities of natural gas are often generated. Gas can be found in varying amounts in all coal types and generally comprises methane (greater than 95%) with varying proportions of heavier hydrocarbons and other gases such as carbon dioxide.

3.2 Production of natural gas from coal seams

In coal seams, natural gas and water are stored in the cleats (fractures) that naturally occur in coal. However, the majority of the gas is adsorbed in the coal matrix. The gas is held in place by confining pressure from the overlying rock, and groundwater (hydrostatic pressure).

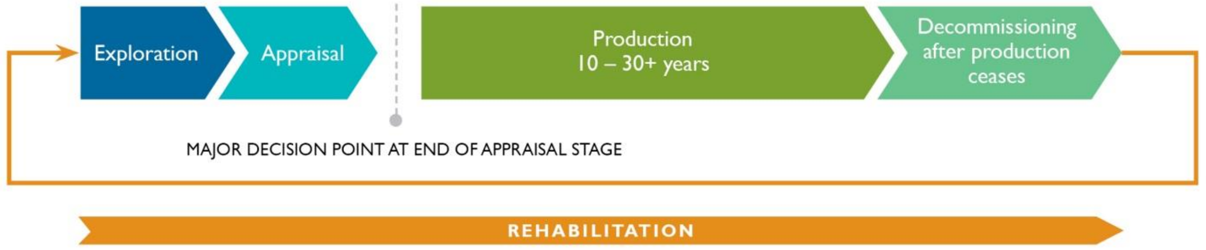
When recovering natural gas from coal seams, the coals remains in place. Gas is produced by drilling a well into the coal seam and removing groundwater from the coal seam to reduce the confining hydrostatic pressure. This allows the gas to separate from the coal (desorb) and flow through fractures within the coal seams to the well and on to the surface. In general, producing natural gas from coal seams does not require all of the groundwater to be removed from the coal seam – typically hydrostatic pressure is reduced only to the extent required to achieve consistent gas flow.

The rate of groundwater extracted from coal seams reduces relatively quickly; however, given the large volumes of gas adsorbed on the coal, it can take more than 20 years for the coal seam to completely deliver its producible gas.

3.3 Gas field development process

Generally, commercial development of coal seam gas fields occurs incrementally. The development cycle for a prospective area includes exploration, appraisal, production well and infrastructure construction, production operations, and then decommissioning and rehabilitation. A conceptual model of the field development process is illustrated in Figure 3-1. New information gained from ongoing exploration, appraisal and production activities is used to inform future field development planning.

Figure 3-1 Ongoing field development process



Not all areas of a gas field are developed at the same time: as areas are expanded or new infrastructure developed, other declining areas are decommissioned and where possible infrastructure, such as components of gas compressors and water management facilities, are relocated. Each production well has a finite life, after which time its gas supply will have been exhausted and it may be replaced by a new production well at a new location so that overall gas production can be maintained. Once exhausted, the wells are decommissioned, surface infrastructure removed and the area is rehabilitated. Rehabilitation occurs throughout the project lifecycle i.e. through exploration, construction and production, as well as after decommissioning. This results in an ongoing program of well development and decommissioning throughout the life of a project.

Exploration and appraisal activities are described here as part of the production lifecycle for completeness. These activities are already being undertaken within the GFD Project area under existing approvals and will be ongoing throughout the life of the GFD Project. Exploration and appraisal are already approved and hence are not assessed as part of this EIS.

3.3.1 Exploration

Exploration for natural gas from coal seams involves the search for a particular set of geological conditions likely to result in natural gas resources that can be economically extracted. It begins with a review of published materials and geophysical surveys to identify locations for exploratory drilling that best represent the geological formation(s) of interest within known constraints such as tenure boundaries, topography and environmental sensitivities.

Further geological and/or geophysical surveys are conducted to characterise subsurface geology and structural features such as depth, inclination, orientation and faults within the target coal seams.

Exploration coreholes are then drilled to collect coal and rock samples for testing. At the end of the exploration phase, coreholes may be decommissioned (refer to section 3.3.6) or converted into wells if field development progresses into appraisal and production phases.

3.3.2 Appraisal

Where testing confirms that a coal seam has the potential to produce gas, appraisal wells are drilled to quantify the size and nature of the gas resource. The appraisal process is a pilot test i.e. a small scale trial comprising production wells with supporting water and gas handling facilities (e.g. gas water separator, water storage, etc.) installed.

If the appraisal process indicates that commercial quantities of gas can be produced economically, full scale production can be planned using the information gathered during the exploration and appraisal stages. Commercial gas production needs the right combination of:

- Coal thickness
- Gas content
- Permeability
- Coal seam depth and coal type
- Access to gas infrastructure
- Market demand.

In addition to defining the commercial viability of gas production, appraisal activities provide critical information for the design of infrastructure including water and gas quality, volumes and flow rates.

3.3.3 Construction

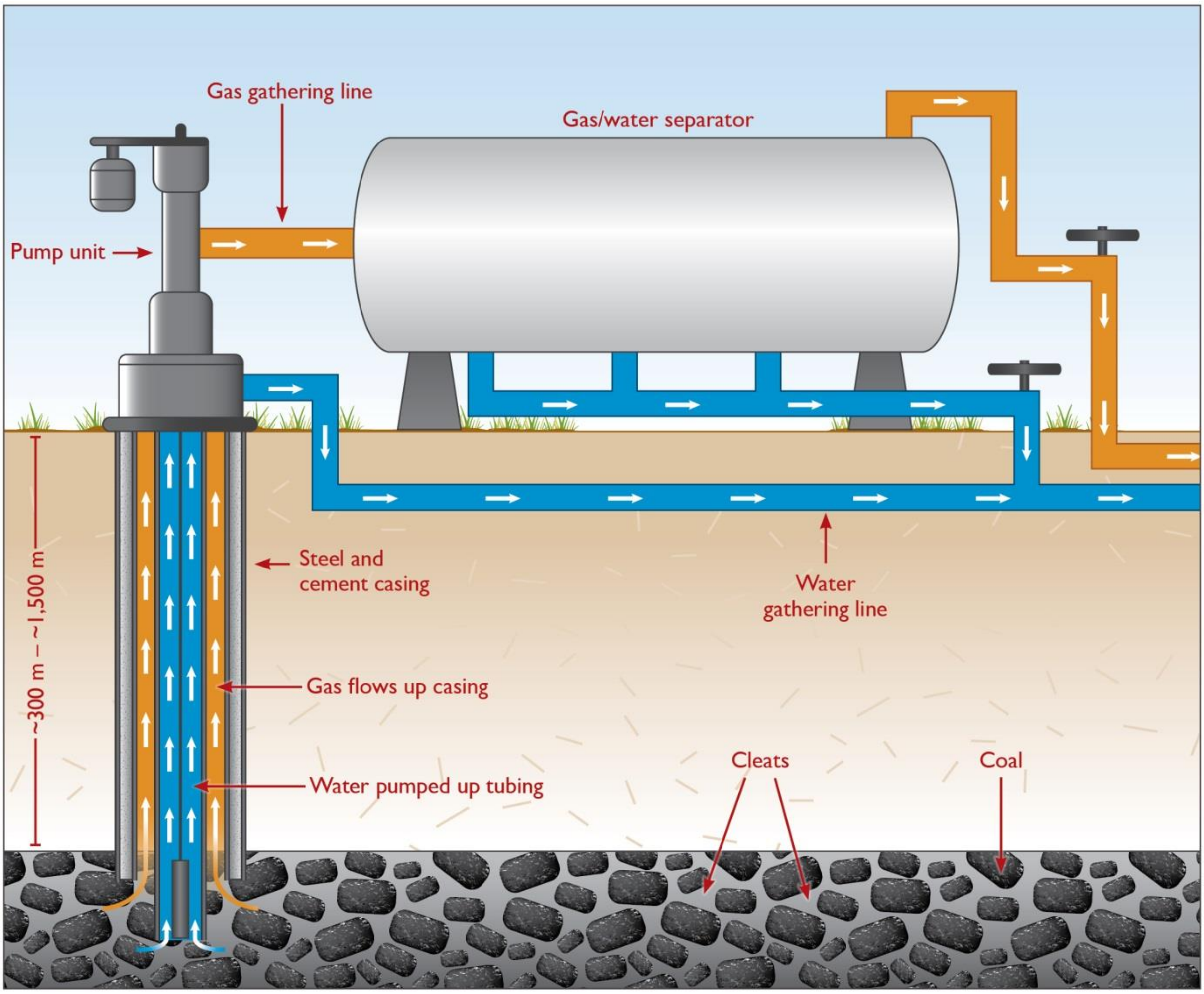
Before a production well is drilled, the well lease (the area where the well and associated surface infrastructure are located) and access tracks must be prepared. Preparation of the well lease typically involves:

- Clearing of surface vegetation and topsoil
- Levelling the ground surface
- Constructing an earthen pit or sump to contain the cuttings removed from the well
- Constructing a flare pit to contain the flare associated with the combustion of produced gas
- Constructing temporary water storage for the drilling activities and water produced from exploration, appraisal or production activities
- Constructing a cellar (a two cubic metre chamber through which the drilling assembly passes) and surface conductor pipe.

The area of a well lease for a single well is typically between 1.0 hectare (ha) and 1.5 ha. For multiple wells, the lease area would be larger, but fewer leases would be required reducing the overall lease density and disturbance footprint. Typically well leases are some 600 metres (m) to 1,200 m apart.

Consistent with standard practice in the oil and gas industry, production wells are designed to match local geological and hydrological conditions and the target depth. They must comply with relevant regulations and standards to ensure that the overlying geological strata, including aquifers, are isolated from the well. A typical (simplified) production well set up is shown in Figure 3-2.

Figure 3-2 Typical production well lease configuration (not to scale)



Production wells are drilled though the overlying strata into the coal seam. Drilling is undertaken on a 24-hour basis for approximately 1 to 3 weeks per well. The time to complete drilling depends on the depth of the well, the geology and drilling rig used. Production wells may be drilled in the vertical direction only or paired with directional (or horizontal) sections drilled into and along the coal seam.

During the drilling process a blow-out preventer is installed to ensure that, in the event of unexpectedly high water or gas pressures, the system can be shut down to prevent water or drilling fluids being released to the environment. Compressed air or a water-based liquid (mud) is circulated down the well. Water-based liquids (drilling fluids) typically contain a mixture of water, barite, clay and chemical additives. Drilling fluids are used to cool the drill bit, lubricate the drilling assembly, remove the formation cuttings, maintain the pressure control of the well (contain the formation water and gases within the hole) and stabilise the hole being drilled. Once removed from the well, both drilling fluids and drill cuttings are treated, recycled and/or disposed.

After the well is drilled, it is lined with steel casing to provide a conduit for the removal of coal seam water and gases. The casing is cemented into position, forming a barrier to prevent fluids in the well from mixing with the surrounding aquifers.

The well casing is pressure tested to ensure that it can tolerate higher pressures than the pressures expected over the life of the well, minimising the risk of liquid or gas leaking into the surrounding formation. The casing of the part of the well in the coal seam is perforated to connect it to the gas resource.

During well completion, a pump and tubing is placed in the well and connected to a surface-mounted drive motor to extract coal seam water and enable of the flow of natural gas to the surface.

3.3.4 Operation

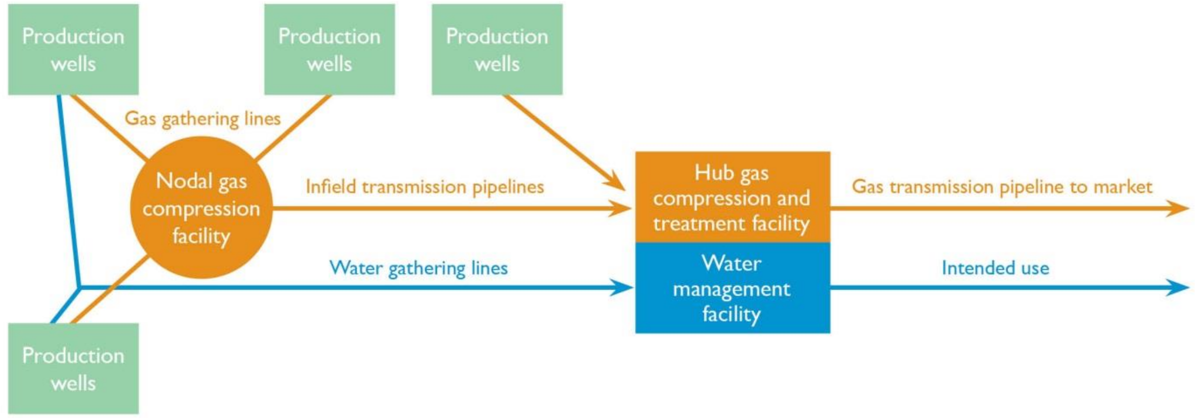
Once the wells have been drilled, they are used to extract coal seam water and enable production of gas. At the well head, the gas is passed through a separator tank to remove water held in the gas. The gas is piped to gas compression facilities and from there delivered via transmission pipelines to market. Extracted water is utilised for GFD Project activities or managed in accordance with regulatory requirements and its intended end use.

3.3.4.1 Gas gathering, transmission, compression and treatment

From the production well, gas flows at low pressure via a network of gathering lines to gas compression facilities. From remote areas of the gas field, gathering lines may be required to direct gas via a field (nodal) gas compression facility, which boosts the gas pressure for further transmission via pipeline to second stage (hub) gas compression and treatment facilities. Here it is compressed to the pressure required for transmission via high pressure gas transmission pipelines to market.

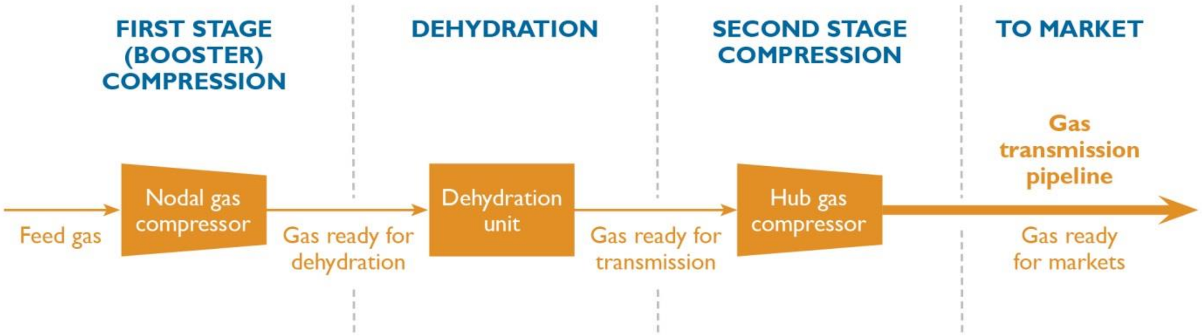
A schematic diagram of this gas gathering, transmission, compression and treatment process is given in Figure 3-3.

Figure 3-3 Schematic of gas gathering, transmission, compression and treatment



The treatment process involves filtration, dehydration, compression and cooling. Where wells are near to the facility, both stages of compression (nodal and hub) may be conducted within the same facility. In the majority of cases, dehydration units will use triethylene glycol (TEG) to reduce the water vapour content of the gas prior to compression (or between stages if there are two stages of compression). The typical gas compression and treatment process is illustrated in Figure 3-4.

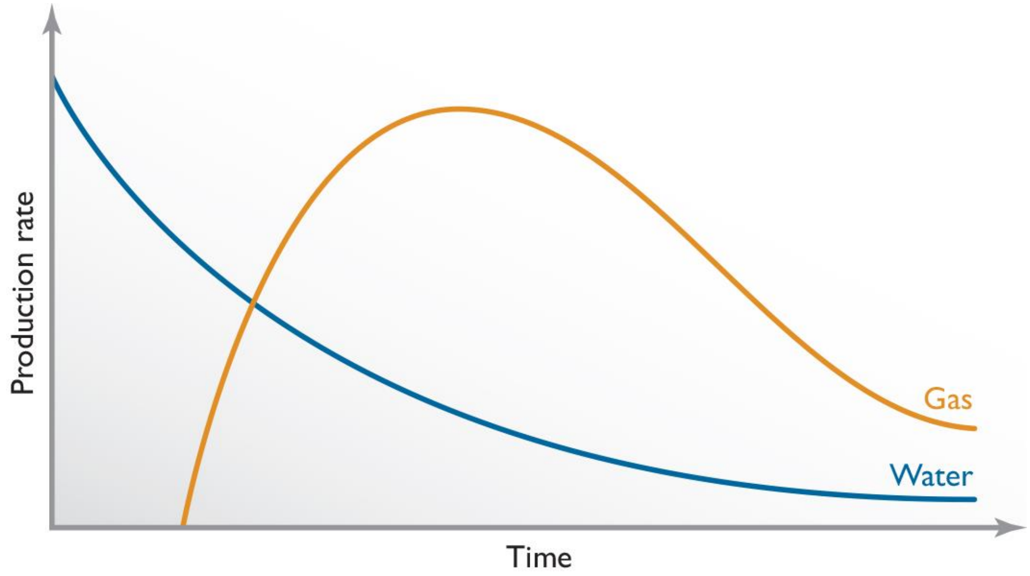
Figure 3-4 Gas compression and treatment process



3.3.4.2 Coal seam water management

Initial pumping and extraction of water from the coal seam is usually required to reduce the confining hydrostatic pressure in the coal seam and release the gas. Normally (as seen in Figure 3-5) water extraction rates fall rapidly and gas production rates increase rapidly after pumping commences. The coal seam depressurisation process can take anywhere from a few days to several months depending on the local geological and hydrological setting and well configuration. The ratio of water extracted to gas produced from a well may vary from more than twenty times to less than one tenth.

Figure 3-5 Typical gas production and water extraction rates



The quality of water extracted from coal seams typically ranges from 100 milligrams per litre (mg/L) total dissolved solids (TDS) (fresh water) to over 10,000 mg/L TDS (brackish water). Water is managed according to its quality and available uses which can include construction, heat exchange, dust suppression, rehabilitation, irrigation, surface water release or reinjection.

From the production well, water is typically either utilised locally or pumped through gathering lines or transmission pipelines to water management storage or facilities. Depending on the intended use or disposal option, coal seam water may need to be treated. The treatment process may involve desalination (e.g. reverse osmosis) to compartmentalise a large portion of the total dissolved solids into a waste stream and produce a higher quality effluent stream (permeate) or by water amendment (i.e. amending the chemical balance of the water).

An overview of a typical desalination treatment process is illustrated in Figure 3-6 and a typical water amendment process is illustrated in Figure 3-7.

Figure 3-6 Overview of typical desalination treatment process via reverse osmosis

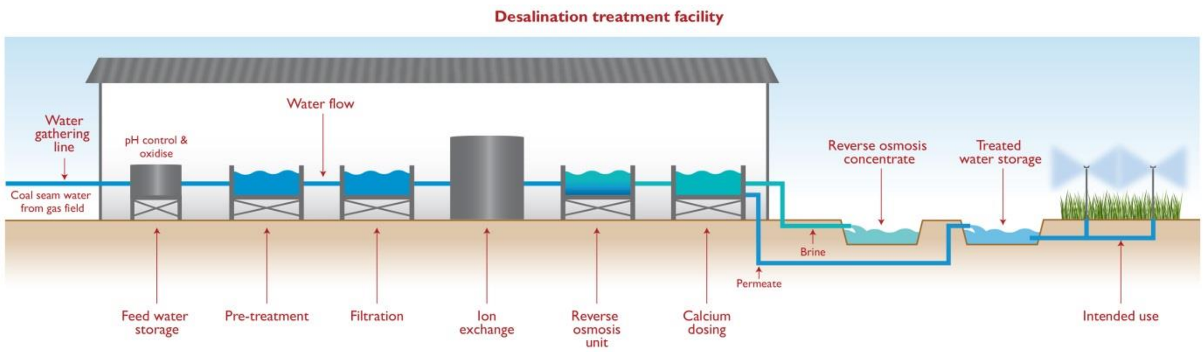
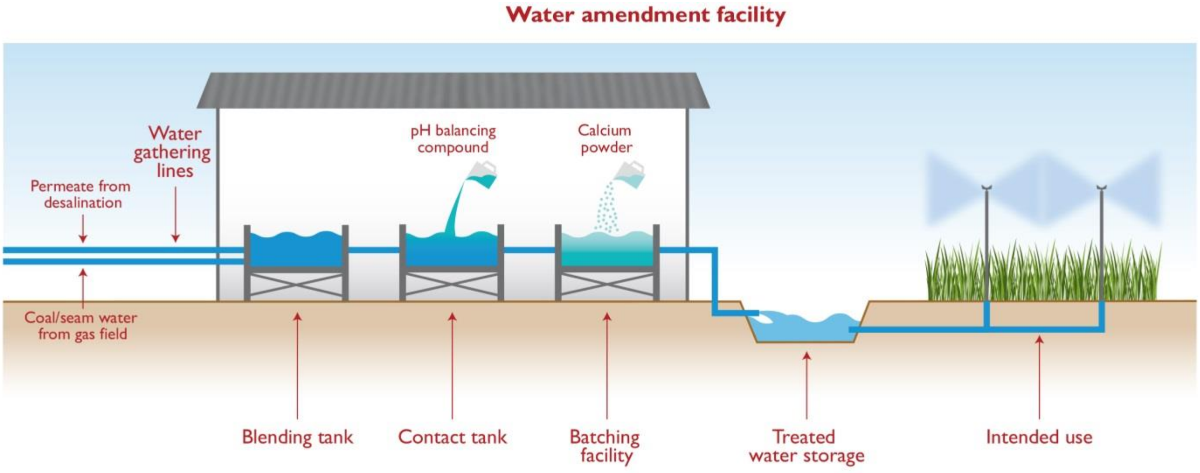


Figure 3-7 Overview of typical water amendment process



3.3.5 Well workover and stimulation

Where required, maintenance activities called well workover operations are performed periodically to maintain or increase well production. Workover operations are carried out on production wells by re-entering the well to perform pump repairs, well deepening, isolation of intervals or re-perforation.

Well stimulation techniques are sometimes used to increase the recovery of gas resources by increasing the permeability of the coal seam or increasing the effective connection of the well to the coal seam. This is conducted through a range of techniques including hydraulic fracturing.

Hydraulic fracturing involves pumping a fluid under pressure into the coal seam to open up and connect fractures within the coal, thereby increasing the opportunity for gas to move within the coal seam and flow toward the well. Water and sand are pumped down the well and into the coal seam to stimulate and hold open fractures within the coal seam. Up to 99.5% of the material pumped into the well is water and sand. The remaining portion is made up of minor quantities of additives used to:

- Enhance fracture initiation
- Help lubricate the flow of the sand into the fractures
- Prevent microbial or chemical reactions following introduction of surface water
- Prevent formation of scale deposits that may affect the well or pumps.

After the fracture process is completed, the fracture fluid and groundwater are extracted from the well to depressurise the coal seam, allowing gas to move through the well to the surface.

The use of specific chemicals such as benzene, toluene, ethyl-benzene and xylene in fracturing fluids is not permitted under Queensland legislation and the use of other chemicals is controlled through the risk assessment process. Further discussion and detailed assessment of this process is provided in Appendix AE-F: Hydraulic fracturing risk assessment.

3.3.6 Decommissioning and rehabilitation

Rehabilitation is an ongoing process that occurs over the lifetime of a gas field development. When an area is no longer producing sufficient gas for extraction to be economically viable, infrastructure will be decommissioned and rehabilitated, or ownership will be transferred with agreement to a third party such as a landholder or local councils in accordance with regulatory and approval requirements and industry best practice.

Key to this incremental process is the decommissioning and rehabilitation of wells. Once drilling is completed, the drilling equipment on the well lease is removed and the majority of the well lease area rehabilitated to the operations footprint. When a well is no longer required for gas operations, it is decommissioned in accordance with regulatory and approval requirements and industry best practice. Decommissioning wells involves removing the remaining surface infrastructure and sealing the well from bottom to surface using a series of cement plugs to isolate the well from the surface. The steel casing in the well is cut off below surface level, sealed with a metal identification plate, and buried.

Gas gathering lines and transmission pipelines will be decommissioned along with wells. Surface gathering lines will be removed and the land rehabilitated. On the other hand, to reduce unnecessary disturbance, buried gathering lines and transmission pipelines will be left in situ in accordance with the regulatory requirements and Queensland Government's *Code of Practice for constructing and abandoning coal seam gas wells and associated bores in Queensland* (Department of Natural Resources and Mines, 2013).

Similarly, gas compression and water management facilities and other supporting GFD Project infrastructure (such as water storage, access roads and accommodation camps) will be decommissioned, with the equipment transferred to other areas and the impacted area rehabilitated. In the event that the landholder requests to retain aspects of this infrastructure, a written agreement will be entered into between the parties and the infrastructure will be retained in place (if acceptable to the regulatory authorities).

The decommissioning and rehabilitation process is detailed in section 4.7 of Section 4: Project description.