



Chapter 6

Project description

Table of Contents

Chapter 6	Project description	6-1
6.1	Introduction	6-4
6.2	Major facilities	6-8
6.3	Gas field infrastructure and activities	6-25
6.4	Ancillary infrastructure	6-44
6.5	Construction activities	6-49
6.6	Maintenance activities throughout operations	6-71
6.7	Decommissioning and rehabilitation	6-79

Table Index

Table 6-1	Key project components	6-6
Table 6-2	Proposed water management infrastructure	6-14
Table 6-3	Leewood and Bibblewindi safety flare design features	6-23
Table 6-4	Medium pressure gas pipeline	6-25
Table 6-5	Pilot well flare design features	6-34
Table 6-6	Gas and water gathering lines - indicative design parameters	6-42
Table 6-7	Description and illustration of the key steps involved when drilling a typical vertical gas well	6-55
Table 6-8	Approximate quantities of primary construction materials for a single vertical well	6-56
Table 6-9	Typical components of drilling fluids	6-58
Table 6-10	Anticipated average volume of drill cuttings by production well type	6-59
Table 6-11	Depth of cover for gas and water gathering lines	6-61
Table 6-12	Approximate power requirements during construction	6-65
Table 6-13	Indicative construction timing and duration	6-66
Table 6-14	Construction working hours	6-67
Table 6-15	Estimated peak and ongoing construction workforce	6-67
Table 6-16	Estimated construction traffic	6-69
Table 6-17	Indicative quantities of construction materials	6-70
Table 6-18	Indicative types of construction equipment	6-71
Table 6-19	Power requirements for operational plant and equipment	6-77

Figure Index

Figure 6-1	Existing infrastructure	6-3
Figure 6-2	Summary diagram of the project's produced water management strategy, including beneficial reuse options	6-5
Figure 6-3	Indicative project construction schedule	6-8
Figure 6-4	Location of key project components	6-9
Figure 6-5	Indicative locations of existing and proposed infrastructure at Leewood	6-11
Figure 6-6	Process diagram of the central gas processing facility	6-12
Figure 6-7	Indicative layout of the Leewood central gas processing facility	6-13
Figure 6-8	Overview of the water treatment process	6-15
Figure 6-9	Indicative layout of the Leewood water treatment plant	6-16
Figure 6-10	Indicative layout of the optional power generation facility at Leewood	6-19
Figure 6-11	Bibblewindi facility showing existing and proposed major facilities	6-21
Figure 6-12	Indicative diagram of the Bibblewindi in-field gas compression facility including safety flare	6-22
Figure 6-13	Indicative layout of underground infrastructure corridor between Bibblewindi and Leewood	6-24
Figure 6-14	Indicative Narrabri Gas Project phased development	6-26
Figure 6-15	Process for locating project infrastructure	6-28
Figure 6-16	Narrabri Gas Project Conceptual layout – Indicative sketch plan	6-30
Figure 6-17	A typical seismic vehicle	6-32
Figure 6-18	A core sample	6-33
Figure 6-19	Typical pilot well flare showing the safety and vegetation free zones	6-34
Figure 6-20	Typical 40 kilolitre water balance tank with bunding used for pilot wells	6-35
Figure 6-21	Diagram of a typical three-well pad layout	6-36
Figure 6-22	Closeup of a typical three-well pad layout (inset from Figure 6-21)	6-37
Figure 6-23	Example of a vertical well	6-38
Figure 6-24	Example of a deviated well	6-38
Figure 6-25	Example of a typical production well set consisting of a multi-lateral well and vertical intercept well.	6-39
Figure 6-26	Diagram of possible production well configurations	6-39
Figure 6-27	Typical well pad configuration	6-40
Figure 6-28	Co located gathering lines and access track with new rehabilitation	6-41
Figure 6-29	Indicative diagrams of radio towers	6-43
Figure 6-30	Diagram of the proposed upgrade of Newell Highway / Old Mill Road intersection	6-44
Figure 6-31	Diagram of the proposed upgrade of Newell Highway / X-Line Road intersection	6-45
Figure 6-32	Demountable buildings in typical workers' camp	6-46
Figure 6-33	Diagram of the current and proposed Westport workers' accommodation facility	6-47
Figure 6-34	Approximate location of the treated water managed release area	6-48
Figure 6-35	Typical drill rig used on the project	6-54
Figure 6-36	Typical well pad layout during drilling	6-56

Figure 6-37	Indicative peak construction workforce	6-68
Figure 6-38	Low point drain along gathering lines	6-75
Figure 6-39	High point vent along gathering lines	6-75

Chapter 6 Project description

The project seeks to develop natural gas from the Gunnedah Basin, south-west of the town of Narrabri, New South Wales. Previous chapters introduce the project and its location, and explain how the project is needed to make gas available to the NSW market. This chapter details the project's activities along with the infrastructure required to extract and treat the gas.

The project comprises development of a natural gas field with project activities to occur wholly within the project area, covering approximately 95,000 hectares of land near Narrabri. The project area incorporates petroleum assessment lease (PAL) 2 and petroleum production lease (PPL) 3.

The proponent will operate the project on behalf of its joint venture participants and the holders of Petroleum Exploration Licence 238, Petroleum Assessment Lease 2, Petroleum Production Lease 3 and Petroleum Production Lease applications 13, 14, 15 and 16 (and other tenures that may derive from these tenures). Santos NSW Pty Ltd and its joint venture participants are the holders of these tenures. Santos NSW (Eastern) Pty Ltd and Santos NSW Pty Ltd are both wholly owned subsidiaries of the Santos Limited group of companies (Santos). Santos is an Australian petroleum company established in 1954 and has been supplying natural gas to NSW since 1976.

As described in Chapter 1, key pieces of infrastructure are required to support the extraction, transport and processing of gas and water from the field. Gas exploration and appraisal activities have been underway in the area for over a decade, and this project proposes to utilise and build on the existing activities footprint as far as practicable. The project would strategically locate this key infrastructure on or adjacent to existing sites to minimise environmental impacts. This is discussed in Chapter 2, with Figure 2-3 showing the existing infrastructure in the project area, reproduced below as Figure 6-1.

Gas and water extracted from gas wells in the gas field would be collected in dedicated gas and water gathering lines. The project would extract around 37.5 gigalitres of produced water over the 25-year assessment period. Gas would be directed to an upgraded and expanded existing site within Bibblewindi State Forest known under the project as 'the Bibblewindi site'—or simply, Bibblewindi. Bibblewindi has hosted gas exploration and appraisal infrastructure for over a decade, prior to purchase by Santos Group in 2011. Under the project, the site would host gas compression facilities in order to allow for the effective transfer of the gas in a pipeline to the proposed central gas processing facility at the 'Leewood Property'—or simply, Leewood. Leewood currently hosts four produced water and brine storage cells in two ponds that are used to manage water under the approved exploration and appraisal program.

The gas would be made available to the NSW market via a high-pressure gas transmission pipeline which would connect to the existing Moomba to Sydney gas pipeline. The pipeline will be constructed and operated by specialist pipeline company APA Group, and is not part of this project Environmental Impact Statement (EIS).

Leewood would also be the site of the proposed centralised water management infrastructure, where an average over the project's life of approximately four megalitres per day of produced water would be directed from the gas field for treatment and amendment. Treatment would include solids removal, reverse osmosis, brine concentration and crystallisation, ammonia removal, dechlorination, and pH adjustment. Amendment would include the addition of calcium sulphate to adjust the sodium absorption ratio. The treated and amended water would be beneficially re-used in irrigation, stock watering, construction, dust suppression and/or drilling activities. At times when Bohena Creek (located some 400 metres to the east of Leewood), flows at greater than, or equal to, 100 megalitres per day as measured at the Newell Highway gauging station, treated water would be released.

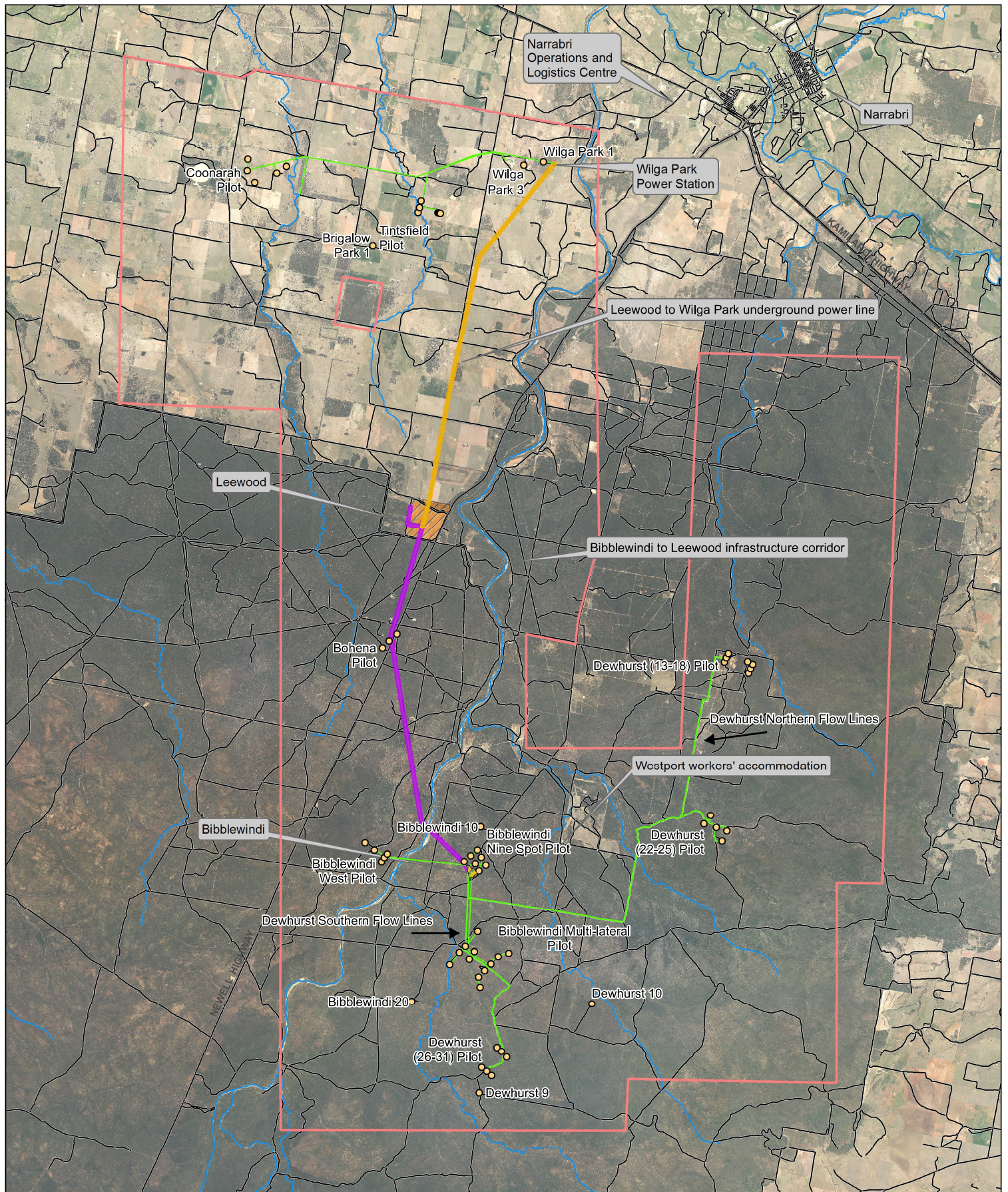
Bibblewindi would also host water management facilities, with one existing pond to be used for produced water and brine storage and another smaller pond at the site to be used for the storage of treated or bore water for use in construction and/or dust suppression.

Transfer of the gas and water between Bibblewindi and Leewood would be facilitated by the installation of further pipelines into an existing pipeline corridor between the two sites, which would require some widening. The corridor would also host power and communications services. An underground power line would also be installed between Leewood and the Wilga Park Power Station within the existing corridor. Supporting infrastructure would include workers' accommodation at a private property towards the middle of the project area known as 'Westport'—previously used during exploration and appraisal activities, and proposed for expansion under the project to host some of the construction workforce.

The project has been designed to have a minimal and temporary impact on land surface area with project infrastructure taking up to one percent of the project area. The gas wells and supporting linear infrastructure (access tracks and water and gas gathering lines), would be located within the project area in accordance with an approved Field Development Protocol— a document that is discussed further in this chapter, and is included in this EIS as Appendix C.

This chapter is structured as follows:

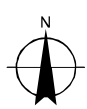
- Section 6.1 provides an overview of the process of natural gas extraction to frame the information provided in this chapter on the gas and water infrastructure required for the project. It also lists the key project components, and the project costs and schedule.
- Section 6.2 provides information on the major facilities required for the project.
- Section 6.3 provides information on the gas field infrastructure required for the project.
- Section 6.4 provides information on the ancillary infrastructure required for the project.
- Section 6.5 describes the construction activities that would be required for the major facilities and gas field infrastructure.
- Section 6.6 describes the maintenance activities that would be required for the major facilities and gas field infrastructure.
- Section 6.7 describes the decommissioning and rehabilitation activities for the major facilities and gas field infrastructure.



LEGEND

 Project area	— Watercourses	— Leewood to Wilga Park infrastructure corridor	● Existing wells
 Leewood	—+— Train line	— Bibblewindi to Leewood infrastructure corridor	
 Bibblewindi	— Existing flowlines	— Roads/tracks	

0 1.75 3.5 7
Kilometers



Narrabri Gas Project
Environmental Impact Statement

Job Number 21-22463
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Existing infrastructure

Figure 6-1

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NSW Department of Lands: DTDB and DCDB - 2012.

6.1 Introduction

6.1.1 The process of gas extraction

The project proposes to extract gas from within the coal seams by depressurisation. This is done through the extraction of water from within the seam via a number of wells. The water generated from the coal seams in order to extract the gas is known as produced water. Managing produced water, which is a key component of gas production, is described further in this chapter, and also in Chapter 7.

Coal seam depressurisation and produced water

The reduction of pressure resulting from the extraction of water from within coal seams allows natural gas to flow to the surface via the gas wells. The volume of water extracted through each well would vary depending on the hydrogeological conditions and the length of time the well has been operating. A detailed groundwater model has been developed for the project to assess the impact on hydraulic pressures and groundwater flows in other geological units as a consequence of extracting produced water from the coal seams (refer Appendix F).

Produced water is collected from each gas well through water gathering lines and passes through in-field balance tanks, and in some instances via Bibblewindi, prior to being transferred to the Leewood central water management facility for treatment and beneficial reuse. The central water management facility is described further in this chapter and Chapter 7. Studies have been completed to assess potential environmental impacts associated with the treated water beneficial reuse options (refer Appendices G1 and G2).

Chapter 7 provides a consolidated overview of produced water management for the project, including volumes produced, treatment methods, and the beneficial reuse options proposed. A diagram showing a summary of the produced water management strategy, including beneficial reuse options, is presented as Figure 6-2. It is expected that produced water volumes will peak at around 10 megalitres per day in at around years two to four, gradually declining over the life of the project. The long term average would be around four megalitres per day, which equates to some 1.5 gigalitres per year over the 25-year assessment period. The estimated total volume of produced water over the project assessment period is around 37.5 gigalitres.

The amount of water the project would extract each year (being around 1.5 gigalitres on average) from the target coal seams is equivalent to approximately 0.7 per cent of the long-term annual extraction limit of 205.6 gigalitres per year set for the Gunnedah-Oxley Basin by the NSW Department of Primary Industries - Water. Current water usage licenses for the Gunnedah-Oxley Basin water source, allocated to existing irrigators, resource projects, industrial users and those drawing for stock and domestic use, allow up to a maximum of 23.1 gigalitres to be extracted each year (refer to Figure 7-3). In comparison, the project is expected to extract a cumulative total of 37.5 gigalitres over its 25-year life.

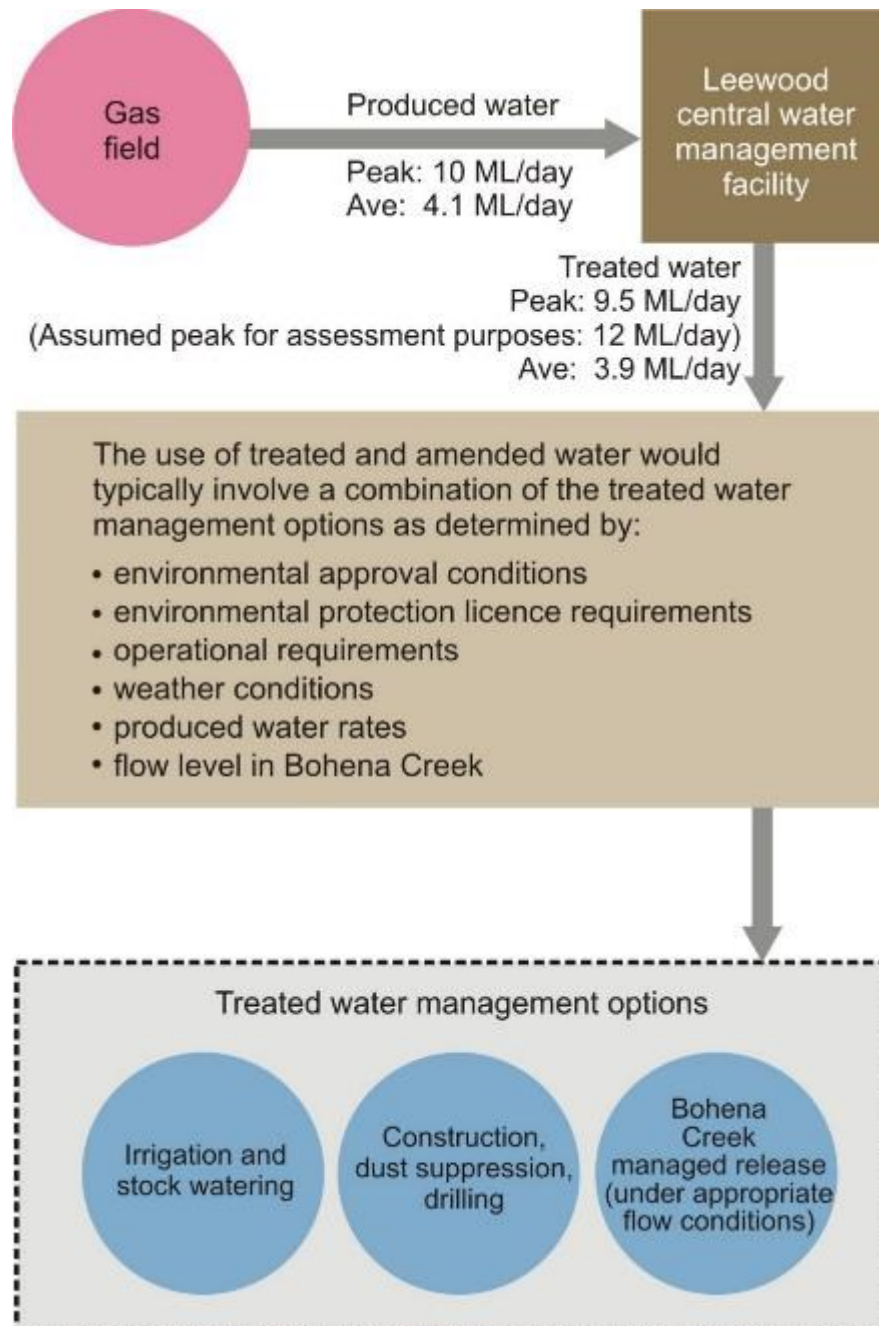


Figure 6-2 Summary diagram of the project's produced water management strategy, including beneficial reuse options

6.1.2 Key project components

The project would involve the construction and operation of a range of exploration, development and production activities and infrastructure. The key components of the project are presented in Table 6-1, which are in addition to the use of existing, and approved though not yet constructed, infrastructure under the proponent's exploration and appraisal program, as outlined in Table 2-1.

Table 6-1 Key project components

Component	Infrastructure or activity
Major facilities	
Leewood	<ul style="list-style-type: none"> • a central gas processing facility for the compression, dehydration and treatment of gas • a central water management facility including storage and treatment of produced water and brine • optional power generation for the project • a safety flare • treated water management infrastructure to facilitate the transfer of treated water for irrigation, dust suppression, construction and drilling activities • other supporting infrastructure including storage and utility buildings, staff amenities, equipment shelters, car parking, and diesel and chemical storage • continued use of existing facilities such as the brine and produced water ponds • operation of the facility
Biblewindi	<ul style="list-style-type: none"> • in-field compression facility • safety flare • supporting infrastructure including storage and utility areas, treated water holding tank, and a communications tower • upgrades and expansion to the staff amenities and car parking • produced water, brine and construction water storage, including refurbishment and recommissioning of two existing ponds • continued use of existing facilities such as the 5 ML water balance tank • operation of the expanded facility
Biblewindi to Leewood infrastructure corridor	<ul style="list-style-type: none"> • widening of the existing corridor to allow for construction and operation of an additional buried medium pressure gas pipeline, a water pipeline, underground power (up to 132 kV), and buried communications transmission lines
Leewood to Wilga Park underground power line	<ul style="list-style-type: none"> • installation and operation of an underground power line (up to 132 kV) within the existing gas pipeline corridor
Gas field	
Gas exploration, appraisal and production infrastructure	<ul style="list-style-type: none"> • seismic geophysical survey • installation of up to 850 new wells on a maximum of 425 well pads <ul style="list-style-type: none"> – new well types would include exploration, appraisal and production wells – includes well pad surface infrastructure • installation of water and gas gathering lines and supporting infrastructure • construction of new access tracks where required • water balance tanks • communications towers • conversion or upgrade of existing exploration and appraisal wells to production in addition to the 850 new wells

Component	Infrastructure or activity
Ancillary	<ul style="list-style-type: none"> • upgrades to intersections on the Newell Highway • expansion of workers' accommodation at Westport • a treated water pipeline and diffuser from Leewood to Bohena Creek • treated water irrigation infrastructure including: <ul style="list-style-type: none"> – pipeline(s) from Leewood to the irrigation area(s) – treated water storage dam(s) off site from Leewood • operation of the irrigation scheme

6.1.3 Project capital cost

The construction of the project is expected to involve an estimated nominal capital investment of \$3.6 billion.

6.1.4 Project schedule

The planning, development and construction of the project, as shown indicatively in Figure 6-3, would generally include the following:

- planning and approvals
- front-end engineering and design (FEED)
- gas field exploration and appraisal
- construction including drilling
- operations and maintenance
- well and infrastructure decommissioning and rehabilitation.

As shown, planning and approvals would occur simultaneously with front end engineering design. Additional exploration and appraisal activities would assist to inform a final investment decision on the production project and in field planning throughout the project life.

Once constructed, the major facilities at Leewood and Bibblewindi would operate throughout the life of the project. Much of the major infrastructure is modular in nature, thereby enabling partial operating capacity prior to the complete installation of all plant and equipment.

Subject to obtaining the required regulatory approvals and a final investment decision regarding the gas production project, an indicative construction start date for the purposes of impact assessment is around early/mid 2018, with first gas scheduled for around 2019/2020. Construction of the staged gas processing and water management facilities would occur as part of the first stage of the project.

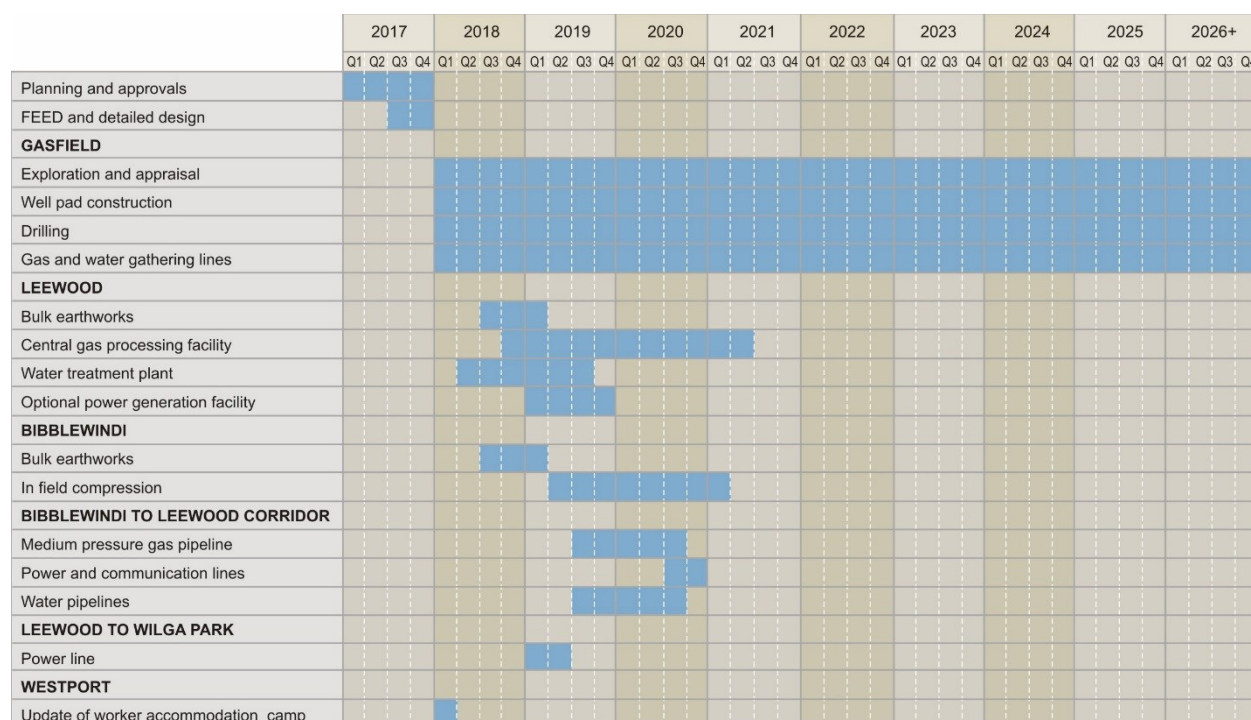


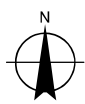
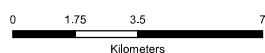
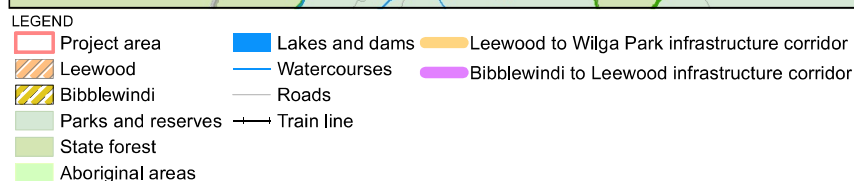
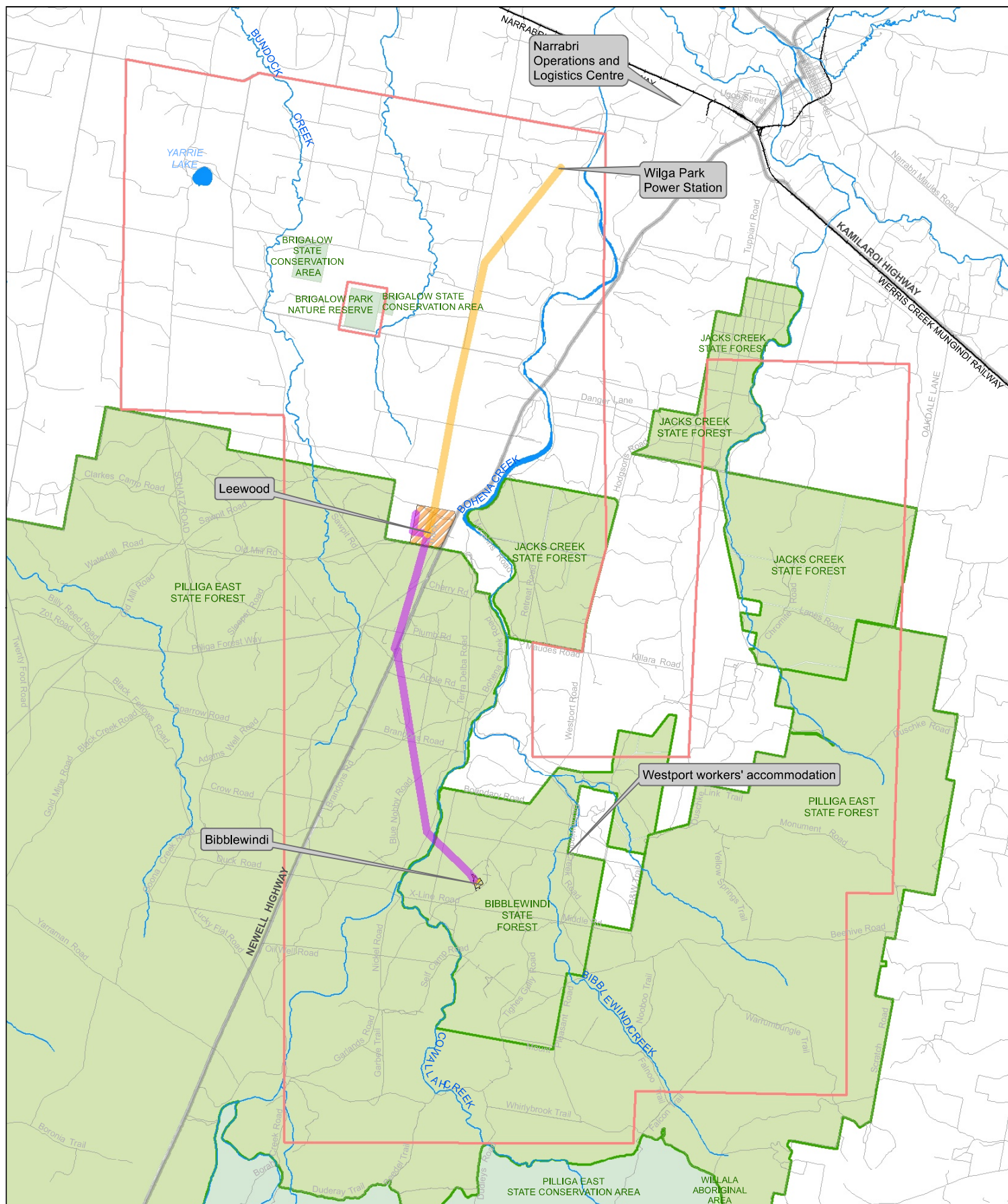
Figure 6-3 Indicative project construction schedule

The gas wells would be progressively drilled over approximately the first 20 years of the project. The number of wells drilled per year would be based on a number of factors including gas production rates and requirements, construction timing and rig availability. It is anticipated that a peak rate of drilling would occur in the first three to four years of the project when up to six drilling rigs and two completion rigs could be operating concurrently, prior to scaling back to two drilling rigs and a completion rig. Each drilling rig would be expected to drill between 10 and 30 wells per annum, depending on well type.

The commercial life span of a gas production well can be greater than 20 years. When gas wells are no longer considered commercially productive, they would be progressively decommissioned or converted to monitoring bores and the well pads would be rehabilitated. For the purpose of impact assessment, a 25-year assessment period has been adopted.

6.2 Major facilities

Major facilities are required to support the development of the gas production activities, with these major facilities being located on or adjacent to sites that currently support existing facilities, including Leewood, Bibblewindi, the Leewood to Bibblewindi infrastructure corridor, Westport workers' accommodation, and the Leewood to Wilga Park infrastructure corridor (refer to Figure 6-4).



Narrabri Gas Project
Environmental Impact Statement

Job Number 21-22463
Revision A
Date 14 Jul 2016

Location of key project components

Figure 6-4

6.2.1 Leewood

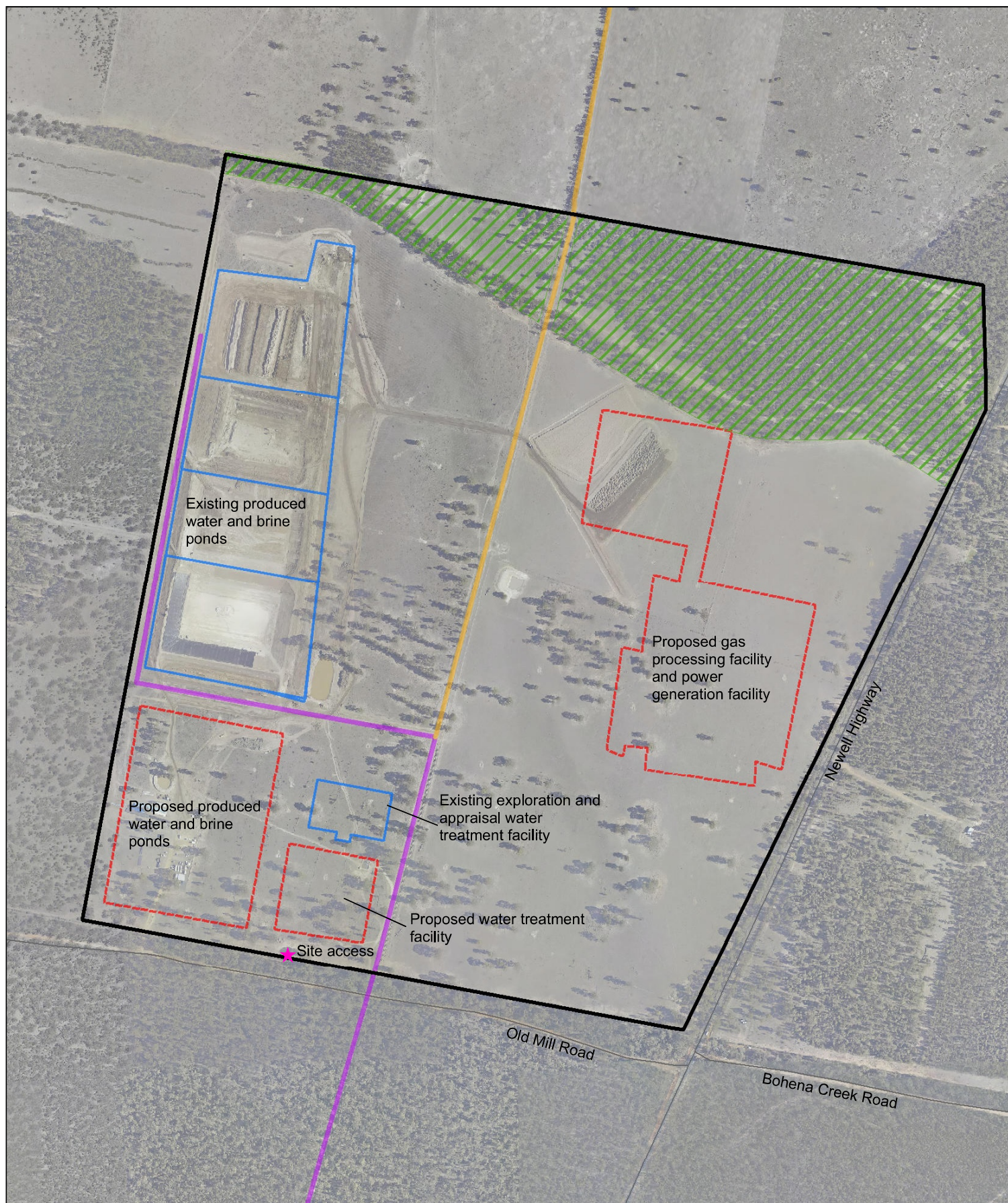
Leewood hosts existing infrastructure established for Santos' exploration and appraisal program, including:

- two double-lined produced water and brine storage ponds, each pond with two cells
- a water treatment facility to manage water produced during the exploration program
- a storage and utilities area
- staff amenities
- car parking.

The project would continue to utilise this infrastructure where practicable. The following new infrastructure would also be required at Leewood:

- a central gas processing facility
- a safety flare
- water management facilities
- a covered interim storage facility for salt prior to its transfer and disposal off site
- optional power generation
- a telecommunication tower
- laydown areas
- various buildings including a control room, equipment shelters, offices, a workshop, ablutions and sewage treatment, storerooms and a first aid room
- other supporting infrastructure including car parking, chemical storage, and diesel and lubrication oil storage tanks.

The existing infrastructure and an indicative layout of the proposed infrastructure at Leewood is shown in Figure 6-5. Additional information is provided below.

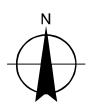


Aerial Imagery: Dec 2013

LEGEND	
Leewood	Leewood to Wilga Park infrastructure corridor
Roads	Bibblewindi to Leewood infrastructure corridor
Existing facilities	
Proposed infrastructure	
Vegetation to remain	

0 0.075 0.15 0.3
Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55



Narrabri Gas Project
Environmental Impact Statement

Job Number 21-22463
Revision A
Date 15 Jul 2016

Existing and proposed infrastructure at Leewood

Figure 6-5

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Central gas processing facility

A central gas processing facility would be constructed and operated at Leewood; which has been strategically located at the Leewood site to minimise impacts to vegetation and fauna habitats.

The central gas processing facility would treat gas through additional compression, carbon dioxide removal and dehydration. A schematic of the various stages of gas processing is shown in Figure 6-6. As previously noted, the gas export pipeline proposed to transport the gas to market would be subject to a separate approval.

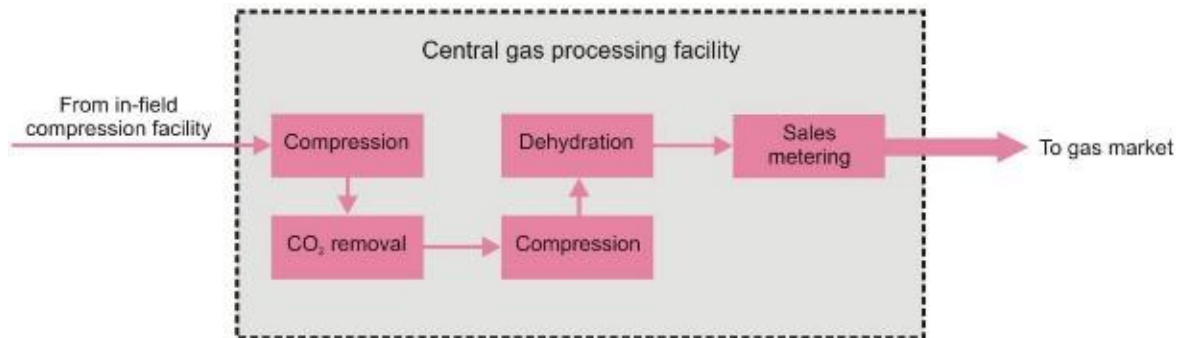


Figure 6-6 Process diagram of the central gas processing facility

An indicative layout of the central gas processing facility is shown in Figure 6-7. Four processing trains are proposed, each with a nominal processing capacity of 50 terajoules per day. Each discrete element of the central gas processing facility, including the four processing trains, would be mounted on concrete pads.

Each of the four processing trains shown in Figure 6-7 may include:

- a compression plant and after coolers
- membrane carbon dioxide (CO₂) removal including pre-treatment
- an amine system including an absorption and a stripping tower
- a triethylene glycol (TEG) dehydration unit, or similar.

Other infrastructure within, or near, the central gas processing facility would include:

- fuel gas skids
- a safety flare (the same or similar to that proposed at Bibblewindi; refer to Section 6.6.2 and Table 6-3 for details)
- optional power generation (discussed below), substations and a switch room
- diesel and lubrication oil tanks
- chemical storage facilities
- sales gas metering
- various buildings and facilities including a control room, equipment shelters, offices, a workshop, storerooms, a first aid room, and sewage treatment.

In addition, up to five compressors may be relocated from Bibblewindi to Leewood during the project. Remote monitoring and control capability would be incorporated into the design of the central gas processing facility.

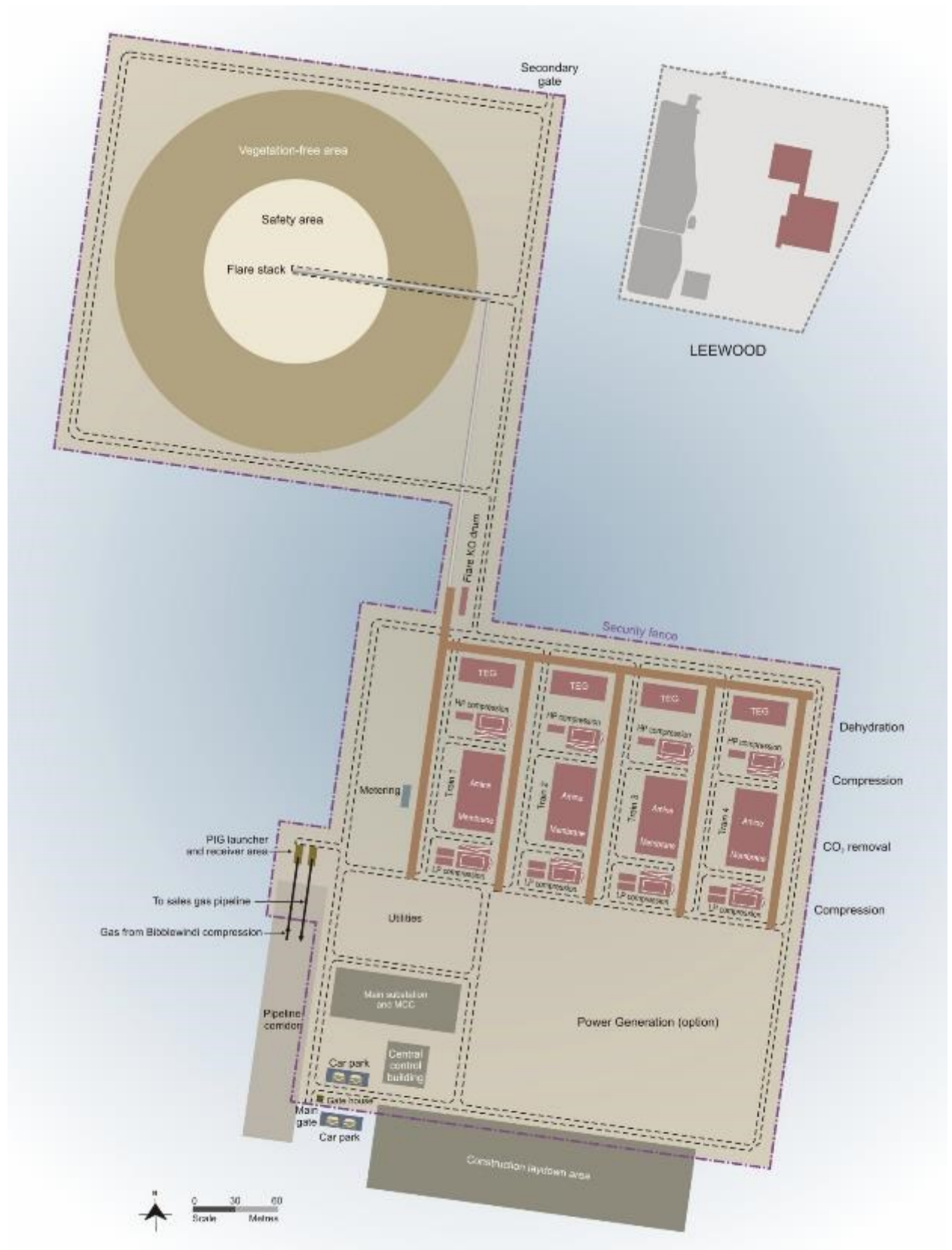


Figure 6-7 Indicative layout of the Leewood central gas processing facility

Water management infrastructure

The produced water management strategy is discussed in Chapter 7. This section provides an overview of the water management infrastructure that would be located at Leewood to manage the produced water.

As noted above, the siting of the major facilities is aligned to existing sites. Table 6-2 summarises the status of the existing and proposed water management infrastructure at Leewood.

Table 6-2 Proposed water management infrastructure

Water infrastructure requirements	Proposed additions/changes to current infrastructure
Three produced water / brine ponds totalling 900 ML capacity	The existing two ponds of approximately 300 ML storage capacity each would be supplemented by the construction of a third pond of the same size. Each of the three ponds would have two cells, each of approximately 150 ML capacity.
Water treatment plant	<p>The water and brine treatment plant for the exploration and appraisal program would largely be removed and a new plant constructed. The 5 ML treated water storage tank would be retained and used in the project.</p> <p>The new treatment plant would be designed to have capacity to treat up to 14 ML per day, and would likely be downsized as produced water volumes decrease over time.</p>
Brine treatment plant / concentrator	This would be a new plant with indicative capacity of up to approximately 4 ML per day.
Salt crystalliser	This would be a new plant with indicative capacity of up to approximately 2 ML per day.
Beneficial reuse - irrigation	<p>The existing supporting infrastructure such as flanges and piping at Leewood would be used in the project.</p> <p>A new irrigation system for beneficial reuse of treated water would require treated water storage / balance dam(s) with a capacity of at least 200 ML on third party properties, and pipeline infrastructure to transfer the treated water from Leewood to the irrigation area or areas.</p>
Beneficial reuse – dust suppression, drilling, construction and fire fighting	<p>Treated water would be transferred to Bibblewindi through one of the proposed new water pipelines for beneficial reuse (refer Section 6.2.3).</p> <p>Treated water would be beneficially reused for stock watering, dust suppression, drilling, and construction in the project area and / or for firefighting.</p>
Managed release to surface waters (Bohena Creek)	Managed release of treated water would be via a pipeline from Leewood to Bohena Creek and a diffuser in Bohena Creek at the release point (refer Section 6.4.3).

Once produced water enters the Leewood property it would be received in storage ponds, from where it would be pumped to the water treatment plant. As noted in Table 6-2, the new treatment plant would be designed to have capacity to treat up to 14 megalitres per day, and would be downsized as produced water volumes decrease over time. An overview of the water treatment process for the expected peak (of around 10 megalitres per day) and long term average (of approximately 4 megalitres per day) produced and treated / amended water volumes is shown below in Figure 6-8. A brief overview of the process is provided below, with Figure 6-9 showing the indicative layout of the water treatment plant.

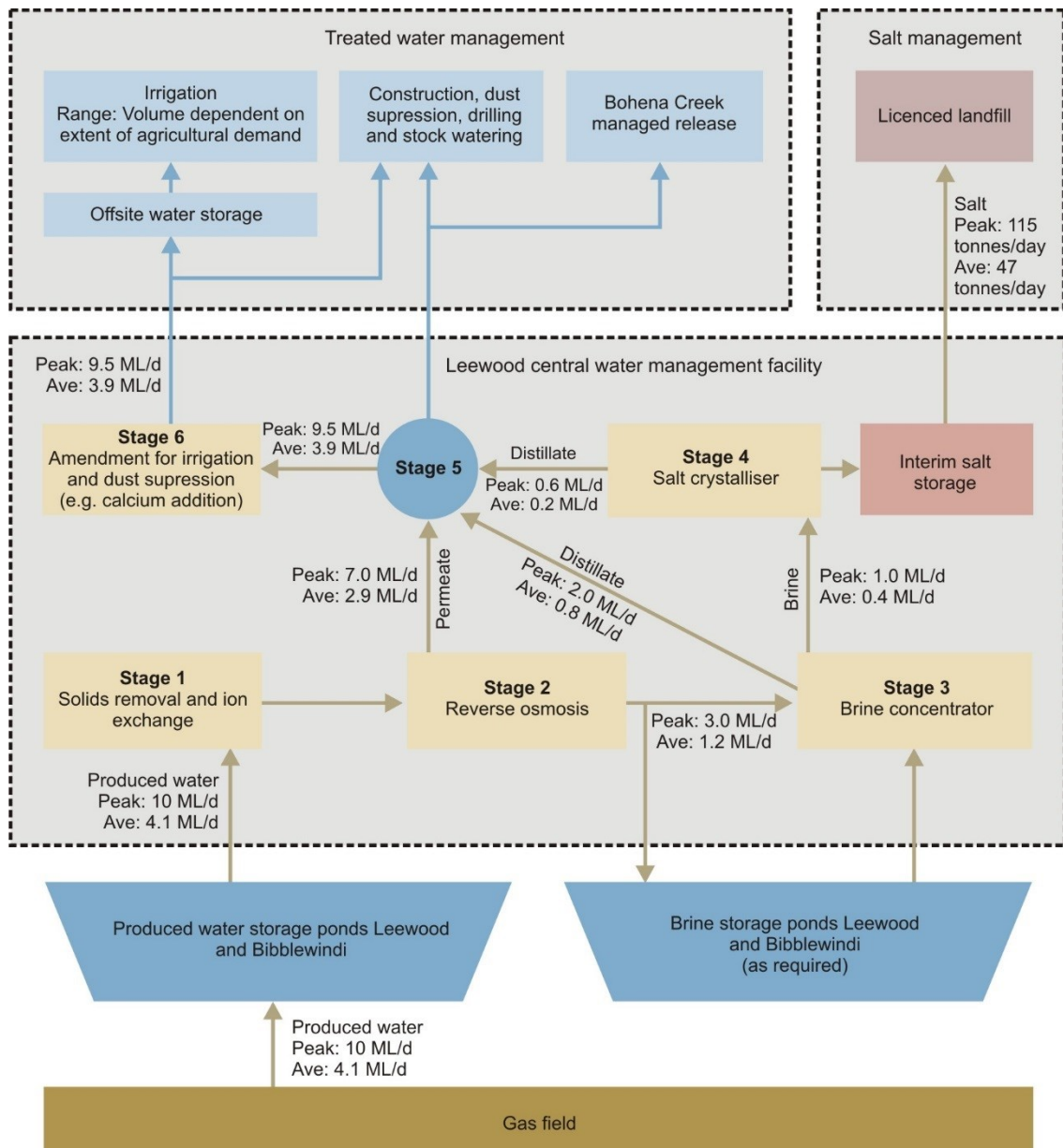


Figure 6-8 Overview of the water treatment process

The first stage of treatment involves solids removal using dissolved air flotation technology. Dissolved air flotation uses micro-bubbles of dissolved air that attach to solids, causing them to float to the surface where they are removed by a mechanical skimmer. Solids which do not float settle to the base of the dissolved air flotation chamber and are removed as sludge. Water then passes through microfiltration or ultrafiltration to remove yet finer solids; a physical barrier in the form of a membrane is used for this process. Water then passes through an ion exchange, which removes certain cations that can foul the reverse osmosis plant through scale build-up. The removal of solids via dissolved air flotation and microfiltration or ultrafiltration, and the subsequent use of ion exchange, all help protect the reverse osmosis plant to maximise its performance.

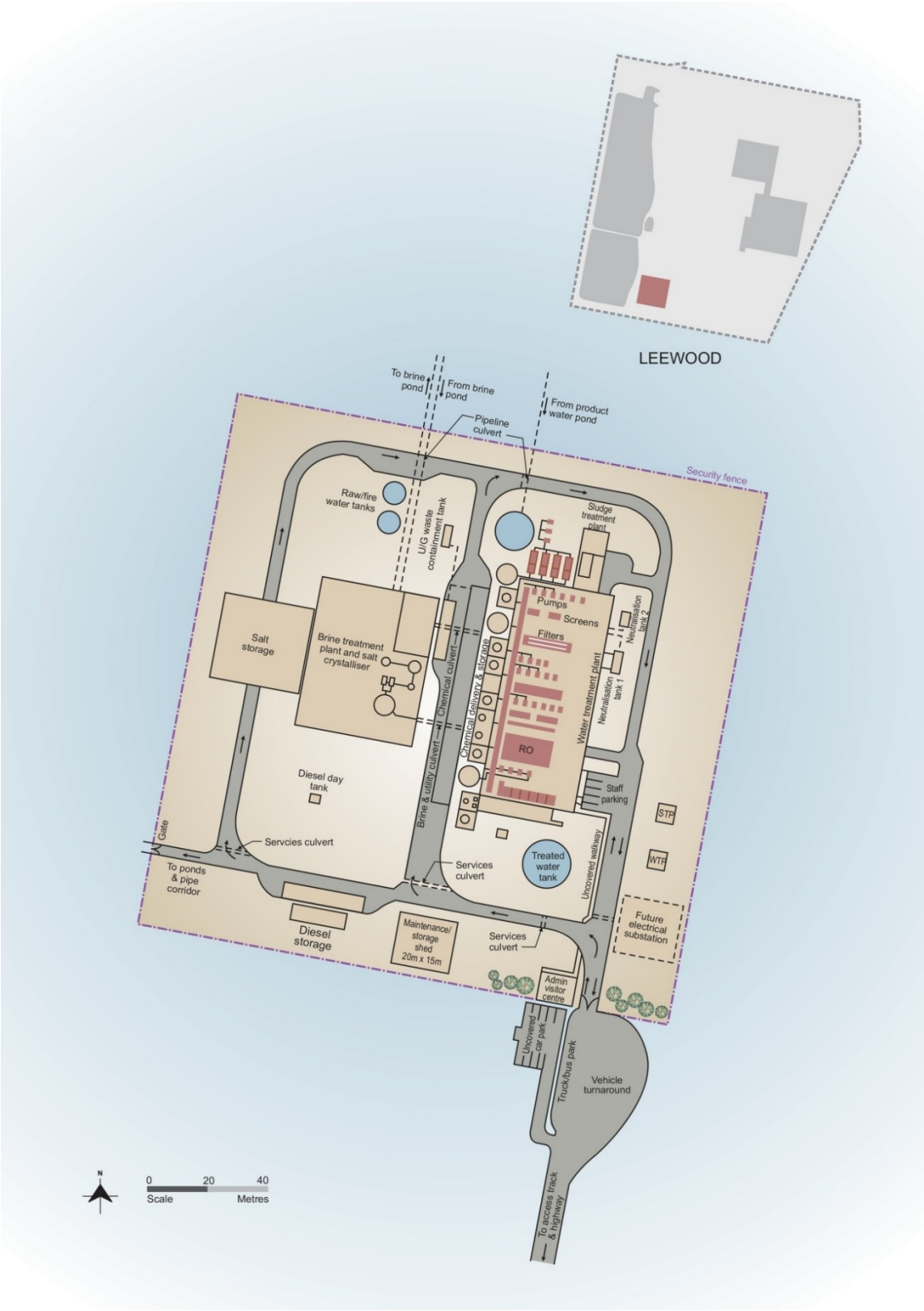


Figure 6-9 Indicative layout of the Leewood water treatment plant

The second stage is reverse osmosis which removes salts and other particles; this process generates brine. Reverse osmosis operates by pumping water through a semi-permeable membrane that concentrates the dissolved solids into one stream (the rejected concentrate, or brine), and the purified water into another stream, which is called permeate. The water is pumped at high pressure through the membranes, typically separating over 99 per cent of the total dissolved solids (mostly salts) from the water. Approximately two-thirds of the water entering the process becomes permeate, with the remainder becoming brine. The brine is pumped to storage ponds and subsequently reticulated through the Stage 3 brine concentrator, which recovers additional treated water (distillate) by increasing the concentration of dissolved solids in the brine solution so that a salt can be produced in the fourth stage of treatment. A thermal process in the brine concentrator is used which concentrates the dissolved solids in solution by evaporation, thereby recovering additional treated water for beneficial reuse.

The fourth stage involves the concentrated brine being passed through a salt crystalliser to produce a solid salt product, along with additional distillate recovery for beneficial reuse. The salt crystalliser produces a solid salt by concentrating dissolved solids beyond their precipitation point. As in the brine concentrator, the dissolved solids content of the brine is concentrated by evaporation.

The fifth stage involves the following:

- ammonia removal through chlorination
- dechlorination
- pH adjustment by acid or alkaline amendment to meet the nominated treated water quality criteria prior to beneficial reuse.

The sixth stage is the water amendment which involves the addition of calcium sulphate (gypsum) to adjust the sodium adsorption ratio, thereby making the amended water more suitable for beneficial reuse in irrigation.

The treatment process includes systems for cleaning, conditioning and anti-scaling the plant and periodic sanitisation using biocides would be undertaken to prevent biofouling in the piping, equipment and beneficial reuse infrastructure such as water distribution systems. Chemical dosing systems and associated storage would be contained within the plant and appropriately bundled.

During the project, it is estimated that average salt production would be just under 50 tonnes per day over the 25-year assessment period (refer Chapter 7 for further information). In comparison, this is around four and a half per cent of the approximately 1,090 tonnes of salt diverted from the Murray River by Government-run salt interception schemes in 2013-2014 (Murray-Darling Basin Authority 2014). Salt production would be a function of the volume of produced water generated, with greater volumes during the produced water peak in around years two to four of the project. The salt waste product is classified as general solid waste under the *NSW Waste Classification Guidelines* and would be disposed of to a licenced facility in accordance with all transport tracking and other regulatory requirements. The proponent would also investigate options for beneficial reuse or treatment methods.

Both the treated water and amended water (treated water that has undergone calcium sulfate addition to lower sodium absorption ratios) would be beneficially reused through:

- irrigation
- dust suppression, drilling, construction and fire fighting

There would also be an option for the release of treated water to Bohena Creek under managed conditions at a point close to Leewood. The exact location of the pipeline and release point would be determined during detailed design. Similar to the water and gas gathering lines, the final location of the managed release pipeline would be subject to land access approvals and would be sited using the Field Development Protocol. Refer to Section 6.4 for additional detail.

The beneficial reuse of treated water is assessed in this EIS. In order to provide operational flexibility, the assessment is based on the beneficial reuse of 12 megalitres per day of treated and / or amended water for irrigation, and the release of up to 12 megalitres per day of treated water to Bohena Creek—around 2 megalitres per day more than the peak produced water daily volume of around 10 megalitres per day. Beneficial reuse options are described in more detail in Chapter 7 and the potential impacts are described and assessed in the relevant chapter.

Power generation

There are two options to provide power to the infrastructure at Leewood and Bibblewindi. They are:

- connection to the NSW power grid. This option also includes the ability to draw power from the existing Wilga Park Power Station via a new power distribution line proposed for installation within the existing infrastructure corridor between Leewood and Wilga Park (refer Section 6.2.4)
- construction and operation of a gas-fired power generation facility on Leewood producing approximately 100 megawatts (MW) of electrical power.

Under both options, power would be reticulated to Bibblewindi from Leewood via the Bibblewindi to Leewood infrastructure corridor (refer to Section 6.2.3). A schematic of the proposed (optional) power generation facility at Leewood is provided in Figure 6-10.

Both power options are assessed in this EIS. If constructed, the power generation facility would be located adjacent to the largest energy consumer on Leewood—the central gas processing facility (refer to Figure 6-7).

Required upgrades to the NSW electricity transmission network and associated infrastructure would be subject to a separate approval process.

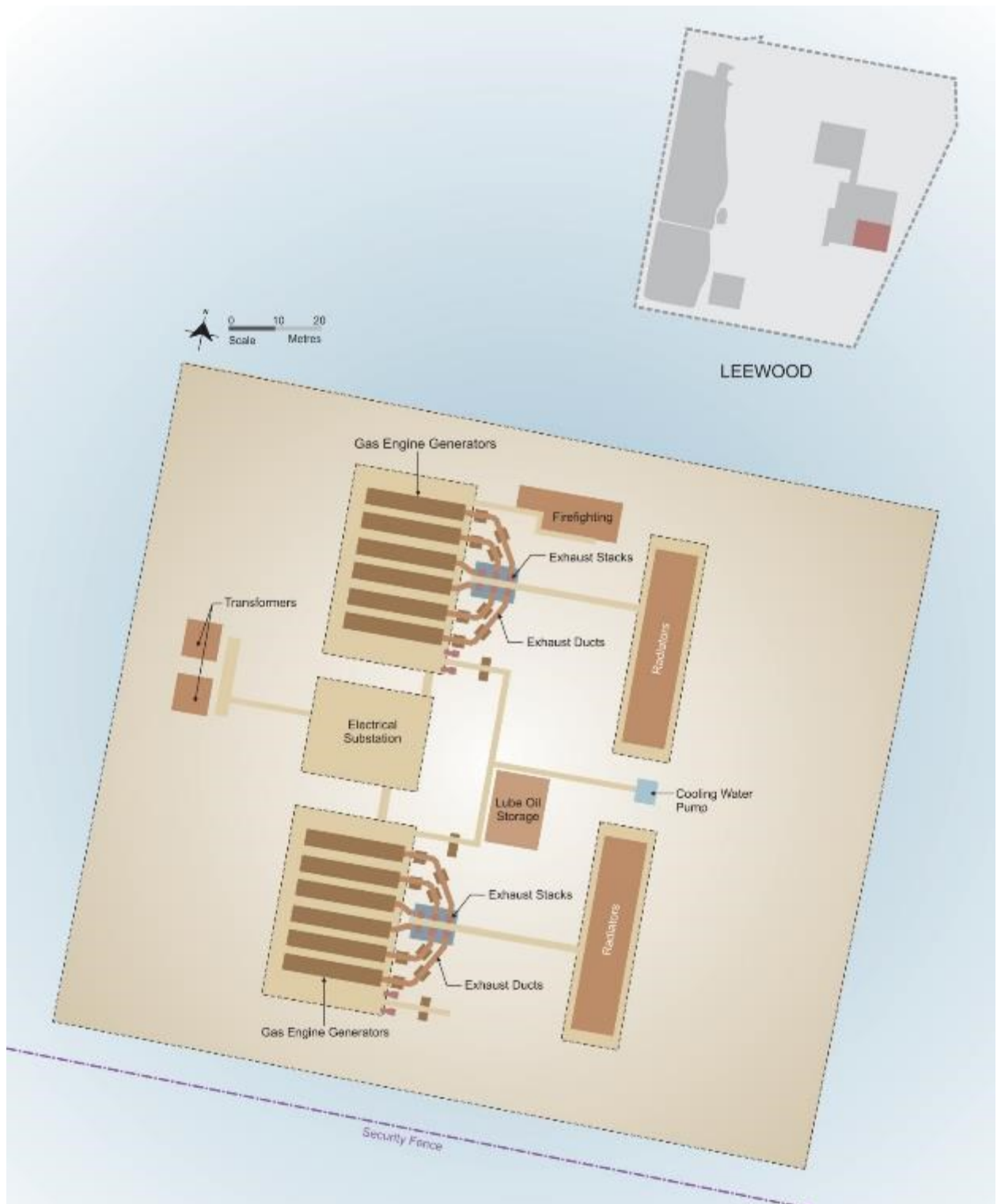


Figure 6-10 Indicative layout of the optional power generation facility at Leewood

6.2.2 Bibblewindi

Bibblewindi currently hosts infrastructure established for the existing exploration and appraisal program, including:

- a small capacity gas compression station (currently not in use)
- a safety flare
- a water balance tank—used to manage produced water flows between the gas field and the water treatment plant
- two water storage ponds (Bibblewindi Pond 2 and 3)
- storage and utilities areas
- staff amenities
- car parking.

The project would utilise and / or upgrade this existing infrastructure where practicable. It is anticipated that an additional 16 hectares of vegetation disturbance would be required at the Bibblewindi site, primarily to accommodate the in-field gas compression facility. The existing flare would be replaced with a larger flare whilst the water balance tank would continue to be used. Both water storage ponds would also be used following works required for their recommissioning. The larger existing pond (Pond 3) would be upgraded in order to meet the standards set out in *Exploration Code of Practice: Produced Water Management, Storage and Transfer* (NSW Department of Industry, Skills and Regional Development 2015c).

Figure 6-11 shows the proposed location of the in-field gas compression facility and flare at Bibblewindi, within the indicative area to be expanded. The final location would be determined through micro-siting in accordance with the Field Development Protocol.

The new infrastructure required for the project at Bibblewindi is described below.



LEGEND

- Indicative Bibblewindi site boundary
- Bibblewindi to Leewood infrastructure corridor
- Indicative infrastructure location
- Existing wells

Aerial Imagery: Dec 2013

0 0.05 0.1 0.2
Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55



Narrabri Gas Project
Environmental Impact Statement

Job Number	21-22463
Revision	A
Date	07 Sep 2016

Existing and proposed infrastructure
at Bibblewindi

Figure 6-11

In-field gas compression

An in-field compression facility at Bibblewindi is required to boost gas pressure to enable it to be transported via a buried gas pipeline to the Leewood central gas processing facility. Gas from the gas field would flow through an inlet separator into the compression unit. There would be up to 20 compressors (refer to Figure 6-12 for an indicative layout), which would be installed on concrete pads. The installation of the 20 compressors would be staged to meet demand from the evolving gas field development.

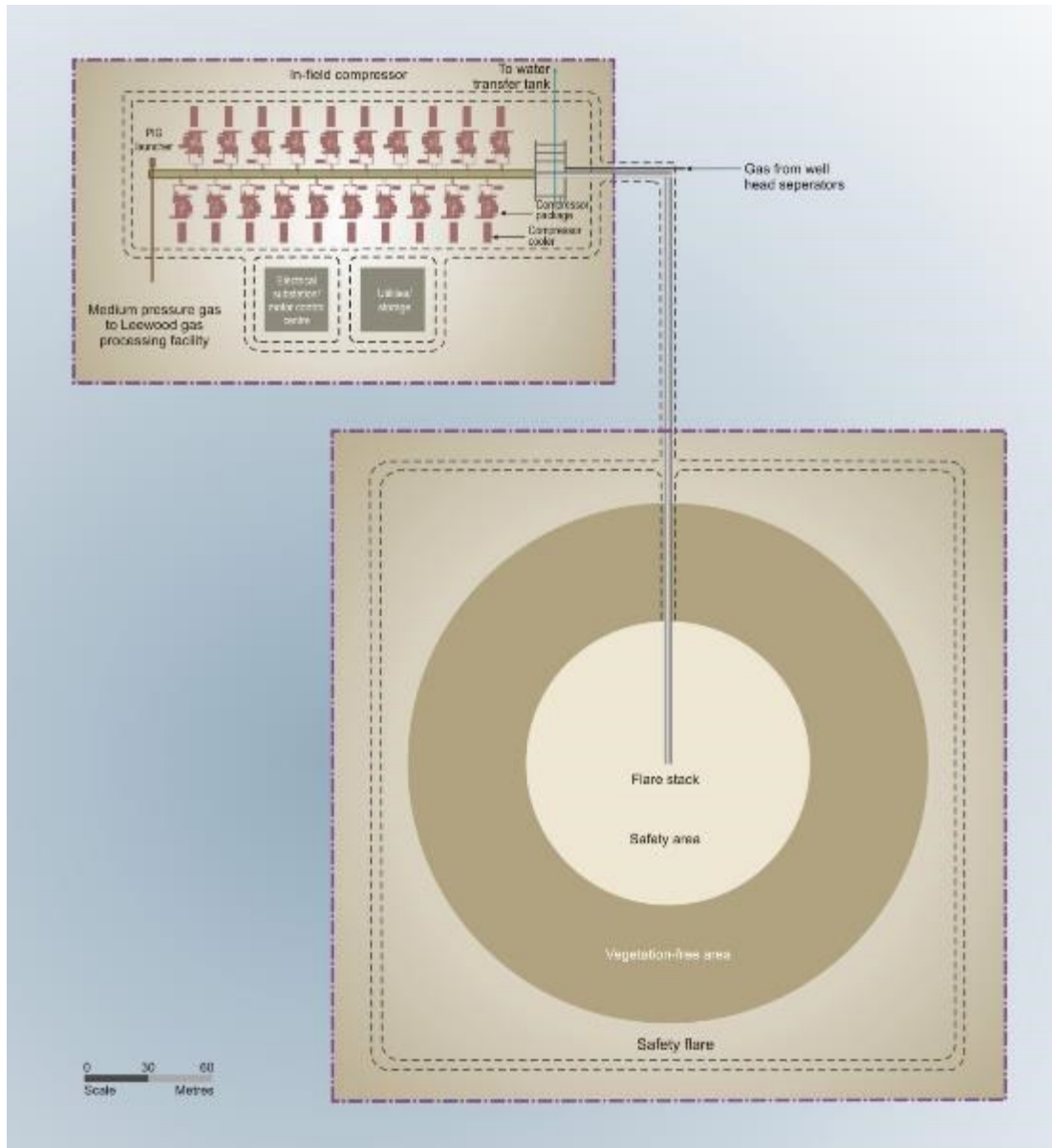


Figure 6-12 Indicative diagram of the Bibblewindi in-field gas compression facility including safety flare

The existing safety flare associated with the in-field gas compression facility would be replaced to meet the capacity required to support up to 200 terajoules per day. It is required to safely manage gas during commissioning and maintenance activities or in non-routine situations (expected to occur infrequently). Table 6-3 lists the design features of the upgraded flare.

Table 6-3 Leewood and Bibblewindi safety flare design features

Design feature	Indicative details
Average flame height	1.5 m ^a from flare stack during normal operations. Up to 30 m if required to operate at design flow rate.
Design flow rate	244 standard cubic feet per day (equates to 200 TJ / day)
Typical flow rate ^a	0.03 standard cubic feet per day (equates to 0.02 TJ / day)
Stack height (to flare stack tip)	up to 50 m
Vegetation free zone (from stack base) ^b	up to 130 m radius
Safety zone (from stack base) ^b	up to 60 m radius

^a Based on the minimum flow of purge gas to maintain the flare during standard operations

^b The vegetation free and safety zones have been sized based on acceptable radiation limits. This would be refined during detailed design.

Water infrastructure

As discussed above, the existing ponds at Bibblewindi would be used for the project. The larger pond (Pond 3) would be used for the storage of produced water and brine for the project and will be upgraded to meet the standard set out in the *Exploration Code of Practice: Produced Water Management, Storage and Transfer* (NSW Department of Industry, Skills and Regional Development 2015c). The smaller existing water pond (Pond 2) would store either fresh or treated water for use in construction and drilling. The existing water balance tank would also be utilised.

In addition, a water tank with capacity of approximately 300 kilolitres would be installed to store potable water for staff amenities. The tank would be located near the existing five megalitre water balance tank.

All stored water at Bibblewindi would be made available for firefighting if required.

Other infrastructure

Other new infrastructure at Bibblewindi would include:

- an electrical substation and motor control centre
- an upgrade and expansion to the existing staff amenities, car park, and storage and utility areas
- a communications tower
- diesel and chemical storage facilities, and sewage management facilities.

6.2.3 Bibblewindi to Leewood infrastructure corridor

The Bibblewindi to Leewood infrastructure corridor currently hosts existing infrastructure, including:

- an existing gas pipeline
- an existing water pipeline
- an approved (not yet constructed) second water pipeline. Each water pipeline would contain produced or treated water able to be pumped in either direction.

The three gas and water pipelines described above would be utilised for the project. In addition, the following new infrastructure would be constructed:

- a third water pipeline
- a medium pressure gas pipeline
- 132 kV power transmission
- communication lines.

The existing corridor would be widened to 30 metres to accommodate construction of the new underground infrastructure. An indicative layout of the expanded corridor is shown in Figure 6-13.

A new water pipeline would be installed to allow water transfers between Leewood and the Bibblewindi site. Its design specifications would be similar to the approved, though yet to be constructed high density polyethylene (HDPE) water pipeline in the same corridor (refer to Figure 6-13).

The new medium pressure gas pipeline would be constructed to convey medium pressure compressed gas from the Bibblewindi in-field gas compression facility to the Leewood central gas processing facility.

A new underground transmission line up to 132kV would be constructed between Bibblewindi and Leewood to reticulate power from either the Leewood power generation facility or from a grid connection to Bibblewindi. Communications cabling would also be installed within the corridor.

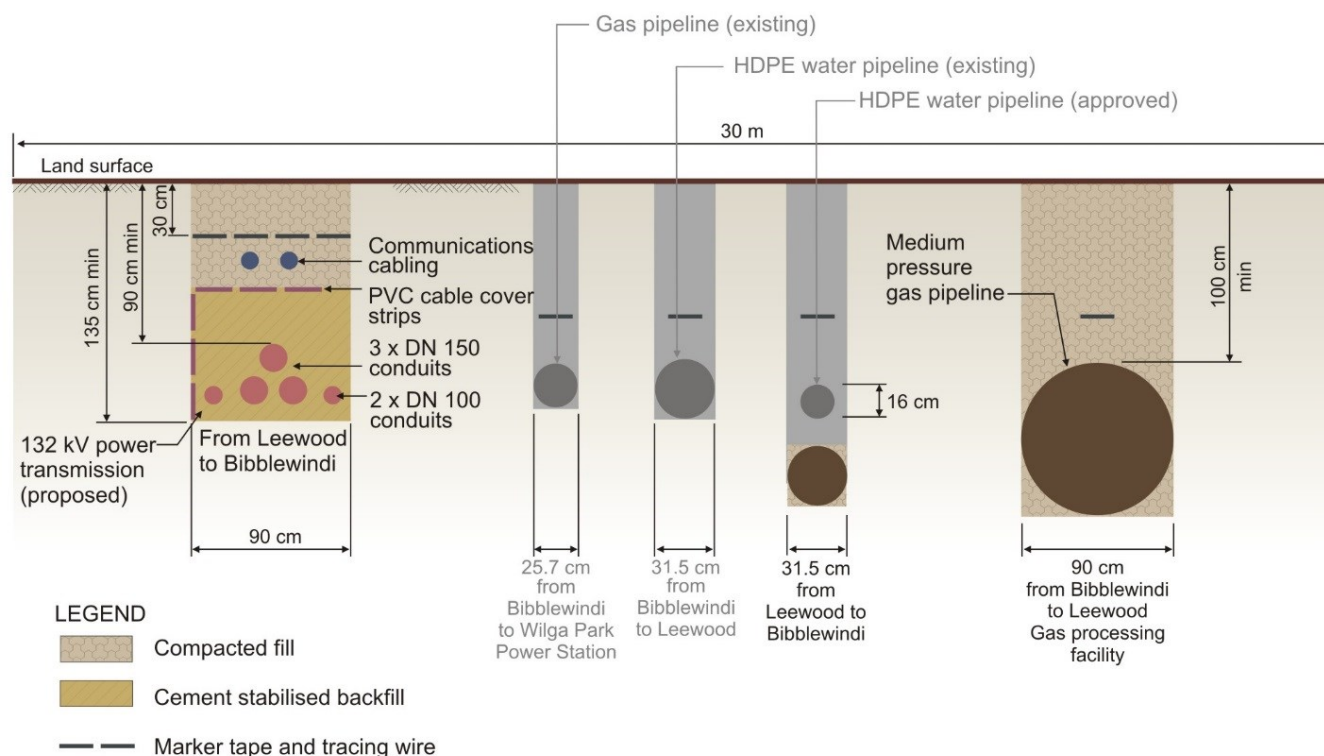


Figure 6-13 Indicative layout of underground infrastructure corridor between Bibblewindi and Leewood

Table 6-4 provides technical details for the proposed medium pressure gas pipeline.

Table 6-4 Medium pressure gas pipeline

Parameter	Gas flow line
Gas pressure	approximately 2,000 kPa
Pipe diameter	approximately 900 mm
Material	glass reinforced epoxy, flexible composite or carbon steel
Static pressure rating	approximately 3,000 kPa
Depth cover	a minimum of one metre

6.2.4 Leewood to Wilga Park infrastructure corridor

A new underground transmission line up to 132 kV would be constructed between Leewood and Wilga Park to reticulate power from the Wilga Park Power Station to Leewood and onto Bibblewindi to power the project infrastructure under the grid power option. The Leewood to Wilga Park infrastructure corridor is shown on Figure 6-4. Power would be supplied from the grid and / or the Wilga Park Power Station. The existing corridor width would be sufficient for installation of the underground transmission line.

6.3 Gas field infrastructure and activities

Planning and development of a natural gas project requires a degree of flexibility given the iterative nature of the project whereby exploration activities inform future development. For this reason, exploration and appraisal activities continue to be part of the project. Up to 850 new wells on up to 425 new well pads would be established across the defined project area to extract the gas. The location of each well depends on the location of the gas reserves; however, the wells and supporting infrastructure would be sited in accordance with landholder consultation and the Field Development Protocol. The actual area of surface disturbance relative to the project area is relatively small, being up to 1,000 hectares, which is around one percent.

The ongoing development of the gas field and selection of well locations will be guided by the information gained through the ongoing exploration and appraisal activities as gas reserves continue to be proven and developed.

The planning and development process is explained in more detail below.

6.3.1 Gas field planning

The field development is planned from information obtained during exploration and appraisal activities. Figure 6-14 shows indicative phases of development of the field based on the current understanding of the resource, and the location of existing infrastructure.



Figure 6-14 Indicative Narrabri Gas Project phased development

Phase 1 development

Production wells would be initially drilled and operated in the phase one area of the project, predominantly located in State forest. Phase one of the project would also see construction of the water and gas collection and processing infrastructure at Leewood, Bibblewindi and the pipeline corridor between the two locations (refer to Figure 6-4) to support development of the field. Phase one would also include exploration and appraisal activities, and the drilling and operation of production wells and associated gas field infrastructure. Construction and operation of water and gas gathering systems, and other associated infrastructure including at Westport and the Leewood to Wilga Park infrastructure corridor to support gas field development would also be undertaken.

Early development of the field is likely to be predominantly located within the forested portion of the project area. It remains possible, however, that exploration and appraisal activities being undertaken outside of the indicative phase one area may highlight additional areas suitable for further development.

Subsequent phase

The subsequent project phase would include ongoing exploration and appraisal activities, and the drilling and operation of additional production wells and associated gas field infrastructure. Activities would be located across the entire project area in the subsequent project phase, including continuing operations in the phase one area, and would incrementally increase to full production of the field.

Field planning would continue to be informed and refined by exploration and appraisal activities that would occur across the project area over the life of the project.

6.3.2 How gas field infrastructure is sited

As outlined above, developing natural gas from coal seams requires a flexible framework that considers the iterative development of the field. The location and siting of well pads and other infrastructure such as access roads, gas and water gathering lines, water balance tanks and telecommunication towers, would be undertaken in accordance with a Field Development Protocol. The Field Development Protocol has been developed using the findings of the environmental impact assessment to outline the key constraints and requirements to be considered during the siting of infrastructure, ensuring that the project to be constructed is consistent with the project that has been assessed in this EIS.

This approach has been adopted successfully for gas field projects across Australia and overseas. The Field Development Protocol includes the following constraints that would guide the siting of gas field infrastructure for the project:

- no project infrastructure within 200 metres of an occupied residence, unless otherwise agreed with the landholder
- no surface infrastructure within the Brigalow State Conservation Area and/or a 50 metre surface exclusion zone around the Brigalow State Conservation Area
- no surface infrastructure within 200 metres of Yarrie Lake
- production well pads would be spaced at least 750 metres apart.
- maximum ecological disturbance limits by vegetation community and for individual threatened flora
- surface development exclusion areas for the 90 known Aboriginal cultural heritage sites
- surface development exclusion areas for identified historic heritage sites
- major facilities, non-linear gas field infrastructure and large ponds and dams are excluded from watercourses and a watercourse buffer zone, with widths determined by Strahler stream order
- large ponds and dams will be located outside of the one percent annual exceedance probability flood extent
- compliance with noise criteria at occupied residences, unless otherwise agreed with the landholder
- The Brigalow Nature Reserve is excluded from the project area.

The Field Development Protocol provides a framework that ensures the development of the project, particularly the siting of gas field infrastructure, minimises impacts on the environment and takes place in accordance with:

- relevant State and Commonwealth legislation
- environmental impacts identified in the impact assessment reports that accompany this EIS
- environmental management plans or procedures
- conditions of approval.

The Field Development Protocol would apply for the life of the project, including each phase of field infrastructure development planning and design, construction, operation, and decommissioning and rehabilitation.

Developing the project through the implementation of the Field Development Protocol provides the necessary flexibility for locating field infrastructure, whilst ensuring environmental performance objectives are met throughout the life of the project.

In practice, the Field Development Protocol, along with other environmental requirements imposed through conditions of consent, would inform the micro-siting of well pads and field infrastructure. The process would also occur in consultation with relevant landholders and would be subject to landholder agreement. Well micro-siting, in accordance with the procedure set out in the Field Development Protocol, would be undertaken during detailed site surveys to further minimise the impact of the activity. Micro-siting refers to the practice of precisely locating a piece of field infrastructure to maximise avoidance of the most sensitive features and minimise impacts.

A Plan of Operations showing detailed locations for the proposed field infrastructure would be prepared on a regular basis and submitted to the NSW Department of Planning and Environment (refer Figure 6-15). This is discussed further in Chapter 30—Environmental Management and Monitoring.

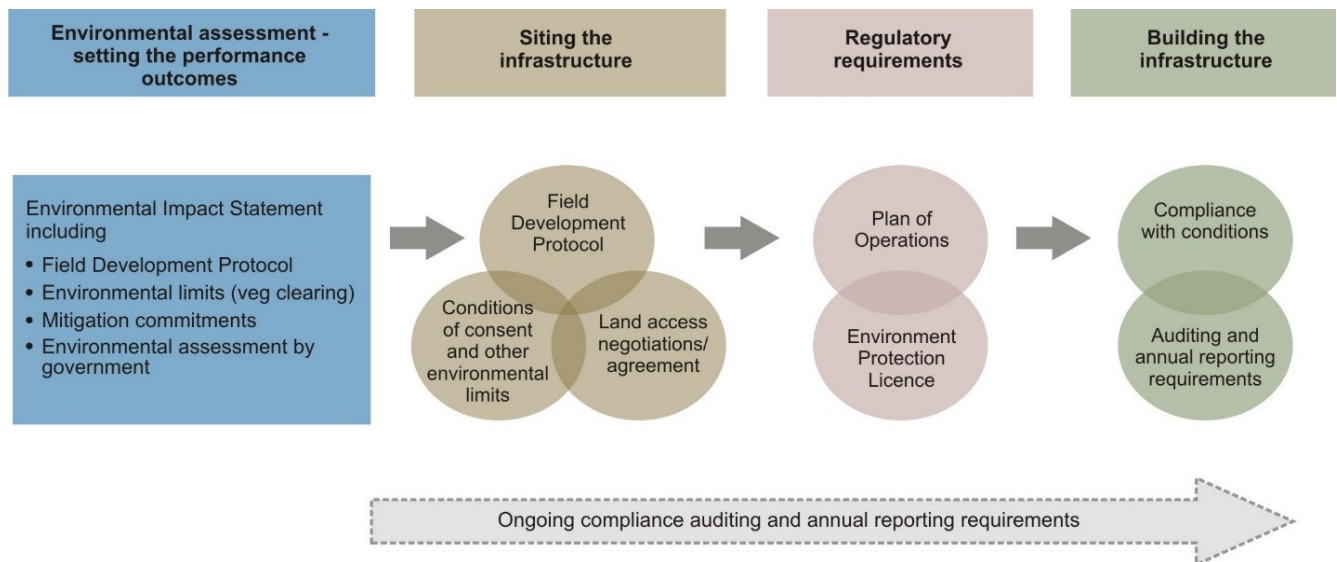


Figure 6-15 Process for locating project infrastructure

In summary, field planning and development would be an iterative process that would evolve over time. This EIS proposes an environmental management framework that is based on environmental and social impact assessment. The framework provides sufficient flexibility, as necessitated by the practical realities of how a field develops, while providing certainty around environmental performance.

An indicative sketch plan showing the conceptual layout of the project is provided in Figure 6-16.

The inclusion of this sketch plan is a government assessment requirement for the EIS. Gas wells will only be drilled on a landholder's property where there is a landholder agreement in place. It must be noted that the location of all proposed field infrastructure is conceptual only and does not represent the final location of field infrastructure under the project. The actual location of field infrastructure would be determined as the project is developed.

The conceptual layout shows an example of how the project's infrastructure may be located across the project area in accordance with the constraints contained within the Field Development Protocol. All well pads are shown as one hectare in size (being the maximum size of the construction footprint), are at least 750 metres apart and avoid stream buffer exclusions. Known surface development exclusions are also applied including the 200 metre buffer around occupied residences. All known Aboriginal cultural heritage sites have been avoided as have sites of historic heritage significance.

The conceptual layout demonstrates the project can be delivered within the project's environmental and social constraints, including the vegetation community disturbance limits. As described above, the exact location of field infrastructure would be determined as the project is developed, new wells are drilled, and understanding of the gas resource increases.

NARRABRI GAS PROJECT – CONCEPTUAL LAYOUT
INDICATIVE SKETCH PLAN

- Notes:
- The inclusion of this sketch plan is a government assessment requirement for the EIS;
 - The sketch plan provides an indicative conceptual layout for project infrastructure on the State Forest estate only;
 - In accordance with the Agreed Principles of Land Access, no drilling activities would be undertaken on private land without the voluntary consent of the landholder;
 - The layout of project infrastructure on private land would be negotiated with the landholder as part of the voluntary access agreement;
 - Aboriginal heritage sites have been removed from EIS maps at the request of Registered Aboriginal Parties.

Vegetation Type - PCT

- 141\Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South
- 202\Fuzzy Box Woodland on alluvial brown loam soils mainly in the NSW South-western Slopes Bioregion
- 256\Green Mallee tall mallee woodland rises in the Pilliga - Goonoo regions, southern BBS Bioregion
- 27\Weeping Myall open woodland of the Darling Riverine Plains and Brigalow Belt South Bioregions
- 35\Brigalow - Belah open forest / woodland on alluvial often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion
- 379\Inland Scribbly Gum - White Bloodwood - Red Stringybark - Black Cypress Pine shrubby sandstone woodland mainly of the Warrumbungle NP - Pilliga region in the BBS Bioregion
- 397\Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga - Warialda region, BBS Bioregion
- 398\Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north BBS Bioregion
- 399\Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, BBS Bioregion
- 401\Rough-barked Apple - red gum - cypress pine woodland on sandy flats, mainly in the Pilliga Scrub region
- 402\Mugga Ironbark - White Cypress Pine - gum tall woodland on flats in the Pilliga forests and surrounding regions, BBS Bioregion
- 404\Red Ironbark - White Bloodwood +/- Burrows Wattle heathy woodland on sandy soil in the Pilliga forests
- 405\White Bloodwood - Red Ironbark - cypress pine shrubby sandstone woodland of the Pilliga Scrub and surrounding regions
- 406\White Bloodwood - Motherumbah - Red Ironbark shrubby sandstone hill woodland/open forest mainly in east Pilliga forests
- 408\Dirty Gum (Baradine Gum) - Black Cypress Pine - White Bloodwood shrubby woodland of the Pilliga forests and surrounding region
- 40X\White Bloodwood - Dirty Gum - Rough Barked Apple heathy open woodland on deep sand in the Pilliga forests
- 418\White Cypress Pine - Silver-leaved Ironbark - Wilga shrub grass woodland of the Narrabri-Yetman region, BBS Bioregion
- 425\Spur-wing Wattle heath on sandstone substrates in the Goonoo - Pilliga forests, Brigalow Belt South Bioregion
- 428\Carbeen - White Cypress Pine - Curracabah - White Box tall woodland on sand in the Narrabri - Warialda region of the Brigalow Belt South Bioregion
- 55\Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions
- 78\River Red Gum riparian tall woodland / open forest wetland in the Nandewar and Brigalow Belt South Bioregions
- 88\Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion
- Derived Native Grassland

LEGEND

Study

Riparian Corridors

Roads

Tracks

Biblewindi Site

Leewood Site

Westport Site

Pilliga East SCA

Historic Heritage Sites

Occupied Residences

Gathering System

Existing

Proposed

Well Pads

Existing

Proposed

6.3.3 Well pad numbers, sizing and partial rehabilitation

To commercially extract the gas within the project area, up to 850 new wells on a maximum of 425 new well pads would be developed. The 850 new wells would include new exploration, appraisal and production wells, though exclude existing or approved exploration and appraisal wells (refer to Table 2-1). The wells would be progressively commissioned and decommissioned within the project area. Exploration and appraisal wells may be converted to production wells depending on their gas yields.

In addition, the following previously approved or existing field infrastructure under the proponent's exploration and appraisal program may be utilised (including up to 70 chip and core holes, and pilot wells—refer to Table 2-1):

- previously constructed chip or core holes
- previously approved though not yet constructed chip or core holes
- previously constructed pilot wells
- previously approved though not yet constructed pilot wells.

To convert pilot wells to production, the wells would be connected to the gas and water gathering network. Pumps and other surface infrastructure may be upgraded, but changes would be minimal. This EIS assesses activities for the conversion of pilot wells to production wells. Refer to Figure 2-3 and Table 2-1 for the location and description of existing infrastructure respectively.

Wells would be constructed on well pads of approximately one hectare in size, which would be partially rehabilitated once production had commenced. During partial rehabilitation, approximately three quarters of the well pad would be rehabilitated using a proportion of the original topsoil and seedbank from the site. The remaining area of approximately one quarter of a hectare, being around one quarter of the construction area, would remain cleared to allow for the operation of the well head infrastructure, associated production equipment, and day to day vehicle access. The remaining cleared area would remain fenced in accordance with legislative requirements.

Well pads that host other supporting infrastructure such as telecommunication towers would not be partially rehabilitated and would remain approximately one hectare in size.

Periodic maintenance equipment including workover rigs may be required from time to time. They would utilise the remaining cleared area of the well pad plus approximately 0.2 hectares for equipment lay down and to meet safety requirements.

6.3.4 Exploration and gas field infrastructure

Significant exploration and appraisal activities have already been undertaken in the project area under existing planning approvals. To assist in informing the ongoing development of the field, the project would include new exploration and appraisal activities across the project area as the field develops.

Exploration activities are a critical input informing how a field develops over its life. Exploration typically begins with seismic or other geophysical surveys to determine the geological setting of the area. This is undertaken to compile detailed reservoir data to help better understand gas content, gas composition, and gas and water flow rates. Geophysical survey is usually followed by drilling core or chip holes to improve the understanding of the characteristics of the coal; including coal thickness, and its gas content and quality. Appraisal pilot wells may also be required to determine the production potential of the coal seams. The data obtained during exploration and appraisal is then assessed to identify if the area is suitable for development and production.

Seismic surveys

Seismic surveys identify suitable geological formations through the generation and receipt of sound waves. Typically specialised vehicles would traverse a seismic line and vibrate a heavy plate to generate a seismic signal, while other vehicles record the data for later interpretation (refer Figure 6-17).



Figure 6-17 A typical seismic vehicle

The seismic vehicles are supported by other specialists including surveyors and line crews—the latter managing cable deployment and retrieval. Approximately 500 kilometres of seismic surveys are proposed; the majority would be undertaken on existing cleared areas including roads and pre-disturbed areas.

Core and chip holes

Core and chip holes are drilled to determine the geology of a site and help assess gas content through geological interpretation and gas sampling and analysis. Core and chip holes are vertical wells that are drilled using similar equipment to pilot and production wells, and may be typically drilled to depths of between approximately 500 and 1,200 metres.

A geological sample—which is generally around two to 15 centimetres in diameter and 50 to 100 metres in composite length—is collected from a core hole. An example of a core sample is provided as Figure 6-18.



Figure 6-18 A core sample

Rock samples collected from chip holes are much smaller and are generally fragmented. Samples from core and chip holes are collected to assess the geology.

Once the geological sample is taken, the core or chip hole may be completed by:

- sealing with cement from bottom to top, with a name plate attached and the surface rehabilitated in accordance with the *NSW Code of Practice for Coal Seam Gas Well Integrity* (DTIRIS 2012)
- conversion into a monitoring bore in accordance with relevant requirements
- conversion into an appraisal or production well.

Pilot wells

Pilot wells (also known as appraisal wells) are constructed to evaluate the quality and quantity of gas at a given location. A pilot well is essentially a small scale production well with associated water and gas management facilities. They operate during appraisal to allow for sufficient data collection. The pilot wells would be spaced at least 250 metres apart, typically (although not always) in sets of up to six wells (known as a pilot well set). It is anticipated that up to 25 new well pads would accommodate pilot wells. A number of the new and existing pilot wells may be operated at a given time.

To enable gas quality, and gas and water flow rates to be measured, the coal seams must first be depressurised; therefore, water management equipment must also be installed. Water and gas from the pilot wells would be managed as follows:

- each well in the pilot set can be directly connected to the production well gas and water gathering system. New gas and water gathering systems may be installed for this purpose, with the water being reticulated to Leewood for treatment
- there may be a water tank of approximately 40 kilolitres that pilot wells in the set connect to. The water tank may connect directly connected to the production well gas and water gathering system
- the gas may be flared on one of the pilot well pads. The flare combusts methane and burns with a low intensity, and is designed to manage fluctuations in gas volume and composition. Table 6-5 describes the typical design features of a pilot well flare. If the gas is initially flared, the pilot can later be connected to the gas gathering system for the project if the proponent chooses to
- The proponent can cease the pilot at a time of its choice, and the pilot wells can then be a part of the production system for as long as the wells remain economically viable.

A typical pilot well flare with safety and vegetation free zones is shown in Figure 6-19, while a typical 40 kilolitre water balance tank with bunding is shown in Figure 6-20. The safety and vegetation free zones surrounding the flare are to provide safety and to mitigate bushfire risk respectively.

Table 6-5 Pilot well flare design features

Design feature	Proposed flare
Average flame height	up to 4 metres from the top of stack
Design flow rate	up to 6 million standard cubic feet per day
Average flow rate	3 to 5 standard cubic feet per day
Stack height	up to 6 m
Vegetation free zone (from base of stack) ^a	up to 40 m radius
Safety zone (from base of stack) ^a	up to 15 m radius

^a Safety and vegetation free zones would be sized using API 521 – Pressure-relieving and Depressuring Systems to calculate acceptable radiation limits depending on flare location.

The design and construction of a pilot well is similar to a production well. Where successful, pilot wells would be converted into production wells. This would involve connecting the wells to the gas and water gathering network, and removing the flare and water balance tank.



Figure 6-19 Typical pilot well flare showing the safety and vegetation free zones



Figure 6-20 Typical 40 kilolitre water balance tank with bunding used for pilot wells

Production wells

Production wells would be installed to the target seam depth. The depth and thickness of the seams vary across the project area. Generally, the target seams are located between 500 and 1200 metres below ground level in the project area; however, in some areas, the Hoskissons seam rises to around 300 metres below ground level. Production wells would be installed to the target seam depth.

Production well pads would be spaced at least 750 metres apart, depending on surface geography, coal physical and chemical properties, environmental constraints, land access arrangements and subsurface characteristics. Each well pad would accommodate up to three well heads, diagrams of which are shown in Figure 6-21 and Figure 6-22.

A production well may be vertical (Figure 6-23), deviated (Figure 6-24) or lateral. The lateral may include numerous connections in which case it is called a multi-lateral well (refer Figure 6-25). The lateral well may or may not include a vertical intercept well. A range of well scenarios is shown schematically in Figure 6-26.

Typical surface infrastructure at a gas well includes the well head, a gas and water separator, metering skids, a diesel or gas generator, and a remote sensor telemetry unit (Figure 6-27). The telemetry unit provides real time information on well operations via a supervisory control and data acquisition (SCADA) system that also has the ability to remotely shut in wells. Access to the well pads would be via existing roads and access tracks wherever practicable. Where this is not practicable, new access tracks would be constructed in accordance with the Field Development Protocol.

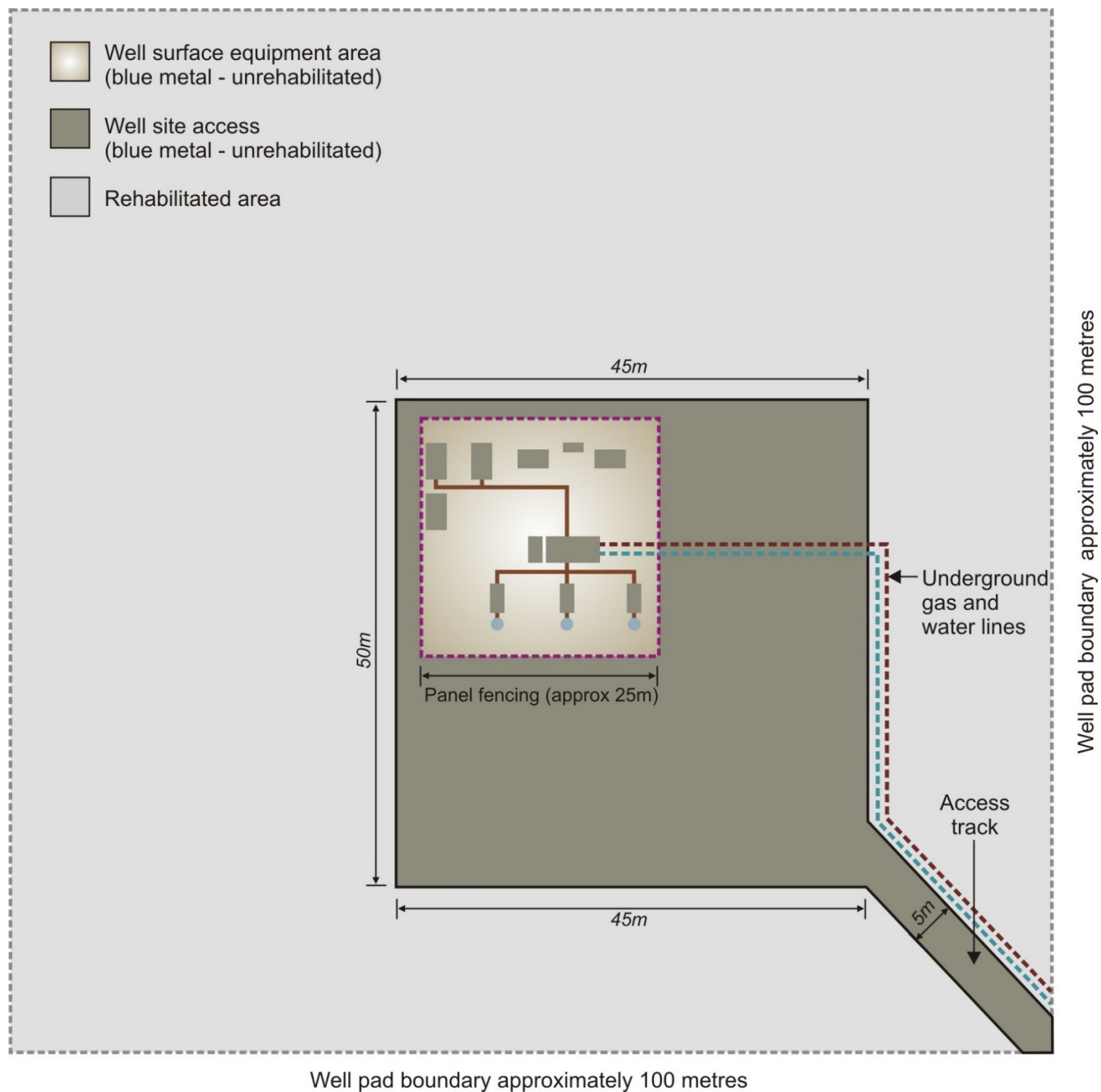


Figure 6-21 Diagram of a typical three-well pad layout

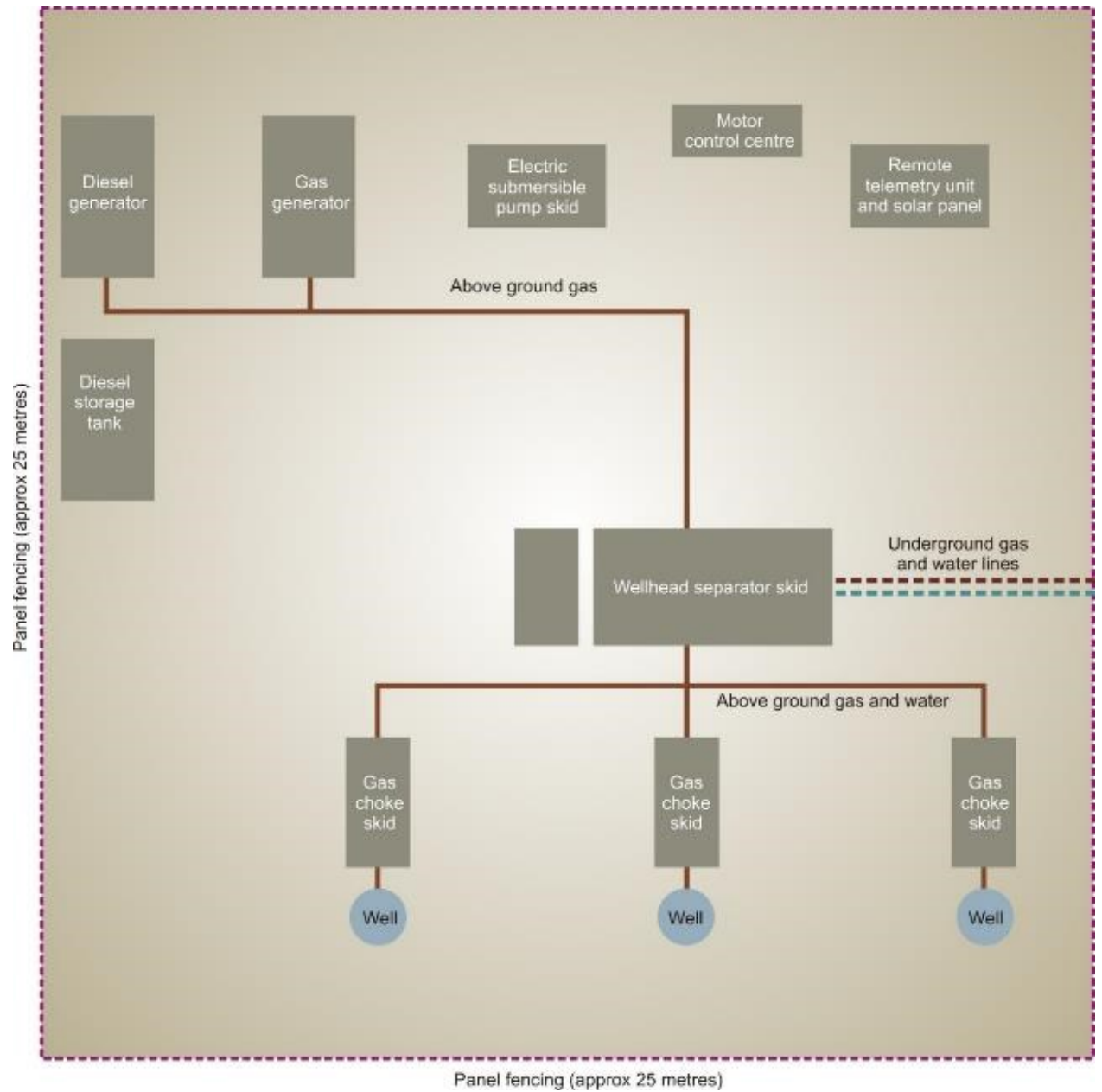


Figure 6-22 Closeup of a typical three-well pad layout (inset from Figure 6-21)

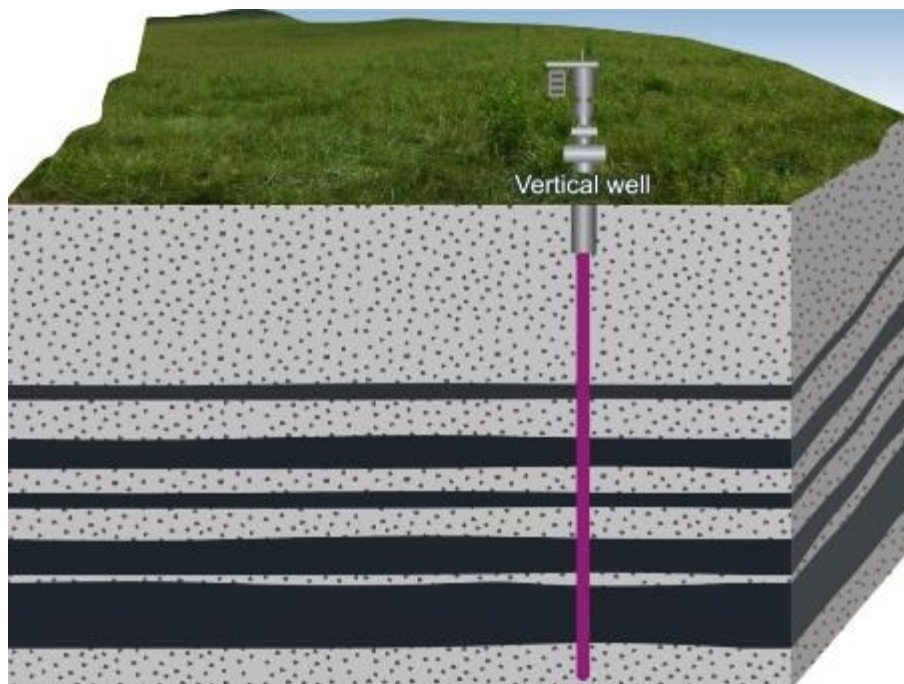


Figure 6-23 Example of a vertical well

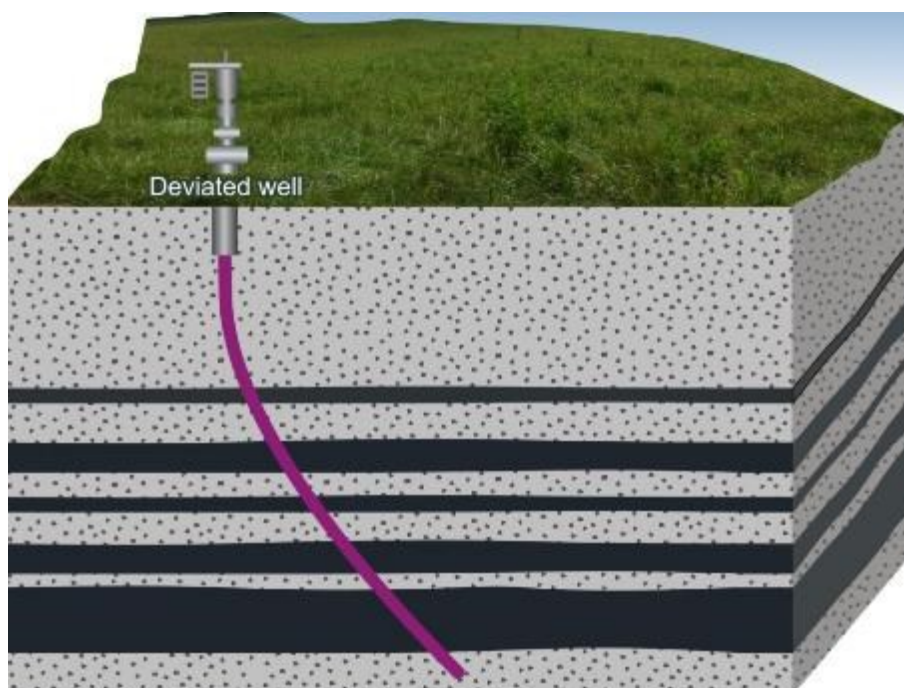


Figure 6-24 Example of a deviated well

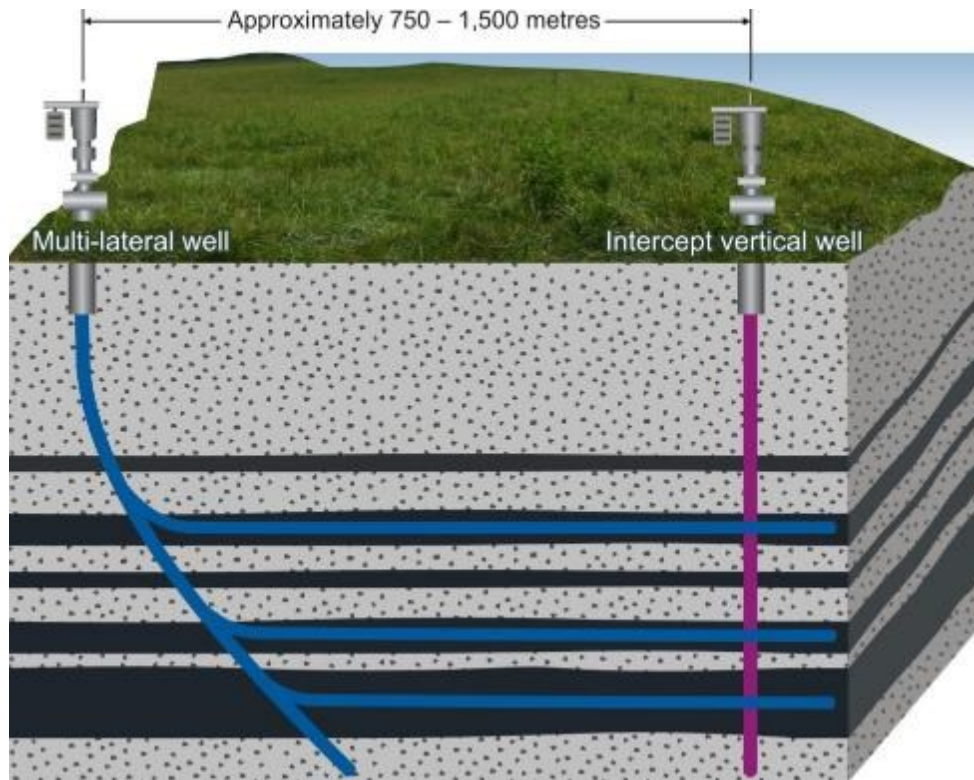


Figure 6-25 Example of a typical production well set consisting of a multi-lateral well and vertical intercept well.

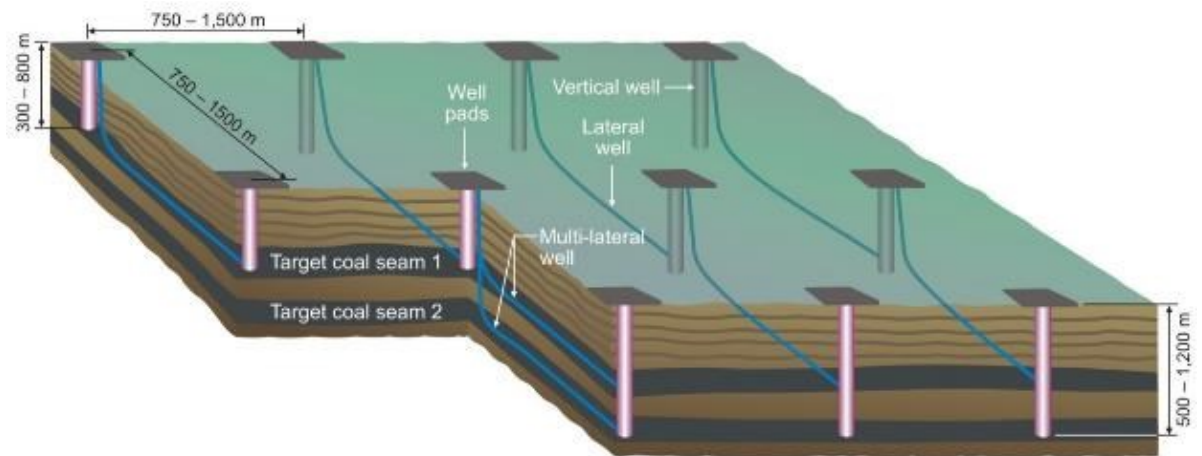


Figure 6-26 Diagram of possible production well configurations



Figure 6-27 Typical well pad configuration

Access tracks

To minimise disturbance, access to well pads would be via existing roads and access tracks where practicable. Where this is not the case, new tracks would be constructed. New access tracks would generally be co-located in the same corridor as required gas and water gathering lines. The corridor would be on average 10 metres wide, up to a maximum of 12 metres.

The corridor would be reduced to a five metre access track for the operational phase following partial rehabilitation (refer to Figure 6-28), slightly wider on intersections and bends as required. The rehabilitated area would be over the gathering lines so deep-rooting vegetation including over storey tree species would need to be removed in order to prevent damage to the pipes.



Figure 6-28 Co located gathering lines and access track with new rehabilitation

The access tracks would also contain vehicle passing bays as required. The frequency and dimensions of the passing bays would be determined on a site by site basis. Passing bays are needed to ensure safe passage of vehicles.

Gas and water gathering lines

The gas and water gathering lines would form an underground system across the project area. Minor gas and water gathering lines from individual wells would connect into larger gas and water gathering lines that link into field water balance tanks and facilities at Bibblewindi or Leewood. The underground gas and water gathering lines, also known as flow lines, would consist of a network of low pressure underground high density polyethylene pipes. Refer to Section 6.5.2 for gas and water gathering line disturbance areas.

Produced water captured at the well head for wells in the southern part of the project area would be transferred via Bibblewindi to the produced water storage at Leewood. Therefore, water balancing and temporary storage at the Bibblewindi facility is required as described in Section 6.2.2. Gas and water gathering lines would be co-located with access tracks as far as is reasonably practicable.

All gas and water gathering lines would be designed to the relevant Australian Standard including the Australian Pipeline Industry Association Ltd (APIA) *Code of Practice for Upstream Polyethylene Gathering Networks in the CSG Industry*. Low-point drains and high-point vents would be installed along the gathering lines, with the number and specific location of these determined through detailed design.

Typical design parameters for the gas and water gathering lines, and flow lines, are provided in Table 6-6.

Table 6-6 Gas and water gathering lines - indicative design parameters

Parameter ^a	Water	Gas
Pipe diameter -gathering line - flow line	up to 315 mm up to 450 mm	up to 700 mm up to 900 mm
Material	High density polyethylene (PE100)	High density polyethylene (PE100)
Static pressure rating	To AS4130	To AS4130
Depth of cover	Minimum 750 mm	Minimum 750 mm

^a Indicative parameters only based on preliminary engineering design.

Water balance tanks

The purpose of water balance tanks is to manage high and low flows of produced water across the project area.

There may be up to five water balance tanks, each with a five megalitre capacity, located around the project area. These would facilitate the effective transfer of produced water from the field directly to Leewood, or to Leewood via Bibblewindi, for treatment. These balance tanks would be located on pads of approximately one hectare that would be sited using the Field Development Protocol.

Each water balance tank would typically be made from galvanised steel with either an internal polypropylene or polyethylene bladder. The water balance tanks would be located within earthen bunds that would be lined with high density polyethylene. The tanks would include instrumentation to monitor water levels for appropriate management.

Telecommunication towers

Telemetry services would be provided to facilitate the operation and monitoring of field production and infrastructure. Strategically located radio towers would be used for both data telemetry and voice radio services. These services would be connected to the data networks at operations or administration facilities. One tower would be located at Leewood and one at Bibblewindi, with the balance across the project area as noted below. They would be located on well pads of approximately one hectare that would contain a gas well or wells, and would be located using the Field Development Protocol.

It is anticipated that across the project area there would be:

- up to ten 60 m high towers; or
- up to twenty 30 m high towers; or
- a combination of both.

Power would be supplied to the communications tower base through a generator located at the site.

Indicative designs for the towers are shown in Figure 6-29. The towers would be progressively constructed to meet communication requirements as the project develops over time.

Telecommunications services would include voice and data network services, in addition to telemetry. Existing carrier services would be used where available. Generally, towers would be constructed where existing services are insufficient. It is therefore possible that in some locations, communications facilities may include:

- installation of telecommunication towers to extend existing carrier services to the project area
- a fibre optic network extended from existing facilities and installed parallel with the water and gas gathering systems
- microwave links used to extend the network where use of fibre optic cable is deemed not suitable
- communications equipment accommodated in operational or administration buildings
- satellite communications used in remote locations without carrier services
- a VHF radio network for legacy telemetry installations.

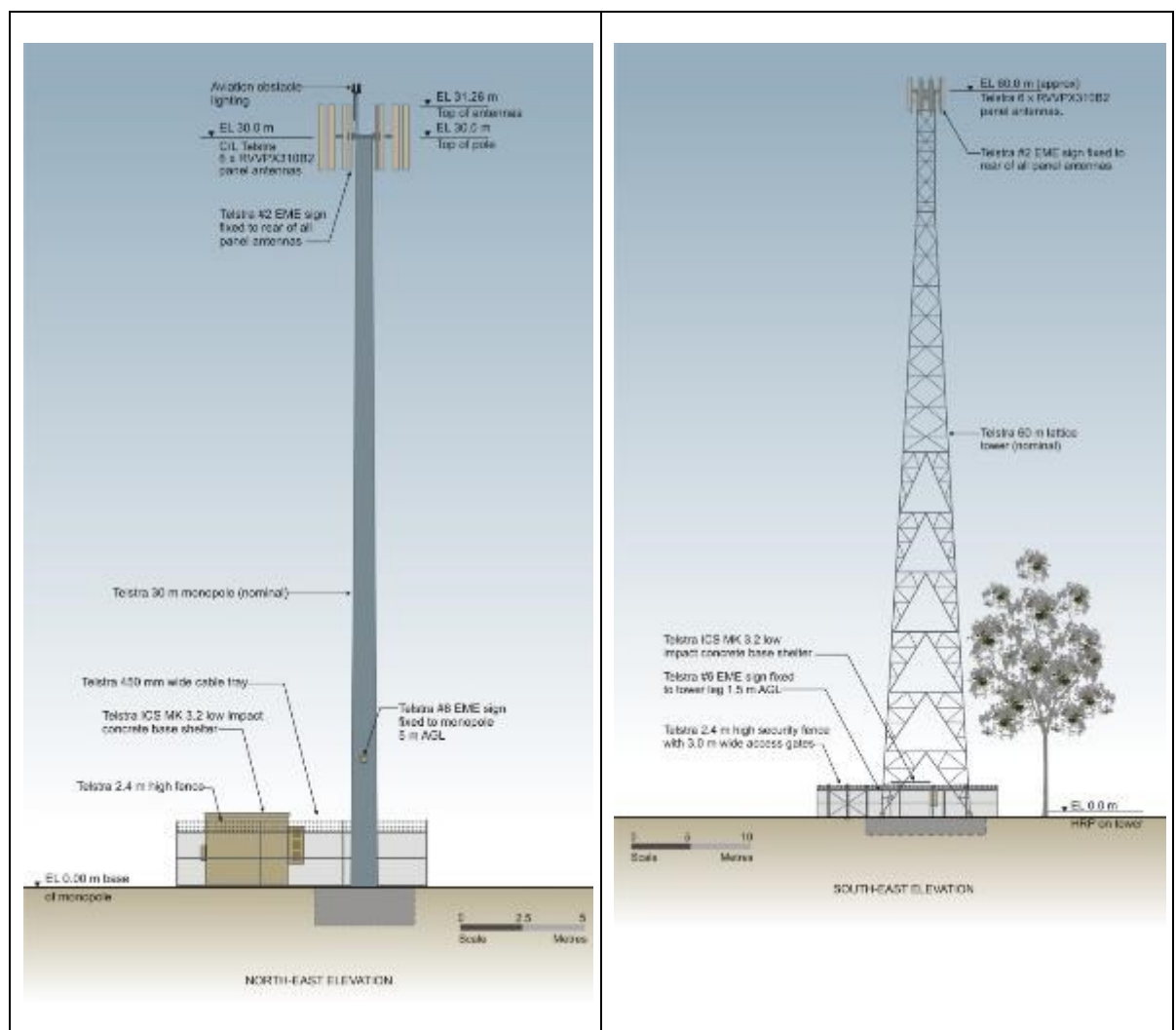


Figure 6-29 Indicative diagrams of radio towers

6.4 Ancillary infrastructure

6.4.1 Road and Intersection upgrades

Subject to obtaining the required regulatory approvals and a final investment decision regarding the gas production project, the proponent proposes to undertake an upgrade to the intersections of Old Mill Road and X-Line Road with the Newell Highway. The timing of the works would be guided by the requirements of the Austroads Guide to Traffic Management – Part 6 Interchanges and Intersections (Austroads 2014) based on predicted traffic levels during the peak construction period.

The Old Mill Road intersection upgrade would involve construction of a channelised right turn treatment on the Newell Highway. The X-Line Road intersection upgrade would involve construction of an auxiliary left turn treatment on the Newell Highway. Diagrams of the indicative upgrades are shown in Figure 6-30 and Figure 6-31 respectively.

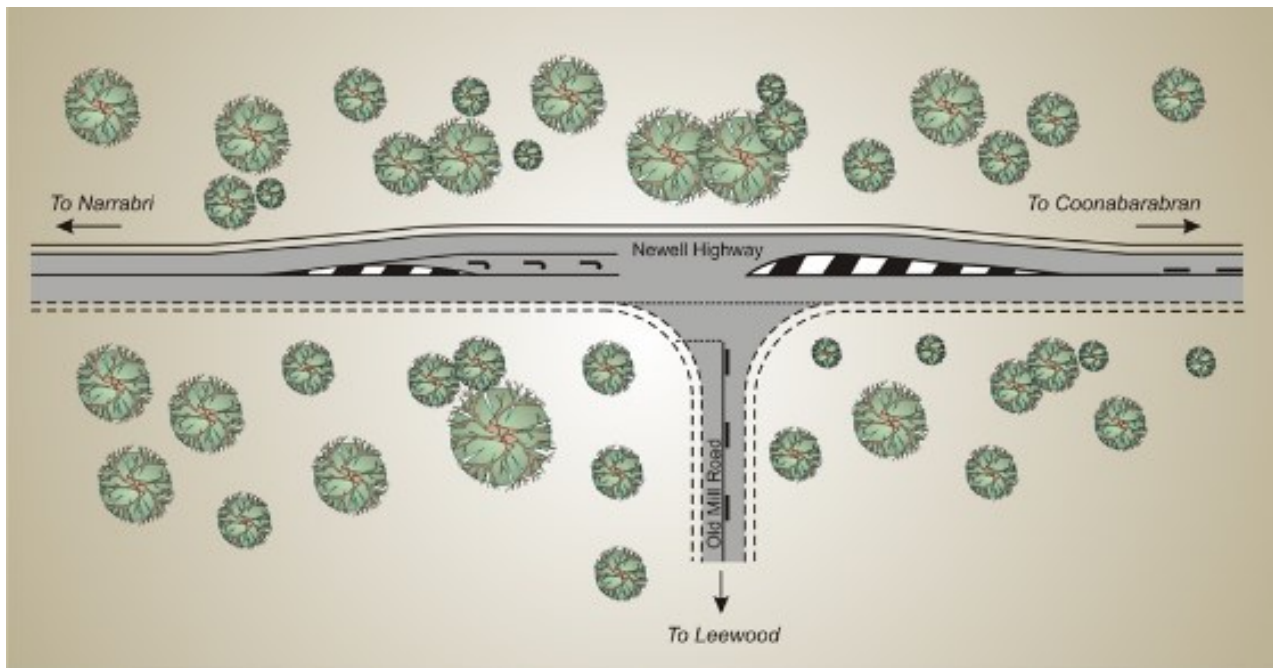


Figure 6-30 Diagram of the proposed upgrade of Newell Highway / Old Mill Road intersection

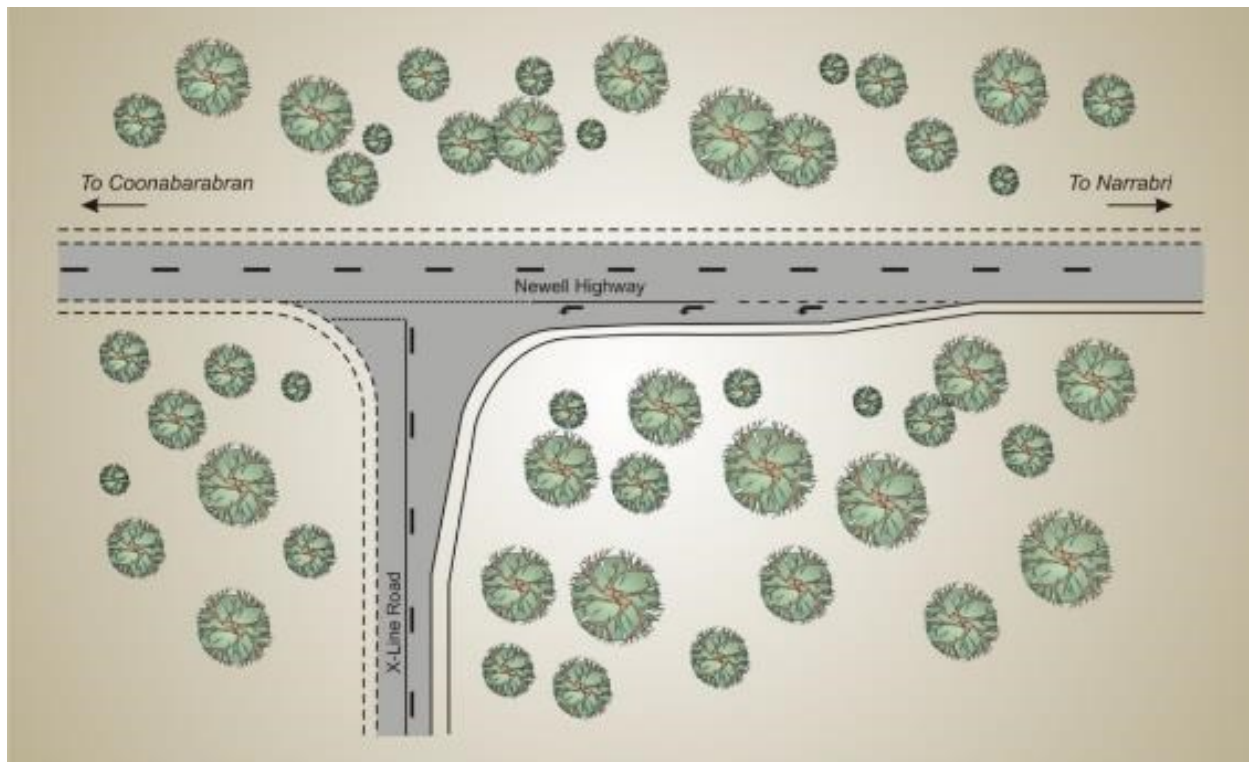


Figure 6-31 Diagram of the proposed upgrade of Newell Highway / X-Line Road intersection

6.4.2 Workers' accommodation

There is existing approval for accommodation of 64 workers at the Westport workers' accommodation (or simply, Westport) located in the southern part of the project area (refer Figure 6-4). Under the project, the capacity at Westport would be expanded to provide accommodation for up to 200 people so work crews could be housed.

Westport would include fully secure, fenced areas and consist of:

- demountable buildings providing shared sleeping quarters (refer to Figure 6-32). Buildings would be mounted on skids and raised plank walkways may be installed between buildings to improve access
- kitchen and dining room facilities and a recreation room
- other utility rooms for storage, cooling and laundry facilities
- a series of tanks for water and diesel storage.

The indicative layout and location of the expanded workers' accommodation is shown in Figure 6-33. An expansion would be consistent with requirements under the *Rural Fires Act 1997*.

In addition to Westport, crews would be accommodated in privately operated workers' accommodation or other facilities in the greater Narrabri region.

Worker numbers accommodated at Westport would expand and contract based on the drilling schedule, number of rigs, and construction schedule (as shown in Figure 6-3); with the site dismantled and rehabilitated upon completion of the drilling program.



Figure 6-32 Demountable buildings in typical workers' camp

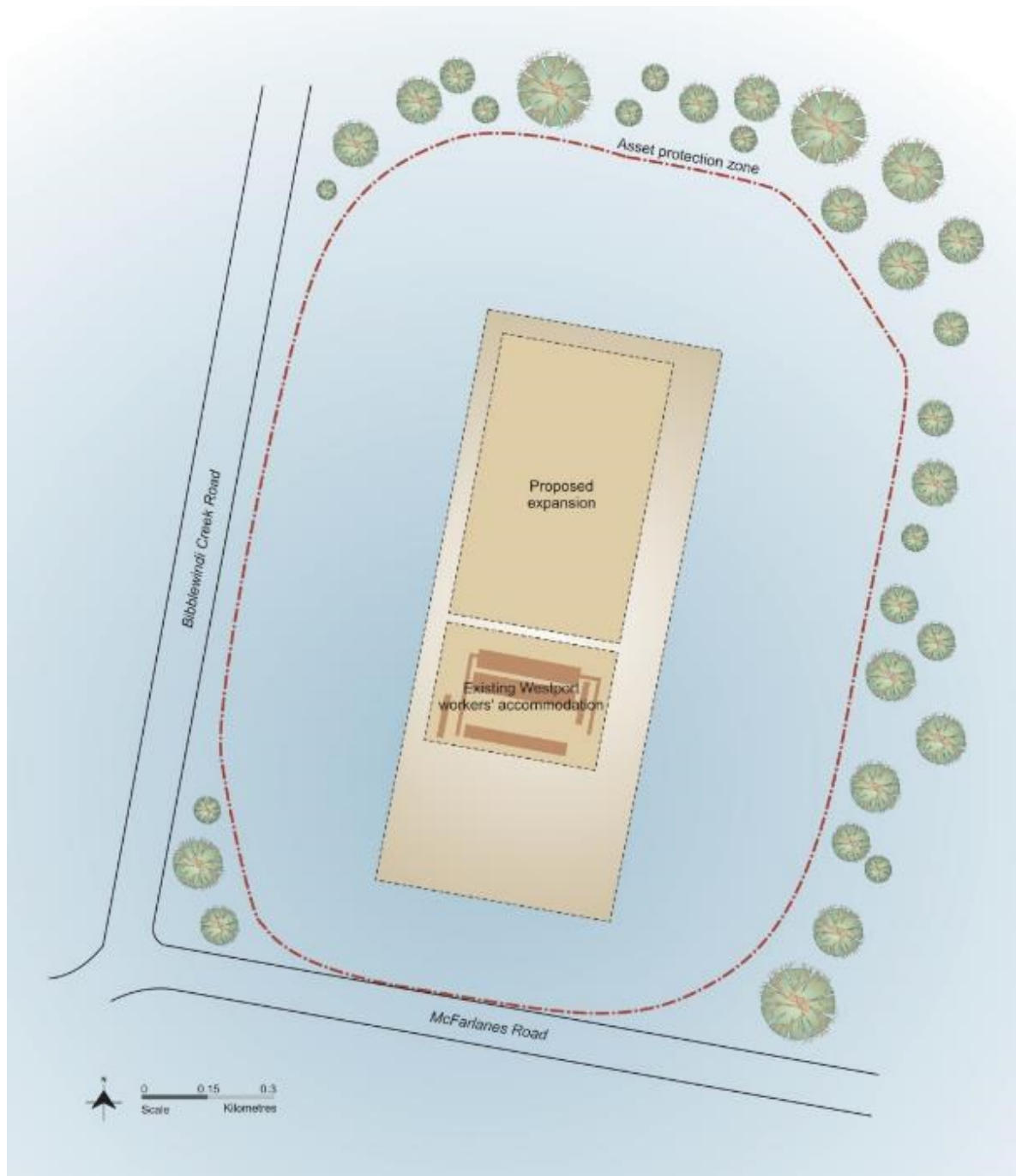


Figure 6-33 Diagram of the current and proposed Westport workers' accommodation facility

6.4.3 Treated water managed release pipeline and diffuser

A treated water managed release pipeline would extend from Leewood to the Bohena Creek managed release point. The managed release point would be located within the managed release area as shown in Figure 6-34. The exact location of the Bohena Creek treated water managed release pipeline and managed release point would be determined during detailed design.

Similar to the water and gas gathering lines, the final location of the managed release pipeline would be subject to the application of the Field Development Protocol, and land access approvals.



Figure 6-34 Approximate location of the treated water managed release area

Treated water would be released to Bohena Creek under appropriate natural flow conditions as measured by flows equal to, or greater than, 100 megalitres per day at the Newell Highway gauging station. The managed release is discussed further in Chapter 7.

The managed release point for treated water would have a diffuser, scour protection and engineered energy dissipation to minimise erosion. Preliminary design of the managed release diffuser has been undertaken for the purposes of undertaking the environmental assessment. The preliminary design of the diffuser comprises two parallel pipes sitting atop rock armour around 45 metres long with numerous release ports oriented with the flow.

6.4.4 Irrigation infrastructure

A treated water transfer pipeline (or pipelines) would be required from Leewood to the irrigation area or areas. The location of the pipeline (or pipelines) would be determined following agreement with water users, in addition to the location of the treated water storages. Similar to the water and gas gathering lines, the final location of the pipeline (or pipelines) would be subject to the application of the Field Development Protocol, and land access approvals.

Treated water storage capacity of up to 200 megalitres would be required across the irrigation area (or areas). New treated water storage dams would be located using the Field Development Protocol, with existing farm dams also considered for treated water storage.

6.5 Construction activities

6.5.1 Major facilities

Leewood

Site preparation

Site preparation would be undertaken at Leewood prior to the establishment of major components. Site preparation activities would include:

- construction of access road and connection to Newell Highway (refer to Figure 6-30)
- sheeting of laydown areas for all-weather useability
- construction of a temporary water pond for construction activities
- establishment of site drainage.

Central gas processing facility

The central gas processing facility would be constructed predominantly from prefabricated units transported to site. The intent is to progressively construct the facility with two processing trains constructed initially and then a further two trains at approximately six-month intervals.

Construction would involve:

- clearing and levelling of the site, and excavation as required

- construction of concrete foundations
- installation of prefabricated skids on concrete foundations
- mechanical and electrical connection of individual skids
- coating and painting activities
- testing and commissioning of the equipment.

The flare located at the central gas processing facility would be constructed in a similar manner as the pilot well flares. It would, however, have a larger vegetation-free zone consistent with that of the Bibblewindi flare as described in Table 6-3. The vegetation-free zone would be constructed using gravel, rather than a geofabric liner as described for the pilot well flare.

It is estimated that the delivery of prefabricated units to Leewood to establish the central gas processing facility would require approximately 550 truck movements over the construction period.

Optional power generation facility

If the power generation facility at Leewood is built, it would be constructed near the central gas processing facility as shown in Figure 6-7. Construction would involve:

- delivery of generators and other major equipment parcels to site
- installation of generators and other major equipment packages on foundations
- installation of electrical cabling and instrumentation
- mechanical works such as installation of interconnecting piping and supporting structural steel
- coating and painting activities
- testing and commissioning of power generation.

It is estimated that the delivery of modular equipment and materials to build the power generation facility would require approximately 250 truck movements over a construction period of about one year.

Water management facilities

Installation of the water treatment plant equipment would involve:

- preparation of the site as required, including bulk earthworks, foundations, screw piles as required, and bund construction
- pouring of concrete pads
- delivery and positioning of equipment
- installation of structural steel and piping
- installation of electrical cabling and instrumentation
- commissioning of equipment.

The water treatment plant would be modular, and after initial approval under this EIS, would allow for further modules to be added or removed throughout the project life, commensurate with the volume of produced water to be treated. The existing produced water and brine ponds would also be supplemented by the construction of a new produced water / brine pond with associated bulk civil earthworks, lining and

commissioning. The new pond would be located south of the current ponds at Leewood, and would be constructed to a similar standard. The pond would be double-lined with a leak detection system installed.

It is estimated that the delivery of modular equipment and materials to build the water management facility would require approximately 800 truck movements over a construction period of around 18 months. Component parts would mostly be trucked from Port Kembla, the Port of Newcastle, and / or the Port of Brisbane.

Other infrastructure

Leewood would have a telecommunication tower installed. Telecommunication towers are discussed in Section 6.5.2.

Bibblewindi

Site preparation

Site preparation would be undertaken at Bibblewindi prior to the establishment of major components. Site preparation activities would include:

- clearing, levelling of the site and excavation as required
- sheeting of laydown areas for all-weather useability
- establishment of site drainage.

In-field compression

The in-field compression facility would be constructed predominantly using prefabricated skids transported to site. Skids would likely be sourced from an international supplier and transported through Port Kembla, the Port of Newcastle, and / or the Port of Brisbane. Oversize vehicles would transfer the equipment to site, following assembly at a facility close to where the equipment was landed.

Construction at site would involve:

- clearing and levelling of the site, and excavation as required
- construction of concrete foundations, including screw piles as required
- installation of prefabricated skids on concrete foundations
- mechanical and electrical connection of individual skids
- coating and painting activities
- testing and commissioning of the equipment.

The flare located at the in-field compression facility would be constructed in the same manner as the Leewood flare.

It is estimated that the delivery of prefabricated units and materials required to build the in-field compression facility would require approximately 250 truck movements over a construction period of approximately two years.

Supporting infrastructure

Ancillary buildings, including upgrades to the staff amenities and storage and utilities area, would be constructed as prefabricated portable demountable units that would be placed onto hardstand areas.

Infrastructure corridors

The medium pressure gas and water pipelines between Leewood and Bibblewindi would be trenched or ploughed in respectively, and directionally drilled under the Newell Highway. The construction method would be consistent with the materials used as described in sections 6.2.3 and 6.2.4, and Figure 6-13. The process would broadly involve:

- surveying the proposed corridors
- slashing and mulching vegetation and stockpiling it within the construction corridors
- digging the trenches and stockpiling soil within the construction corridor (or directionally drilling under the Newell Highway)
- pipe delivery, stringing and bending, and pipe welding
- pre-commissioning the pipelines which involves flushing using water or a 'pigging' process—a 'pig' is a device that is inserted into the pipeline for cleaning and maintenance purposes
- commissioning which includes pressure testing of the pipeline
- laying cable
- returning excavated soil to the trench and compacting the soil for the water and gas pipelines, and communications cabling
- placing cement stabilised backfill into the trench surrounding the power cables
- rehabilitating the construction corridor.

Trenching would achieve a construction rate of approximately 200 to 500 horizontal metres per day; depending on the soil type. The plough-in construction method is able to achieve a construction rate of approximately 400 to 1,000 horizontal metres per day; depending on the soil type.

Cathodic protection would be installed and signposted along the pipeline as required depending on pipe type. The specifics would depend on the type of piping used as determined during detailed design.

Bespoke trailers would be used to mount the cable drums and allow the cable to be pulled into the trench directly from the back of the trailer. The cable trench would be back filled in a similar manner to the water and gas pipelines in the same corridor. The communications cabling would be installed in a similar manner to the power cabling.

6.5.2 Gas field

Seismic surveys

Seismic surveys would be carried out in a way that minimises potential environmental and social impacts, consistent with the requirements of Section 72 of the *Petroleum (Onshore) Act 1991*. In addition, and where practicable, seismic surveys would be undertaken along existing cleared corridors including roads and dry creek beds, to minimise the need for vegetation disturbance. In general, seismic surveys include the following activities:

- pegging and surveying the ground. This involves site inspection, survey of the seismic line, and pegging the ground at set intervals so that the survey line is followed when acquiring seismic data
- line preparation, including:
 - slashing long grass for technical, safety and visibility reasons
 - stick raking to remove logs and large sticks that could create a hazard or barrier
 - light grading to smooth over very rough or sloping surfaces where required
 - limited small tree and shrub trimming and clearing. Before this occurs, alternative options including practical rerouting would be considered to minimise clearing
- seismic data collection
- equipment removal, with rehabilitation undertaken as required.

Well pad preparation

Each well pad would cover approximately one hectare during drilling and construction, with an access track established between the well pad and the road.

Activities during establishment of well pads would include:

- surveying and marking out the well pad and access track boundaries including a pre-clearance survey for ecology
- clearing, mulching and stockpiling of vegetation as required
- clearing and stockpiling top soil. Where the lease area is relatively flat, industrial matting or polymers (acrylate copolymer or similar) may be used rather than removing topsoil. Where industrial matting is used, vegetation would be slashed and the remaining groundcover rolled. Where polymers are used, the polymers would be sprayed on topsoil stockpiles and the lease sites and access tracks to minimise topsoil erosion and / or to suppress dust. The polymers do this by increasing soil cohesion to prevent particle detachment and subsequent erosion. This results in cleaner water runoff during rainfall events
- levelling and compacting the well pad and access track as required
- transporting civil works equipment to site, including bulldozers, excavators, graders, rollers, a cementing unit, a conductor drilling unit, water trucks, and supporting light vehicles
- establishing portable amenities on site
- excavating and installing a typically rectangular steel and concrete cellar approximately two metres deep into which the well would be drilled and the well head would remain during the life of the well
- excavating and lining a drill cuttings pit
- installing erosion and sediment control management equipment
- installing and cementing the conductor casing in the cellar prior to the drilling rig arriving on site.

Materials required for establishing well pads would be sourced from borrow pits, existing quarries or other supplies available from local mining and industrial activities, in accordance with regulatory and licensing requirements.

Drilling

The *NSW Code of Practice for Coal Seam Gas – Well Integrity*, or simply, the Code of Practice, was released in September 2012 (DTIRIS 2012). The Code of Practice establishes a best practice framework for the design, construction and maintenance of gas wells, and has undergone peer review co-ordinated by the NSW Chief Scientist and Engineer. Drilling would comply with the Code of Practice. Application of the Code of Practice for the project would mean that wells must be designed to ensure the safe and environmentally sound production of gas by:

- preventing interconnection between hydrocarbon-bearing formations and aquifers
- ensuring that gas is contained within the well and associated pipework and equipment without leakage
- ensuring zonal isolation between different aquifers and water bearing zones is achieved
- not introducing substances that may cause environmental harm.

How gas wells are drilled

Equipment would be transported to the drill pad prior to drilling activities commencing. It would remain in place for the duration of drilling operations, estimated to be between 10 to 30 days, depending on the well type. The drill rig would move between drill pads, and would be followed by a smaller completion rig to install the remaining production equipment into the well. An example of a typical drill rig used on the project is shown in Figure 6-35.

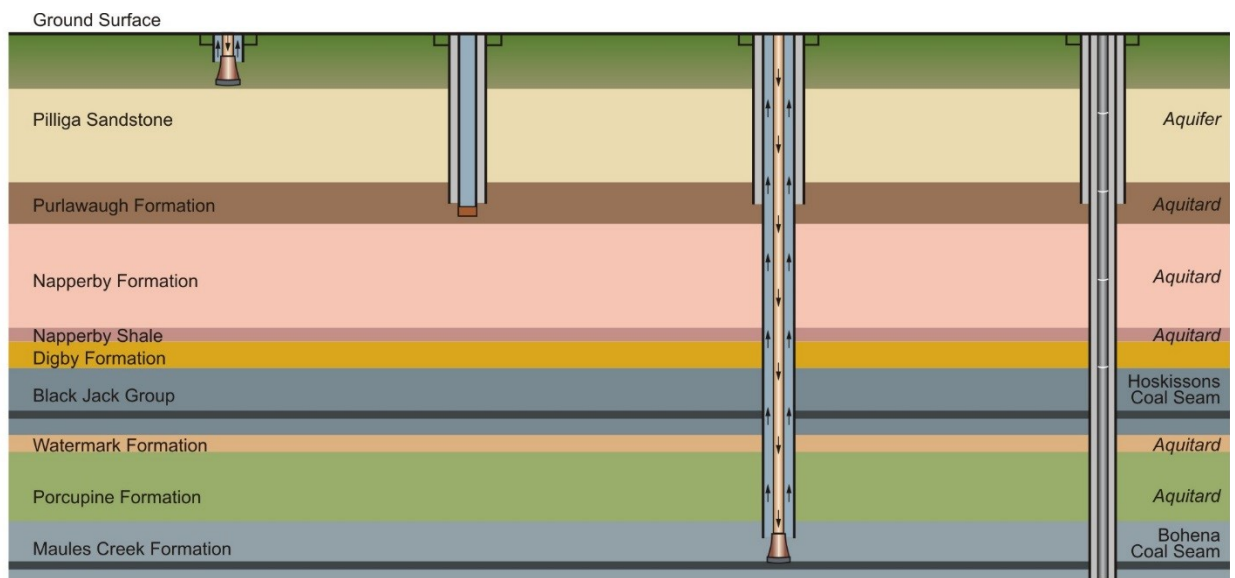


Figure 6-35 Typical drill rig used on the project

Gas flaring does not generally occur during drilling activities. A vent tank is installed on each drilling rig as part of the well control equipment which allows pressure to be released in a controlled manner away from the well head and drilling equipment. Table 6-7 provides a description and illustration of the key stages involved in drilling and constructing a gas well to ensure that its integrity is maintained to protect the environment in which it is located.

Table 6-7 Description and illustration of the key steps involved when drilling a typical vertical gas well

Step 1	Step 2	Step 3	Step 4
<p>Surface drilling occurs to allow a 14-inch steel pipe, called the conductor, to be cemented into the ground, generally to 10 to 20 metres below the surface – refer schematic below.</p> <p>This isolates loose or unconsolidated rock near the surface.</p>	<p>The base of the conductor is drilled out and drilling continues through the permeable strata until a suitable geological rock layer, through which substances like water and gas cannot easily pass, is encountered.</p> <p>A second steel pipe, generally referred to as surface casing, typically with a diameter of 9 5/8", is set into the bottom of the hole, into the impermeable rock layer and cemented in place from top to bottom forming an additional barrier to protect the Pilliga Sandstone – refer schematic below.</p> <p>The surface casing is then pressure tested to ensure well integrity.</p>	<p>The base of the surface casing is drilled through by a few metres and a pressure test is undertaken again to ensure the cement is bonded to the rock and steel.</p> <p>A third narrower diameter hole is drilled down to and through the target coal seams and into the rock below – refer schematic below.</p>	<p>Finally, production casing, typically with a 7" diameter, is run into the base of the hole and cemented in place from bottom to surface. This forms another barrier to isolate the gas well from the shallow aquifers and other permeable formations – refer schematic below.</p> <p>The well head is installed on top of the well to allow production of natural gas and water and also allows for the safe suspension of the production during maintenance operations.</p>



Approximate quantities of primary construction materials used for a single vertical well are shown in Table 6-8.

Table 6-8 Approximate quantities of primary construction materials for a single vertical well

Building materials	Quantity per well ^a
General construction steel	51 to 61 tonnes
Concrete	43 to 48 m ³
Fibreglass production casing	1 to 2 tonnes

^a Quantities would be refined during detailed design.

A diagram of a typical well pad layout during well drilling is provided in Figure 6-36.

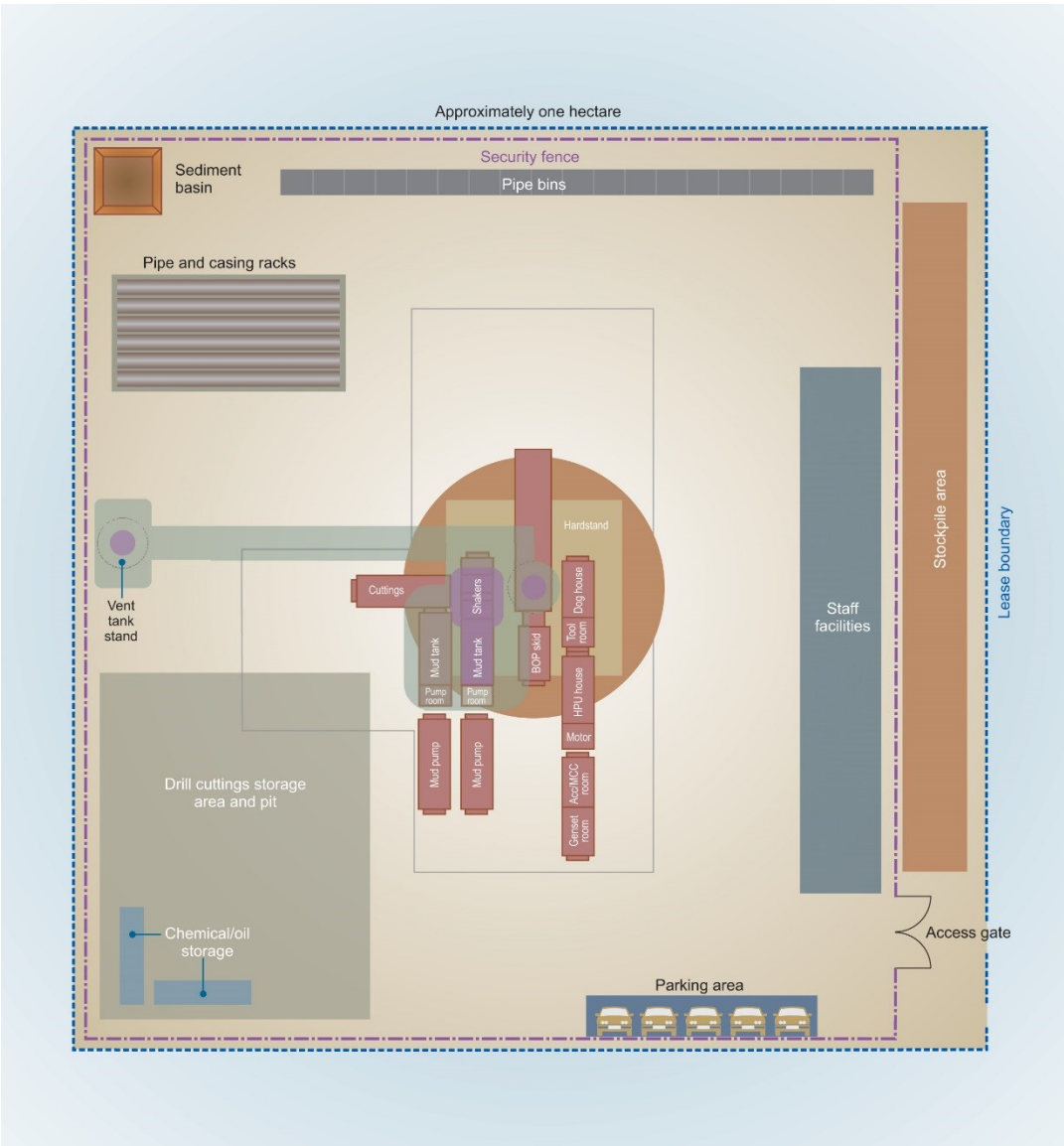


Figure 6-36 Typical well pad layout during drilling

Drilling fluids

A conventional overbalanced drilling fluid system is proposed for the project. During this type of drilling operation, the pressure of the column of drilling fluid is equal to, or greater than, the pressure of the various downhole formations through which they are drilled. This prevents influx of water or gas into the well bore whilst drilling. The drilling operations would use a water-based fluid system that would be designed to maintain well bore stability and well control. Other proven drilling systems can and have been used safely, but for simplicity, are not proposed for use, and are therefore not addressed in this EIS.

Prior to the start of drilling, water and various other approved additives are mixed to create what is known as drilling fluid. The drilling fluid would be prepared on site or transported to site in a tanker from the previously approved drilling fluid treatment facility located at the Narrabri Operations and Logistics Centre, Yarrie Lake Road, Narrabri, and stored in surface tanks on site.

Once drilling is completed at each well, drilling fluids would be transported back to the drilling fluid treatment facility so that it can be beneficially re-used in future drilling operations, or disposed of at a licensed waste facility.

Drilling fluid is predominantly comprised of water (more than 70 per cent) with the balance being weighting agents and additives which are added in varying proportions depending on the geological conditions and the objectives of the drilling activity. Additives commonly used include bentonite or polymer, which are used to form a temporary filter cake on the sides of the uncased bore (Step 1 in Table 6-7). This rapidly reduces the infiltration of drilling fluids into the formations through which the bore extends. The drilling fluid is regularly tested and monitored and is pumped downhole to:

- clear rock fragments and other solids such as drill cuttings from the well and help bring them to the surface
- prevent clays from swelling
- keep the bore hole open until the casing has been cemented in place
- cool and lubricate the drilling equipment.

The compounds would be transported to the well pad in accordance with regulatory requirements. Refer to Table 6-9 for the typical drilling fluid chemicals used in the project.

Table 6-9 provides a list of the typical components of drilling fluids, with potential products identified for use in both primary and secondary (as required) drilling fluids. Similar products may be substituted for those listed based on the suppliers, market availability and product improvement at the time of drilling. All drilling additives would be tested by a NATA-certified laboratory and demonstrated to meet the Australian Drinking Water Guidelines for benzene, toluene, ethyl benzene or xylene (BTEX) compounds.

Table 6-9 Typical components of drilling fluids

Product use	Chemical name	Alternative product use
Primary drilling fluids		
Base fluid	Water	NA
Inhibitor Reduces reactivity and swelling of shales and clays from water based drilling fluids	Copolymer of acrylamide and sodium acrylate Potassium chloride Polyalkylene Silicic acid, potassium salt	Absorbent (e.g. baby nappies) Medical and pharmaceutical uses Additives used in cleaning solutions Salt substitute Silica gel moisture absorption
Fluid loss stabiliser Prevents formation water from entering the well by blocking pores in the permeable / fractured rock	Glyoxal Starch Sodium carboxymethyl cellulose	Coating in textile and paper industries. Thickening agent and stabilizer used in food industry
Biocide / Antimicrobial Prevents bacteria forming within water and / or corrosion occurring	Pentanedial / Glutaraldehyde Methanol Dazomet	Steriliser for medical equipment Cosmetic and pharmaceutical industries Soil fumigant in agricultural industry.
pH stabiliser Used to optimise the pH value of the drilling fluid	Sodium hydroxide Sodium carbonate	Slaked lime Water softener
Viscosifier Assist in cooling and lubricating the drill bit and lifting cuttings from the well	Xanthum gum	Thickening agent and stabiliser used in food and cosmetics industries
Defoamer Removes trapped air and / or gas from drilling fluids	Ethylene oxide/propylene oxide copolymer Polypropylene glycol	Steriliser for medical equipment Antifreeze used by food and pharmaceutical industry
Weight additive Maintains well stability	Sodium chloride	Salt Sterile solution used in medicine
Secondary drilling fluids		
Inhibitor Reduces reactivity and swelling of shales and clays from water based drilling fluids	Copolymer of acrylamide and potassium acrylate	Water gel crystals used in horticulture
Fluid loss stabiliser Prevents formation water from entering the well by blocking pores in the permeable / fractured rock	Almond hulls Walnut hulls Cellophane Wood fibre Calcined petroleum coke	Fibre source used in agricultural industry Cosmetic industry Food packaging industry Paper industry Aluminium and steel production
pH stabiliser Used to optimise the pH value of the drilling fluid	Calcium carbonate	Antacid pharmaceutical

Product use	Chemical name	Alternative product use
Weight additive	Bentonite	Absorbent (kitty litter)
Maintains well stability	Crystalline silica, cristobalite	Glass manufacturing
	Crystalline silica, quartz	
	Crystalline silica, tridymite	

Drill cuttings

It is proposed that drill cuttings would be re-used on well pads using a mix, turn, bury strategy in accordance with advice from the NSW Environment Protection Authority (refer to Appendix E). The application of drill cuttings at well pads would be carried out with regard to the volume and characteristics of the drill cuttings, the characteristics of the receiving soil, and the volume and nutrient requirements of growth media. A balance of these factors would be implemented to ensure successful rehabilitation.

In accordance with advice from the NSW Environment Protection Authority (refer Appendix E), the management of drill cuttings in this manner would not require a resource recovery exemption or trigger other waste licensing requirements.

Further, application of drill cuttings to well pads for site rehabilitation would be carried out in accordance with Section 115 of the *Protection of the Environment Operations Act*, which prohibits a person from disposing of waste in a manner that harms or is likely to harm the environment. Drill cuttings not appropriate for beneficial reuse on well pads for rehabilitation purposes would be transported off site and disposed of at an appropriately licensed waste management facility.

Anticipated average volumes of drill cuttings for different production well types are summarised in Table 6-10.

Table 6-10 Anticipated average volume of drill cuttings by production well type

Configuration	Estimated volume (m ³)
Production well – single vertical	420
Production well – single lateral	600
Production well – double lateral	700
Production well – triple lateral	810
Production well – quadruple lateral	900

Well completion

Pilot and production wells would be completed using a workover rig, sometimes also known as a completions rig, which is generally smaller than the conventional drill rig.

Well completion involves installing the downhole pump assembly, the electric or hydraulic drive head, the well head assembly, and associated valving and surface support equipment. Well completion activities generally take several days.

All well completion activities would be undertaken in accordance with the *NSW Code of Practice for Coal Seam Gas – Well Integrity* (DTIRIS 2012).

Well logging

Some drilling operations require additional information to be collected from the well bore using formation evaluation tools. These tools are typically provided by specialist well-logging companies and are lowered into the well bore using a wireline. They can be used to help verify the quality of the reservoir by collecting subsurface data on lithology, pressure, porosity and acoustic response. These data logs are important to assist with the setting of casing strings to achieve the isolation requirements of the well casing and cement. Depending on the logging activity to be undertaken, logging sources may use a live source such as caesium or beryllium, whilst others use passive sensors that detect or use magnetism as a source to gather information.

Caesium-137 (also referred to as CS-137) is used in density measuring devices that are used to monitor and measure various activities during the drilling and well completion processes. CS-137 is one of the most common radioisotopes used in industry and is used in a range of applications including medical applications such as radiotherapy. CS-137 is used in minute amounts in sealed stainless steel capsules, referred to as encapsulated devices, which are removed from the well after the well logging procedure is complete. In NSW, the use of CS-137 is governed by the *Radiation Control Act 1990* (as amended) and the *Radiation Control Regulation 2013* with oversight and enforcement from the NSW Environment Protection Authority.

Both the well-logging company and the individual technicians using the device are required to be licensed, and, when not in use, the material is securely stored in lead and concrete lined canisters.

Pilot well flares

Construction of pilot well flares would include:

- excavating a pit in the vegetation free zone to a depth of up to approximately 300 millimetres
- lining the pit with geofabric or other appropriate material to deter weed growth
- infilling the safety zone pit with compacted soil and blue metal aggregate
- installing fencing around the safety zone
- installing the flare and aboveground piping that connects the flare to the gathering lines.

Water balance tanks

The installation of water balance tanks would be limited to:

- preparation of the site as required
- establishment of earthen bunds
- installation of high density polyethylene liners within the bunds
- delivery and positioning of, or construction of, water balance tanks
- installation of electrical cabling and instrumentation
- commissioning of water balance tanks
- rehabilitation of residually impacted areas.

Access tracks

Construction of access tracks would involve:

- surveying of a construction corridor up to 12 metres wide to accommodate both the access track and gas and water gathering lines by a registered surveyor before preparatory activities take place (the corridor would be on average 10 metres wide, up to a maximum of 12 metres)
- pre-clearance surveys for ecology
- clearing, mulching and stockpiling vegetation at agreed locations determined during negotiation of the access agreement with Forestry NSW (when located within the forest)
- grading along the access track
- installation of vehicle passing bays as required
- where required, top dressing with gravel to reduce dust and provide all weather access
- partial rehabilitation to an operational width of around five metres; slightly wider on intersections and bends as required.

Gas and water gathering lines

Installation of the gas and water gathering lines would be undertaken via plough-in, trenching or directional drilling, depending on subsurface soil conditions and land use. The construction corridor would be 10 metres wide on average, up to a maximum of 12 metres. This would reduce to a five metre access track following partial rehabilitation, slightly wider on intersections and bends as required, which would be consistent across all construction methodologies. This is the minimum width necessary to safely construct and operate the gas and water gathering lines.

Gas and water gathering lines would typically be installed using plough-in construction methods. Larger pipelines would more likely be constructed using traditional trenching methods, while horizontal directional drilling would be used where plough-in or trenching is not suitable, such as when crossing the Newell Highway. There may also be occasions where ground conditions necessitate some blasting to allow for installation of the gas and water gathering lines. Plough-in, trenching and horizontal directional drilling construction methods are described further below.

Gas and water gathering lines would be installed with cover depths as shown in Table 6-11.

Table 6-11 Depth of cover for gas and water gathering lines

Type of land use	Minimum cover depth
Standard land use	>0.75 metres
Watercourses (when horizontal directional drilling is used)	1.5 metres
Roads and infrastructure	2 metres

Gas and water gathering lines would be co-located within the same construction corridor, and where practicable, also along existing access tracks to minimise vegetation disturbance. Surface disturbance would be further reduced by the ability to concurrently plough-in both the gas and water gathering lines within the same trench.

Plough-in

The plough-in process includes:

- surveying the proposed corridor
- pre-clearance surveys for ecology
- slashing and mulching of vegetation and stockpiling it within the construction corridor
- ripping a one-metre-wide strip along the route
- pipe delivery, stringing, and fusion bonding (welding) of the pipeline along the corridor
- pipe installation as the plough's ripper and pipe insertion unit is pulled through the ground, with the pipe being continuously laid as the machine moves forward
- reinstatement as the ground closes in naturally following the ploughing
- compaction of the remaining small soil bund as required
- pre-commissioning which involves flushing of the pipeline using water or a pigging process
- commissioning which includes pressure testing of the pipeline
- partial rehabilitation of the construction corridor.

The plough-in construction method is able to achieve a construction rate of approximately 400 to 1,000 horizontal metres per day—depending on the soil type.

Trenching

Trenching would occur where short distances, site terrain or pipeline diameter limits the feasibility of plough-in installation. A traditional cut-and-cover approach would be undertaken. This would involve:

- surveying the proposed corridor
- pre-clearance surveys for ecology
- slashing and mulching of vegetation and stockpiling it within the construction corridor
- digging the trench and stockpiling soil also within the construction corridor
- pipe delivery, stringing and pipe welding
- returning excavated soil to the trench and compacting the soil
- pre-commissioning which involves flushing of the pipeline using water or a pigging process
- commissioning which includes pressure testing of the pipeline
- rehabilitation of the construction corridor.

Trenching would achieve a construction rate of approximately 200 to 500 horizontal meters per day; based on the soil type.

Horizontal directional drilling

Where it is not practicable to install pipelines, including water and gas gathering lines, using plough-in or trenching techniques, horizontal directional drilling would be used. This would involve drilling a pilot bore and then enlarging the hole to the size required for the intended use. It would utilise an auguring technique rather than a traditional wet drilling method.

Horizontal directional drilling provides flexibility to locate the pipeline infrastructure to avoid constraints such as existing utilities or sensitive areas. Cuttings from this process would be treated in the same way as drill cuttings (refer to Section 6.5.2).

Horizontal directional drilling would occur at locations where pipeline infrastructure would cross the Newell Highway, and is not used for gas well drilling.

Telecommunication towers

Telecommunication towers would be constructed on well pads across the project area, and also at Bibblewindi and Leewood. The towers would be delivered to the project area by semi-trailer, largely or fully pre-assembled. As such, the establishment of the towers would be limited to:

- preparation of the site as required
- construction of concrete pads and foundations
- delivery and erection of telecommunications tower
- installation of electrical cabling and instrumentation
- commissioning of the telecommunication tower.

6.5.3 Ancillary infrastructure

Road and intersection upgrades

Upgrades to the intersections of the Newell Highway with Old Mill Road and X-Line Road (refer to Section 6.4.1) would be undertaken, in accordance with AustRoads Guidelines, and following approval by the NSW Department of Roads and Maritime Services in the form of a works authorisation deed. The works would entail:

- site vegetation disturbance
- site establishment
- survey
- civil earthworks and drainage
- road surfacing
- line marking and signage installation.

Westport workers' accommodation

The size and configuration of the Westport workers' accommodation may vary over the project depending on the location and schedule of the drilling program. The accommodation buildings would be fully mobile and can be transferred to and from the upgraded Westport site as required.

The workers' accommodation would be established on site consistent with requirements under the *Rural Fires Act 1997*. Each building would be transported by semi-trailer and positioned on the levelled gravel site using a crane or lift. It is anticipated that around 40 to 60 semi-trailer loads of equipment would be required. Set up is generally undertaken during daylight hours and is likely to take several days. If required, a water truck would be utilised on access roads to suppress dust during the construction period.

It may be necessary to undertake minor levelling and import gravel for the car park and crushed granite for other high use areas. However, minimal site works would be needed as the buildings would be skid mounted as previously described. All components of the workers' accommodation would be removed when the facility is no longer required, in accordance with the landholder's requirements and project approval conditions.

Bohena Creek managed release of treated water

Installing the Leewood to Bohena Creek managed release pipeline would involve:

- surveying the proposed corridor
- pre-clearance surveys for ecology and Aboriginal heritage
- slashing and mulching of vegetation and stockpiling it within the construction corridor
- digging the trench and stockpiling soil also within the construction corridor
- pipe delivery, stringing and bending and pipe welding
- returning excavated soil to the trench and compacting the soil
- pressure testing
- rehabilitation of the construction corridor.

Irrigation

Upon confirmation of the property to be used for irrigation purposes, manifolds and pipelines would be constructed at Leewood to connect the water treatment plant to existing, or new, offsite amended water storage ponds or dams.

From these ponds or dams, a pipeline would transfer the amended water to the irrigation area. Refer to Appendix G2 and Chapter 7 for additional information on the managed irrigation scheme.

6.5.4 Utility requirements for construction

Power

Construction activities would likely use temporary power generators to supply sites and facilities prior to the connection of a permanent supply. Approximate power requirements during construction are summarised in Table 6-12.

Table 6-12 Approximate power requirements during construction

Project component	Source
Gas field	Diesel generator at well pad for drilling, self-powered civil equipment and small generators
Leewood property	1 MW diesel generator
Bibblewindi	1 MW diesel generator
Bibblewindi to Leewood infrastructure corridor	Self-powered civil equipment and small generators
Leewood to Wilga Park corridor	Self-powered civil equipment and small generators
Westport	1 MW diesel generator

Sewage

Sewage generated by the construction workforce will be managed using packaged wastewater treatment plants at the Leewood and Bibblewindi sites and Westport worker's accommodation whilst portable ablution facilities for the storage of sewage will be used at construction sites (e.g. during drilling). Packaged wastewater treatment plants, which are extensively utilised in both municipal and project related settings, employ an aerobic process to treat sewage, generating treated effluent that can be released to land and a residual sludge that is held within storage tanks that are periodically emptied for disposal to an appropriate facility.

A 200-person capacity packaged wastewater treatment plant would be installed at Bibblewindi and a 400-person capacity packaged treatment plant would be installed at Leewood. The Westport workers' accommodation has existing approval for 64-person sewage facilities and this would be upgraded to cater for a total of 200 people. The wastewater treatment plants will be designed to Australian Standards and treated effluent would be disposed of to a dedicated on-site disposal area by subsurface infiltration or adsorption trenches, irrigation or similar, in line with all regulatory requirements.

Telecommunications

Telecommunication towers for mobile phone services would be installed early in the project to assist with telecommunications throughout the construction period.

Water

During the first few years of the project, construction water would largely be sourced from the Leewood water treatment plant that services the exploration program and licensed water bores. All relevant licences would be in place prior to sourcing water from other sources such as licensed bores.

Water would be piped to Bibblewindi and stored in one of the water storage ponds on site. Once the proposed Leewood water treatment facility comes on line, it would also be used to provide water for construction purposes.

6.5.5 Construction timing, working hours and workforce

Construction timing

As discussed in Section 6.1.4, construction of the project is expected to commence in early/mid-2018. Indicative timing and duration of construction activities is presented in Table 6-13. Much of the major infrastructure would be modular in nature; thereby enabling partial operating capacity prior to the completion of all plant and equipment being installed to achieve maximum design capacity.

Table 6-13 Indicative construction timing and duration

Project component	Activity / location	Approximate completion of construction	Duration
Gas field	Well site establishment	14 days per well pad	Ongoing for around 20 years
	Drilling	10 to 30 days per well	Ongoing for around 20 years
	Well site surface facilities	60 days per well pad	Ongoing for around 20 years
	Gas and water gathering system	up to 1,000 m per day per construction crew	Ongoing for around 20 years
	In-field compression	Q1 2021	2 years
	Infrastructure between Bibblewindi and Leewood	Q4 2020	18 months
	Power between Leewood and Wilga Park	Q1 2019	6 months
Central gas processing facility	Leewood	Q2 2021	3 years
Water management facilities	Water treatment facility	Q3 2019	18 months
	Managed release pipeline	Q3 2019	4 months
Optional power generation facility	Leewood	Q4 2019	12 months
Other	Westport workers' accommodation	Q4 2017	2 months

Working hours

Proposed construction working hours are shown in Table 6-14. There may be situations where working outside the proposed hours is required. Such times may include periods of hot weather, wet weather, during pipeline pressure testing, or when delivery of key infrastructure is required.

Table 6-14 Construction working hours

Project component	Activity/location	Construction timing/duration
Gas field	Site establishment	12 hours a day, 7 days a week
	Drilling and completion / workover operations	24 hours a day, 7 days a week
	Well site surface facilities	12 hours a day, 7 days a week
	Gas and water gathering system	12 hours a day, 7 days a week
Leewood property	Gas treatment facility, water management facilities, optional power generation facility (if required)	12 hours a day, 7 days a week
Bibblewindi	In-field compression	12 hours a day, 7 days a week
Bibblewindi to Leewood infrastructure corridor	Gas and water pipeline, power and communications cabling	12 hours a day, 7 days a week. Some 24 hour work such as pressure testing.
Leewood to Wilga Park infrastructure corridor	Power cabling	12 hours a day, 7 days a week.
Ancillary	Infrastructure (Westport workers' accommodation, roads, contractor yards)	12 hours a day, 7 days a week
	Irrigation infrastructure	12 hours a day, 7 days a week
	Managed release infrastructure	12 hours a day, 7 days a week
	Utilities	12 hours a day, 7 days a week

Workforce

The estimated peak construction workforce is provided in Table 6-15. Actual workforce numbers would depend on the contractor's construction methodology, and the availability of equipment, and staff.

The average onsite workforce during the peak construction period (the first three to four years) would be approximately 1,300 people. This would decrease to approximately 145 people during ongoing construction. Figure 6-37 provides a graphic illustration of the indicative peak workforce numbers. An operational workforce would also be employed during the ongoing drilling program.

Table 6-15 Estimated peak and ongoing construction workforce

Workforce	Peak construction period (approximate)	Ongoing construction (approximate)
General construction labour	1,050	45
Drilling and completions labour	250	100
Total (approximate)	1,300	145

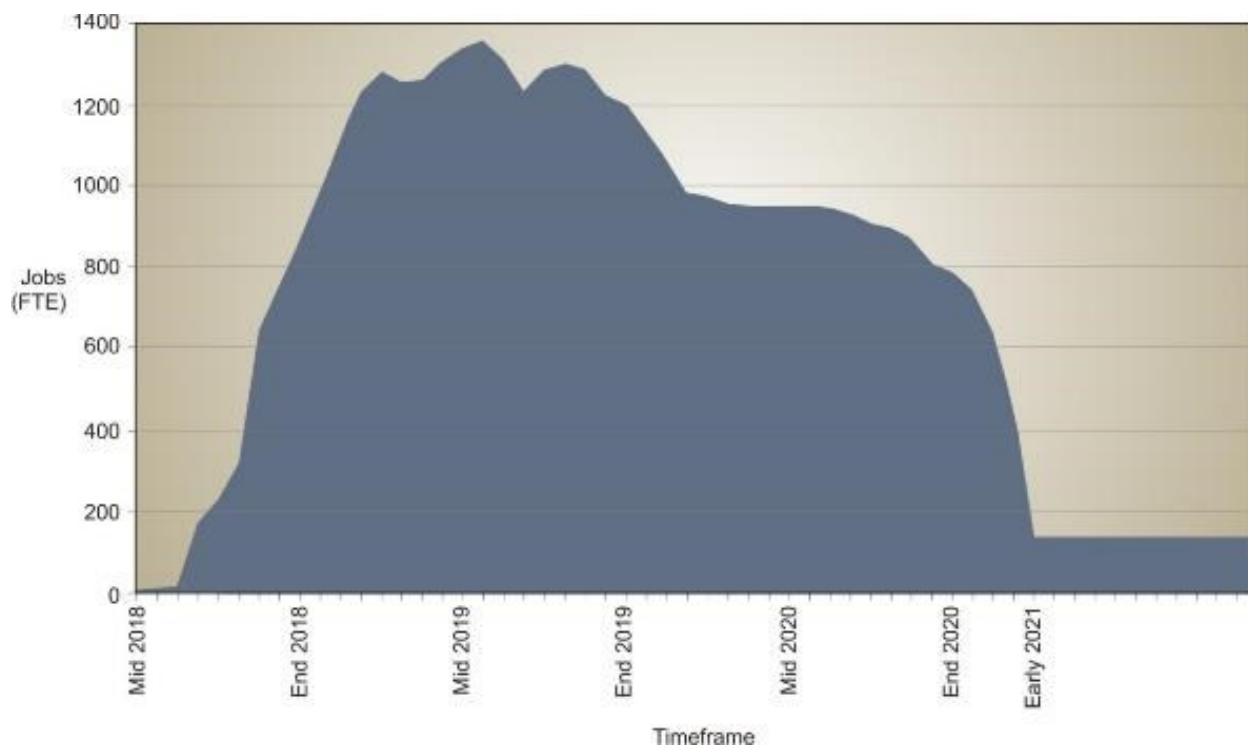


Figure 6-37 Indicative peak construction workforce

6.5.6 Construction access and traffic

Construction traffic

Traffic would peak in the first three to four years of the project as production wells are drilled, the gas and water gathering lines are installed, the in-field gas compression, central gas processing, and water management facilities are constructed, and supporting infrastructure is built.

The peak construction period is likely to generate an estimated peak of approximately 310 construction vehicles per day across the gas field. The peak would coincide with the drilling of gas wells, and the construction of the key major infrastructure at Leewood, Bibblewindi and the two linear infrastructure corridors.

Estimated daily traffic through the construction period is shown in Table 6-16. Conservative, peak estimates have been used to model traffic numbers in this EIS.

Construction movements would predominantly be to the four major construction sites at Leewood, Bibblewindi, the Bibblewindi to Leewood infrastructure corridor, and the gas field. The Narrabri Operations and Logistics Centre would also be used for construction activities, including concrete production, drilling fluid recycling and deliveries.

Equipment and materials would generally be delivered to laydown areas where it would be stored until required. The three main laydown areas would be the Narrabri Operations and Logistics Centre, Leewood and Bibblewindi; the latter two sites would have laydown areas of approximately 100 by 200 metres.

Table 6-16 Estimated construction traffic

Major component	Estimated duration	Estimated total (daily one-way)	Comments
Gas field - wells	Peak in years 1 to 4 then reduced though ongoing for around 20 years	150	Assumes six wells being drilled concurrently. Includes traffic movements along forestry roads Up to six drilling and two completion rigs in the peak years (around year 1 to 4), reducing to two drilling rigs and one completion rig thereafter. Includes truck movements for well material supply and passenger and support vehicles
Gas field - water and gas gathering lines	Peak in years 1 to 4 then reduced though ongoing for around 20 years	20	Includes traffic movements along forestry roads Includes truck movements for material supply and passenger and support vehicles
Bibblewindi	3 years	70	Includes deliveries, staff movements and one-off modular equipment deliveries
Leewood Gas Processing Facility	3 years	15	Oversized vehicles and general trucks
Leewood Water Treatment Facility	18 months	25	Oversized vehicles and general trucks
Bibblewindi to Leewood infrastructure corridor	18 months	20	Oversized vehicles and general trucks
Leewood to Wilga park infrastructure corridor	6 months	10	Oversized vehicles and general trucks

Access to the Leewood construction area would be provided from Old Mill Road via the Newell Highway. The Bibblewindi construction area would be accessed via X-Line Road and via the Newell Highway. The Bibblewindi to Leewood services corridor would be accessed at Bibblewindi, Leewood or other existing roads. The Narrabri Operations and Logistics Centre would continue be accessed via Yarrie Lake Road.

Within the project area, access would be along forestry roads and access tracks with the points of entry from Yarrie Lake Road or Kamilaroi Highway to the north and X-Line Road to the south.

Accommodation for construction workers would be at a workers' accommodation facility in the Narrabri area, or the Westport workers' accommodation. Daily traffic movements would occur between the construction sites and these accommodation facilities.

Haulage routes

Haulage routes from Port Kembla, the Port of Newcastle and the Port of Brisbane would be via the national road network (major highways) to the Narrabri Operations and Logistics Centre and Leewood.

6.5.7 Source and quantity of materials

Table 6-17 includes indicative quantities of construction materials and their use. Quantities would be refined during detailed design.

Table 6-17 Indicative quantities of construction materials

Construction materials	Use / location	Indicative quantities
General construction steel	Wells	50 to 60 tonnes per well
	Bibblewindi	550 tonnes
	Leewood	1,200 tonnes
	Medium compression gas pipeline	17 km
Reinforced steel	Bibblewindi	340 tonnes reinforced steel
	Leewood	425 tonnes reinforced steel
Steel - equipment	Bibblewindi	500 tonnes
	Leewood	800 tonnes
Concrete / cement	Wells	approximately 50 m ³ per well
	Bibblewindi	2,000 m ³
	Leewood	2,500 m ³
HDPE	Water gathering lines	600 km
	Gas gathering lines	600 km
Fibreglass / GRE / flexible composite	Wells	90 m of 7 inch per well (around 1,755 kg)
	Power cable (Leewood to Bibblewindi)	17 km
	Gas gathering line	17 km
	Communications cable (Leewood to Bibblewindi)	17 km
	Water pipeline (Leewood to Bibblewindi)	17 km
	Power cable (Leewood to Wilga Park)	15 km
Asphalt	Leewood	3,000 m ²
Fill	Wells, Leewood and / or Bibblewindi	As required

6.5.8 Construction plant and equipment

Construction equipment

Table 6-18 provides an indicative list of construction plant and equipment.

Table 6-18 Indicative types of construction equipment

Well pad establishment and drilling	Linear infrastructure - gas and water gathering lines, medium compression gas pipeline and power	Leewood and Bibblewindi construction sites
trucks and 4WDs	trucks and 4WDs	truck, semi-trailers and 4WDs
off-road forklift / front end loader	grader	compressors
flatbed trucks	dozer	generators
power generators	crane	welding equipment
logger	generator	cranes
bulldozer	welding rig	loaders and forklifts
motor grader	hand tools	bob-cats, backhoes, dozers and excavators
excavator	trucks	rollers
bobcat skid steer loader	excavator	concrete pump
drill rig	plough	logger
winch	rock breaker	grader/scrapper
mud pump engine	low loader	steer loader
mud shaker	water cart	wacka packa and vibe plate
generator	off-road forklift/front-end loader	tub grinder
hydraulic power unit	mulcher	asphalt paver
hand tools	fire trailer	water cart
mobile crane	trencher	hand tools
welding rig		
lightings		
mulcher		
water cart		
fire trailer		

6.6 Maintenance activities throughout operations

6.6.1 Overview

Ongoing maintenance would be managed through the proponent's internal corporate maintenance management system to ensure the safe operation of above and below ground infrastructure. The proponent would use operational integrity and maintenance governance standards to ensure that the project operates safely.

The maintenance management system would include:

- the execution of maintenance work to keep facilities fit for purpose and meeting regulatory requirements
- reviews of performance against targets in order to effectively allocate and update maintenance strategies to reduce safety risk and optimise performance
- procedures for effective maintenance management, planning and execution of maintenance activity
- controls on the quality of work to ensure it is of an appropriate standard.

A range of operational safety mechanisms would be in place to assist with the monitoring of the project. These automated triggers would occur at different stages of the gas processing and water cycle and would include:

- remote telemetry that monitors operating parameters and well pressure at the well head equipment and the gas and water separator
- instrumentation and associated safety gauges and differential critical alarms on water storage infrastructure
- pressure readings at different stages of the gas processing facility
- safety flares where gas treatment and compression occurs.

A gas leak detection and repair program would also be implemented. Approximately 200 staff and contractors would manage the ongoing operation and maintenance of the gas field, some of who would be physically present in the gas field on a day-to-day basis.

6.6.2 Major facilities

Leewood

All facilities at Leewood would be operated on a continuous basis and would be fully automated. The gas processing facility would be monitored for a variety of operating parameters such as gas flow rate, pressure, temperature and composition, and checking of the fluid levels within tanks and vessels.

Water volumes and quality would be monitored within the produced water and brine storage ponds.

The power generation facility would be monitored for gas flow, pressure and temperature, and power generated.

In addition, monitoring would be conducted at these major facilities to ensure their safe operation including gas, fire and smoke detection, which would trigger the appropriate automated emergency response such as fire deluge systems for example. In this regard, emergency response facilities, such as a trailer with emergency equipment would be located at Leewood and Bibblewindi with personnel appropriately trained in their correct use.

Routine inspections and maintenance would be conducted on equipment at the facilities. This would comprise a combination of scheduled inspection and maintenance of select equipment and, in some instances, full shutdown with more extensive maintenance. The modular design of infrastructure would facilitate partial shutdowns for maintenance in order to minimise operational impacts. During shutdowns of the gas processing facility the safety flare would flare excess gas, as required.

Chemicals would be stored on site in fully bunded facilities in accordance with the relevant Australian Standard.

Up to approximately 45 operations and maintenance personnel would be staffed at the water and gas treatment facilities. Administration buildings and associated staff amenities would be located near the water treatment plant to service the site operations and maintenance staff.

Bibblewindi

The in-field gas compression facility would be manned during the day and remotely monitored at night. Similar to Leewood, routine inspections and maintenance would be conducted on equipment and infrastructure. This would comprise a combination of scheduled inspection and maintenance of select equipment and, in some instances, full shutdown with more extensive maintenance.

During shutdowns of the in-field gas compression facility or individual components of the facility, the safety flare would flare excess gas, as required. A small administration building and associated staff facilities would be located at Bibblewindi to service the team of around 45 people.

Infrastructure corridors

The Bibblewindi to Leewood gas pipeline would be regularly cleaned to remove water which may accumulate in low points along the pipeline. The frequency of these activities would be dependent on gas quality and production conditions. If the medium pressure gas pipeline is constructed of steel, the appropriate internal and external corrosion monitoring would be undertaken.

Visual inspection of the Bibblewindi to Leewood water pipelines would occur, with regular preventative maintenance being undertaken in accordance with typical pipeline standards. Similarly, visual inspections would occur for the power cabling between Wilga Park and Leewood, and for the power cabling and communications lines between Leewood and Bibblewindi.

As with other linear infrastructure, vegetation management including weed monitoring would also be undertaken.

6.6.3 Gas field

Maintenance tasks across the gas field would include routine inspections, and undertaking regular, planned preventative and corrective equipment maintenance. As noted above, maintenance would be managed through Santos internal corporate maintenance management system to ensure the safe operation of all surface equipment.

Equipment, including that at Leewood and Bibblewindi, would be placed on a maintenance schedule based on criticality maintenance periods recommended by vendors. Maintenance would be scheduled to minimise supply impacts to market, whilst maintaining safe operations.

Appraisal and production wells

All appraisal and production wells would be monitored and controlled remotely. Data collected on site from the well head would be transmitted via remote telemetry through the communications network to the operations centre to enable the remote monitoring and control of the surface facilities. The wells would also have automated shutdown systems in the event of non-routine operating conditions. Where appropriate, surveillance systems may be utilised to assist with security monitoring and provide early warning of unauthorised entry to site.

Ongoing activities at well sites during operations would include routine inspections and maintenance of wellhead infrastructure. This can be undertaken 24 hours per day either physically or through remote monitoring. Regular manual inspections of facilities would be conducted to ensure the well and surface facilities are maintained in safe working order. All below ground testing and inspection works would be in accordance with *The NSW Code of Practice for Coal Seam Gas – Well Integrity* (DTIRIS 2012). Production or operations personnel would access each operating well, generally on a daily basis.

Maintenance activities of the wells would include repair or replacement of downhole pumps and pump components, clearing of blockages from within the wells that may be limiting production capacity, or other action required to overcome such issues as required.

Maintenance of wells is generally undertaken using what is called a workover rig. Workover rigs tend to be smaller than the drilling rigs required to drill the well and often require less surface area in which to operate safely. Workover activities would be contained within the operational area of the well pad area of around one quarter of a hectare, with an additional laydown area that could be approximately 0.2 hectares in size.

Routine maintenance activities associated with the well head surface facilities would include, though not be limited to:

- inspection of vessels, piping, valving and instrumentation
- testing of pressure safety valves
- critical function testing of instrumented protection systems
- emptying of filters and strainers
- well head integrity inspections including surface casing pressure checks
- replacement of pumps and pump components
- calibration of instrumentation and replacement if faulty
- generator maintenance and refuelling.

Access tracks and gas and water gathering lines

Operational activities associated with the gas and water gathering lines include monitoring and maintenance in accordance with the pipeline management plans. There would be signage to identify the locations of the gathering lines in accordance with Australian Standards.

Gas gathering lines would include drains and collection points at low points in the terrain (refer Figure 6-38). These allow for water that may condense within the line to be collected and removed and may be either automatically or manually operated.

Produced water gathering lines include vents at high points in the terrain to allow for the safe removal of small volumes of gas that may be dissolved in the produced water (refer Figure 6-39). Drains and vents would be inspected as part of routine field maintenance activities.

To provide for maintenance, future expansion and emergency situations, isolation valves would be installed at strategic locations to enable certain sections of the gathering lines to be isolated.

Access tracks would be maintained in accordance with landholder requirements. Vegetation management, including weed monitoring, would also be undertaken along pipeline right of ways.



Figure 6-38 Low point drain along gathering lines



Figure 6-39 High point vent along gathering lines

6.6.4 Hours of operation and workforce

Operations would be 24 hours per day, seven days per week all year round including all public holidays. There would generally be two shifts; being a day shift and a night shift. The day shift would generally run from 6am to 6pm, and the night shift 6pm through to 6am. Approximately 80 to 90 per cent of operations staff would work the day shift, with the remaining staff working a night shift.

For workplace health and safety reasons, the night shift would focus on maintaining production with routine maintenance being performed primarily during the day. Major maintenance activities may be required to occur on a continuous basis throughout the day and night, but would be infrequent. The proportion of day to night-time staff is subject to operational, reliability and safety requirements being met.

It is anticipated that around 200 full-time equivalent jobs would be required during operation of the project. This would include a mix of existing roles already based in Narrabri, support roles based in the proponent's offices in Sydney, Brisbane, and Adelaide, and new roles that would be created over the life of the project. Preferably, employees would be sought from the local area with training programs instigated where skills are not currently available. The 200 full-time equivalent positions would be in addition to the ongoing drilling and completions workforce which is estimated at approximately 100 staff. All staff would have appropriate training and certification to ensure workplace safety and the ongoing safe operation of the project.

6.6.5 Plant, equipment and utility use

During normal operations, plant and equipment would be limited to that required for the maintenance of infrastructure, deliveries to the site, and the movement of staff. Operational plant and equipment requirements would include, though may not be limited to, gas processing and site office, site deliveries, and water deliveries.

Plant and equipment

Indicative ongoing routine plant and equipment for the project would include:

- skid steers
- small trucks
- dust suppression equipment
- light vehicles
- vegetation management equipment
- maintenance cranes
- emergency response vehicles
- vacuum trucks
- employee transport including coaches
- waste and sewage contractor vehicles
- contractor delivery vehicles
- fire-fighting trailers
- standard trailers.

Utility use

Power and water

During operations, power would be required at:

- each gas production well head
- Bibblewindi for in-field compression
- Leewood for the central gas processing and water management facilities
- Westport.

As previously detailed, two power options are assessed in the EIS—connection to the NSW electricity grid, or gas fired power generation at Leewood. Power for the well sites would be sourced from generators and solar panels, both located on the well site.

The estimated power requirements through operations and maintenance are provided in Table 6-19.

Table 6-19 Power requirements for operational plant and equipment

Project component	Requirement	Source
Well site	114 kVa per well head	Initially diesel-fired generators until sufficient gas is produced to convert to gas fired generators
Leewood	50 MW	Option 1 – power generation facility at Leewood Option 2 – connection to the NSW electricity grid
	Diesel generator	100,000 litre bunded fuel storage
Bibblewindi	50 MW	Power would be distributed from Leewood under power option 1 or 2
	Diesel generator	30,000 litre bunded fuel storage
Westport	Diesel generator	6,000 litre bunded fuel storage

Potable water at Leewood would be sourced from an onsite bore and treated through a potable water treatment package process. Potable water would be sourced from a licenced bore and / or transported into Westport and Bibblewindi as required.

Sewage

The facilities discussed in Section 6.5.4 will accommodate sewage generated by operational staff, and as such, they will continue to be utilised throughout operations, albeit at a reduced scale.

Telecommunications

Telecommunication requirements would be met through the infrastructure constructed as part of the project. Routine planned visual inspections would be undertaken of the telecommunication towers during operations and maintenance.

6.6.6 Traffic generation

The main type of vehicle traffic to and from the project area during operations and maintenance would be light passenger vehicles, private vehicles during shift changes, and delivery supply trucks to Leewood, Bibblewindi and Westport workers' accommodation.

Well workover activities would occur periodically as required on a well by well basis. Two workover rigs would likely be in use across the project area, with each well subject to a workover one to two times on average during its operational life.

A conservative estimate of daily traffic movements during operations and maintenance is approximately 100 vehicles on non-forest roads (mainly staff movements and routine deliveries).

6.6.7 HSE and emergency response

Emergency response

Emergency response and incident management plans would be developed for the project to manage health, safety and environmental incidents and emergencies. The proponent has a four-tiered response team structure for managing emergencies and incidents. Responsibilities and procedures for managing emergencies would be detailed in the Operations Emergency Response Plan. Internal management and governance standards would also be used for HSE emergency response preparedness.

Over the life of the project, there is a chance that a large scale, high intensity bushfire will occur. The project would have strategies and procedures in place to mitigate bushfire risk in the design, construction and operation of the project. A site-specific Bushfire Management Plan would be prepared in conjunction with landholders and the NSW Rural Fire Service, with components under the proponent's control implemented for the project area to mitigate bushfire risk.

While the proponent is able to apply mitigation measures to reduce the potential for fires to start on and escape from the project area, it must also implement measures to mitigate impacts on life and property within the project area from an external fire. These mitigation measures and procedures would be detailed in the Bushfire Management Plan to be prepared for the project area. Additional detail is provided in Chapter 25 – Hazard and Risk.

The mitigation measures and procedures have been successfully utilised during the existing exploration and appraisal activities being undertaken in the project area. The proponent has taken an active role in local fire response planning in conjunction with the local Narrabri / Moree Bush Fire Management Committee and this has included participation in full emergency response and evacuation drills in co-operation with the emergency services.

As a result of these measures, personnel would not be in forested areas on days of elevated fire danger and would have opportunities to shelter at appropriate locations as far as possible from the point of fire impact where it may be expected they could be impacted only by smoke levels causing temporary discomfort (but not serious illness), potentially some ember attack and non-life-threatening levels of radiant heat.

Environmental incidents

A Pollution Incident Response Management Plan has been developed for the current exploration and appraisal activities in the project area to manage potential environmental emergencies or incidents in accordance with the requirements of the *Protection of the Environment Operations Act 1997*.

The Pollution Incident Response Management Plan details responsibilities for site staff managing environmental incidents, regulatory and community notification requirements and provides details of potential pollutants and safety equipment. The Plan would be reviewed and updated to apply to the project. The proponent's internal management and governance standards would also be used for environmental incident emergency response preparedness.

6.7 Decommissioning and rehabilitation

6.7.1 Proposed objective

Decommissioning and rehabilitation strategies have been developed for the project (refer to Appendices W and V respectively). The objectives of these strategies are to:

- undertake decommissioning of assets and rehabilitation in a manner that complies with legislative requirement and approvals
- undertake decommissioning activities and rehabilitation in a manner that meets stakeholder expectations
- leave a landform that is safe, stable and non-polluting and compatible with the intended post closure land use to enable effective transfer to third parties
- provide for the retention and beneficial reuse of project infrastructure to third parties (i.e. landholders and local authorities), where there is an appropriate agreement in place and regulatory authorities are satisfied.

The decommissioning objectives align with the rehabilitation objectives detailed in the Rehabilitation Strategy (refer Appendix V).

The proponent will provide a security deposit in relation to rehabilitation in accordance with the *Petroleum Onshore Act 1991* and associated policies and guidelines.

6.7.2 Major infrastructure

Leewood

Gas processing facility

The compression system, dehydration system and ancillary equipment would be isolated and drained of all accumulated liquids, then purged and vented to remove traces of gas or other potentially hazardous or flammable materials.

All above ground interconnecting pipe work would be removed, dismantled and transported off site. The compressor and after-cooler packages and other process equipment would be disassembled and removed.

Ancillary equipment installed at the site, including power generation and distribution equipment, the plant air system, flare system, various tanks, and other utility systems would be individually isolated and secured before being disassembled and removed.

All concrete pads and foundations would be removed and disposed of as general waste. Natural contours would be reinstated and stockpiled topsoil would be spread across the site. Erosion and sediment control systems installed for the project would be removed as required.

Water treatment facility

Water treatment plant infrastructure would be individually isolated and disassembled into the original modular components and removed from site. All above ground interconnecting pipework would be removed and dismantled into transportable lengths and transported off site.

Optional power generation facility

Power generation and distribution equipment would be individually isolated and secured before being disassembled and removed. Once the generators are no longer needed, the power input to the switchgear would be isolated and both the generators and switchgears would be removed. The remaining earthing grid and other buried cables would be removed during the site clearance operations, as required.

Bibblewindi

The in-field compression system and ancillary equipment would be isolated and drained of all accumulated liquids, then purged and vented to remove traces of gas or other potentially hazardous materials. All above ground interconnecting pipe work would be removed and dismantled into transportable lengths and transported off site. The compressor and after-cooler packages and other process equipment would be disassembled and removed.

Ancillary equipment installed at the site, including power distribution equipment, the plant air system, flare system, various tanks, and other utility systems would be individually isolated and secured before being disassembled and removed.

All concrete pads and foundations would be removed and disposed of as general waste. Natural contours would be reinstated and stockpiled topsoil spread across the site. Erosion and sediment control systems would be installed as required.

Bibblewindi to Leewood, and Leewood to Wilga Park infrastructure corridors

At the cessation of production, infrastructure corridor pipelines would be isolated at their connection points. The pipelines would then be isolated, drained, vented and capped in accordance with the Australian Pipeline Industry Association (APIA) *Code of Environmental Practice for Onshore Pipelines* (2013), or the applicable code in place at the time of decommissioning. All above ground components would be removed, including all pipeline marker signs.

The subsurface components of the infrastructure corridor would remain *in situ* as described above, and vegetation maintenance within the infrastructure corridor would cease, with vegetation allowed to regrow over the corridor. Other support service infrastructure in the corridor such as communications and high-voltage cables would be isolated and also remain *in situ*.

6.7.3 Gas field

Exploration and appraisal wells

At the completion of exploration and appraisal, all wells would either be:

- plugged and decommissioned, with the drill pad rehabilitated to comply with NSW Government guideline documentation (DTIRIS 2012)
- converted to groundwater monitoring bores
- converted to production wells or potential future production wells and counted within the 850 production wells proposed.

Production wells

Well pad partial rehabilitation would occur after the operational performance of the well(s) has been assessed following its installation and commencement of operation. The assessment of well performance would typically be less than six months after the well is drilled, but may take 12 months or more depending on well behaviour.

Once the wells have reached the end of their functional lives or are considered to have no further re-completion potential, they would be plugged and decommissioned in accordance with the *NSW Code of Practice for Coal Seam Gas – Well Integrity* (DTIRIS 2012), or the applicable code in place at the time of decommissioning; and final rehabilitation would take place. This would include removing the well head, surface infrastructure and fencing; capping the well at a minimum depth of 1.5 metres; revegetating the lease site; and weed control.

Works associated with well decommissioning activities are restricted to the existing well pad area and do not require additional significant vegetation disturbance or significant ground disturbance.

Plant and equipment involved in plug and decommissioning operations include:

- a workover rig to retrieve production equipment from the well, and to prepare the well for the installation of cement plugs
- a cement unit to transport, mix and pump cement plugs into the well
- a wireline truck to install casing, cement and formation evaluation logs to confirm isolation and well integrity.

A detailed plug and decommissioning methodology would be prepared for each well that considers the drilling reports detailing the cementing and casing characteristics, and wireline logs detailing the well integrity status.

It is anticipated that decommissioning of surface infrastructure, with subsequent rehabilitation, would be undertaken as close as practicable to when wells reach the end of their operational life. Refer to Appendices V and W for additional information on decommissioning and rehabilitation.

Gas and water gathering lines

At the cessation of production, the gas and water gathering lines would be isolated at the well head and at their connection point at both the water treatment plant and the gas processing facility. The gathering systems would then be isolated, drained, vented and capped in accordance with the *Australian Pipeline Industry Association (APIA) Code of Environmental Practice for Onshore Pipelines* (2013), or the applicable code in place at the time of decommissioning.

After the well sets are decommissioned, the subsurface components of the gathering system would remain *in situ* as described above, and vegetation maintenance within the gathering system corridor would cease. All above ground components of the gathering system would be removed, including all pipeline marker signs.

Works associated with pipeline decommissioning activities would be restricted to the existing vent locations and would not require additional vegetation clearing or significant ground disturbance. All products used in the cleaning of pipelines (that is, water and cleaning products) would be captured and disposed of appropriately to manage potential impacts on local water resources.

Existing infrastructure that is useful to the landholder (such as access tracks) would remain in consultation with the landholder.

Access tracks

Access tracks would be rehabilitated when they are no longer required. If rehabilitated, tracks would be ripped and levelled to re-instate natural contours. Drains and creek crossings would be removed. Tracks would be covered with mulch and seeded as required. Erosion and sediment control systems would be removed at an appropriate time.

Rehabilitation of access tracks would vary from area to area depending on the landholder, Traditional Owners and other relevant stakeholders. Access tracks which are useful to the landholder may remain in place under agreement with the landowner.

Water balance tanks

Water balance tanks would be isolated and drained of all liquids, with disposal to an appropriately licensed facility. All above ground interconnecting pipework would be removed and dismantled and transported off site. Tanks would be disassembled and removed from site unless there is an alternative requirement under an agreement with the landholder.

The earthen bunds would be demolished and the liners removed. Natural contours would be reinstated and stockpiled topsoil spread across the site. Additional material imported to construct the bund would be removed from site. Erosion and sediment control systems would be removed as required.

Telecommunications towers

The telecommunications towers would be dismantled and removed from site at the end of their effective life. All concrete pads and foundations would be removed and disposed of as general waste. Natural contours would be reinstated and stockpiled top soil spread across the site. Erosion and sediment control systems would be installed as required.

6.7.4 Ancillary infrastructure

Road upgrades

The two road upgrades would be left in place as agreed with key stakeholders, primarily NSW Roads and Maritime Services.

Westport

Westport workers' accommodation would be dismantled and removed from site at the end of its operational life. All concrete pads and foundations would be removed and disposed of as general waste. Natural contours would be reinstated and stockpiled topsoil spread across the site. Erosion and sediment control systems would be installed as required.

Irrigation and managed release infrastructure

All above ground pipelines, flanges and ancillary equipment required to facilitate the managed irrigation scheme and the Bohena Creek managed release would be dismantled and removed, with the areas fully rehabilitated. The fate of treated water dams and / or ponds would be determined in agreement with landholders and regulators.