7. PROJECT DESCRIPTION: FEED GAS PIPELINE

The proposed feed gas pipeline will deliver gas to the proposed liquefied natural gas (LNG) plant on Curtis Island from the Arrow Surat Pipeline on the mainland. A single nominal 48” (1,219-mm) internal diameter, high-pressure gas pipeline is proposed to deliver gas to the LNG plant at a nominal pressure of 7.3 MPa. Ancillary pipeline infrastructure required includes metering, isolation valves, an integrated scraper or pig receiving station (which will be located in the gas inlet station at the LNG plant), cathodic protection, telecommunications, and supervisory control and data acquisition (SCADA) systems. Above ground facilities will be enclosed within a security fence. The pipeline will be depressurised through the LNG plant flare system. The 9 km long high pressure gas pipeline will cross under Port Curtis in a tunnel excavated by a tunnel boring machine.

This chapter describes the feed gas pipeline, pipeline control systems, and construction and operation activities for the pipeline and proposed Port Curtis crossing methods.

7.1 Pipeline Route

The proposed feed gas pipeline (Figure 7.1) connects to the proposed Arrow Surat Pipeline approximately 120 m north of the Gladstone–Mount Larcom Road crossing. From this point, approximately 1 km south of Boat Creek, the proposed feed gas pipeline runs in a straight line to the northwest corner of Hamilton Point on Curtis Island. Once on Curtis Island, the feed gas pipeline runs on the southern side of the LNG loading lines and crosses the Gladstone LNG (GLNG) Project haul road to follow the LNG loading lines east in the Curtis Island Corridor Sub-precinct of the Gladstone State Development Area to the Arrow LNG Plant boundary. On entering the site, the pipeline runs up the western side of the proposed LNG plant to the gas inlet station, which is located west of LNG train 1.

Commencing at the proposed Arrow Surat Pipeline, the proposed feed gas pipeline alignment traverses coastal plains covered in dry sclerophyll forest and fringing coastal grasses, and intertidal mudflats, then passes beneath Port Curtis in a tunnel before emerging on Hamilton Point, and passing through dry sclerophyll forest on Curtis Island.

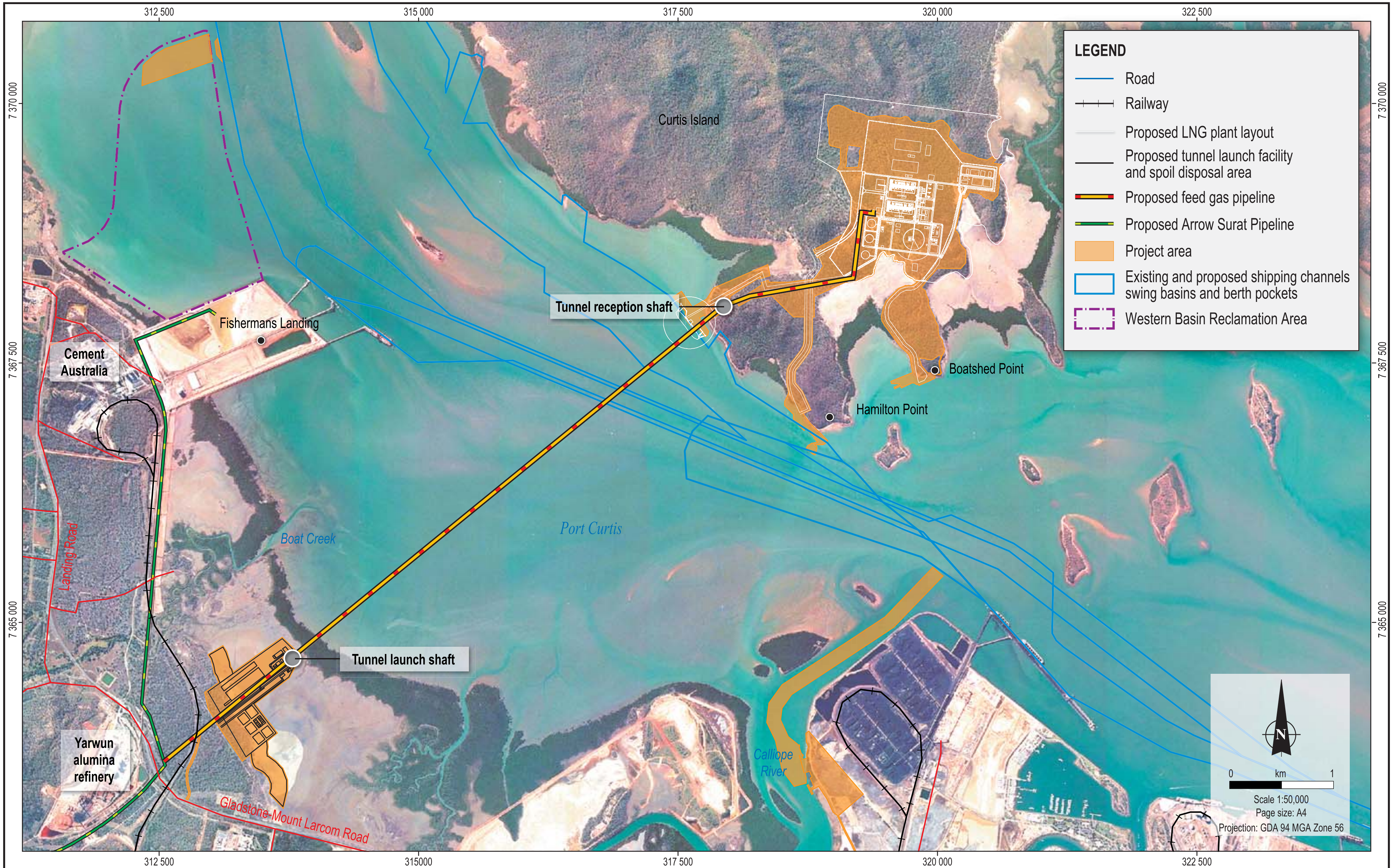
The proposed alignment crosses the Cement Australia railway and Yarwun Alumina Refinery pipelines, and beneath the Port of Gladstone shipping channels, located adjacent to Curtis Island, and the GLNG Project haul road on Curtis Island.

7.2 Pipeline Design

AS 2885:2007 sets out the requirements for design, construction, commissioning, operation and maintenance, and decommissioning of high pressure gas pipelines. Risk assessments are required to inform the development of plans and procedures for the various activities, and take into account site-specific conditions and constraints. The following risk assessments are required by the standard:

- Pipeline design risk assessment.
- Pipeline construction risk assessment.
- Pipeline operation risk assessment.

The feed gas pipeline will be designed, constructed and operated in accordance with AS 2885.



Source:
Place names and watercourses from DME.
Proposed LNG plant layout, ancillary facilities and marine infrastructure from Arrow Energy.
Proposed feed gas pipeline, project area and land tenure proponents from Coffey Environments.
Western Basin Dredging Master Plan and Disposal Project from Gladstone Ports Corporation.
Imagery from SPOT (2004-2007).

coffey environments

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File Name: 7033_07_F07.01_GIS_GL

Arrow Energy

Arrow LNG Plant

arrow energy go further

Proposed feed gas pipeline alignment

Figure No: 7.1

Key inputs to the design process are the feed gas specification, proposed operating pressure and pipe material.

7.2.1 Feed Gas Specification

The composition of gas delivered from the Surat and Bowen basins to the proposed LNG plant is detailed in Table 7.1.

Table 7.1 Typical feed gas composition

Components	Mol%
Methane (CH_4)	98.01
Nitrogen (N_2)	1.65
Carbon dioxide (CO_2)	0.34
Total	**100.00**

7.2.2 Maximum Allowable Operation Pressure

To achieve the required landing pressure of 7.3 MPa, the proposed feed gas pipeline will be designed for a maximum allowable operation pressure of 10.2 MPa. This equates to an ANSI Class 600 pipeline design specification.

7.2.3 Pipeline Materials

The proposed feed gas pipeline will be constructed using coated steel pipe. The pipe's external coating will be an anti-corrosion coating. The requirements for internal coating to minimise corrosion are still being investigated. Pipe joints will be protected using a joint coating compatible with the selected external coating. Concrete weight coating will be employed in locations where ground conditions might cause the pipeline to become buoyant, e.g., in areas with high watertables.

Pipeline valves and fittings will be Class 600. Pipe wall thickness will be determined through the pipeline design risk assessment, and will vary according to the assessed risk at various locations along the pipeline alignment. The pipe will be supplied in 12 m lengths.

7.3 Pipeline Control and Protection Systems

The proposed feed gas pipeline and gas inlet station will be operated from a control room located at the proposed LNG plant on Curtis Island. Pipeline operating conditions will be monitored and controlled using SCADA systems that will use fibre-optic cable buried or installed with the pipeline for communication. Specific pipeline integrity and control systems are described in the following sections.

7.3.1 Leak Detection System

A leak detection system will be installed to monitor pipeline pressures, gas flow rates and other parameters to enable the detection of abnormal conditions caused by leaks to be detected.

7.3.2 Corrosion Protection

A cathodic protection system will be used to protect the proposed feed gas pipeline from corrosion. The system will include isolating joints to separate above ground sections of the pipeline from buried or underground sections of the pipeline, impressed current anodes, transformers/rectifiers and test points. Sacrificial anode beds will be located at appropriate intervals along the pipeline. The system will be designed to account for the electrified Cement

Australia railway and other infrastructure that is crossed by the feed gas pipeline. Cathodic protection data will be amongst the data monitored by the control centre.

7.3.3 Pipeline Depressurisation

An emergency shutdown or isolating valve will be installed on the proposed feed gas pipeline at the gas inlet station. This will enable the LNG plant and pipeline outlet to be isolated in the event of an incident that compromises pipeline or the LNG plant integrity.

The feed gas pipeline will be depressurised at the LNG plant through the plant flare system. The flare will be designed for routine and emergency depressurisation of the pipeline. The flare design flow rate required will be informed by the pipeline specification and operating parameters.

7.3.4 Pipeline Inspection

The safety management plan required as a condition of the petroleum pipeline licence will include inspection and monitoring requirements in accordance with AS 2885. These will include:

- Remote video monitoring of the gas inlet station to detect unauthorised access and any abnormal events or conditions.
- Regular ground and aerial inspection of the pipeline easement to ensure unauthorised activities are not occurring over or adjacent to the pipeline, and to monitor the performance of the cathodic protection system. Specifically, inspection will ensure that:
  - There is no construction of buildings, excavation and removal of soil or other activities that might pose a risk to the continued integrity of the pipeline.
  - There is no erosion, land degradation or weed infestations occurring as a result of construction, and no operation and maintenance activities that might pose a risk to the continued integrity of the pipeline.
  - Pipeline facilities are secure and operating correctly.
- Internal inspection of the pipeline using intelligent pigs (pipeline inspection gauges) at the interval specified in AS 2885 or the pipeline licence.

7.4 Pipeline Construction Schedule and Workforce

The Port Curtis crossing drives the construction schedule for the proposed feed gas pipeline, as laying and installation of the 9 km long pipeline is a relatively short program. Separate workforces will be required for construction of the Port Curtis crossing and the pipeline. This section describes the construction schedule, construction workforce and workforce accommodation requirements.

7.4.1 Construction Schedule

Construction of the tunnel drives the construction schedule for the proposed feed gas pipeline, as it involves procurement of the tunnel boring machine (TBM), which is a long lead time item of equipment. TBMs are often bespoke designs based on the tunnel diameter, boring method and site conditions (geology). Approximately 9 to 12 months is required to design, fabricate, transport and assemble a TBM.

Works and site preparation are expected to commence in Q1 2014 to ensure the tunnel launch shaft is ready to receive the TBM when it is delivered to site. The overall timeframe to construct the tunnel launch and reception shafts and bore the tunnel is approximately 33 months. On completion of the tunnel, construction, installation and commissioning of the proposed feed gas pipeline are expected to take approximately 6 months, resulting in an overall construction program of around 40 months.

7.4.2 Construction Workforce and Accommodation

It is expected that up to 75 people will be required for construction and installation of the proposed feed gas pipeline, and 100 people for construction of the tunnel.

The pipeline construction workforce will typically work a single shift from 7.00 a.m. to 6.00 p.m. with construction activities undertaken continuously on a typical rotational roster, i.e., 28 days on and 9 days off, or 21 days on and 7 days off shift rotation, which will be dependent on the logistics and the contracting strategy. Extended work hours may be required for non-routine works and commissioning.

The tunnel workforce will typically work 2 by 12 hour shifts, 7 days a week on a rotation of approximately 7 days on and 4 days off. The workforce will be split into three shifts to work the seven on and four off rotations. Each shift will comprise 8 management, supervision and administration personnel, a tunnel crew of 20 persons, and 9 mechanical and electrical personnel for operation and management of surface equipment. Workforce numbers, hours and shift rotations will be further defined following detailed design.

Arrow Energy’s preference is to employ locally based workers where suitable skills exist. However, it is expected that specialised pipeline construction and tunnelling methods will require contractors sourced from outside the Gladstone region. Non-local workers will be engaged on a single status, fly-in, fly-out contract with their contracted pick-up and set-down location being a capital city or other major city.

The tunnel workforce is anticipated to be accommodated on the mainland. Options that will be considered for the accommodation of these workers will include residential properties, third party provided construction camp facilities, accommodation facilitated by the project or temporary workers accommodation facility (TWAF), depending on accommodation availability.

The feed gas pipeline workforce is expected to be accommodated in a separate construction camp associated with the construction of the feed gas pipeline assessed as part of the Arrow Surat Pipeline project.

7.5 Port Curtis Crossing Method

The preferred method for laying the proposed feed gas pipeline across Port Curtis is to install the pipeline in a tunnel bored beneath the harbour. This section describes the preliminary design of the tunnel and how it will be constructed.

7.5.1 General Arrangement

This option involves sinking two vertical shafts; one on the mainland (launch shaft) and one on Curtis Island (reception shaft). A tunnel (main tunnel) will be bored between the two shafts under Port Curtis using a TBM (Plate 7.1).

The proposed tunnel will be an approximately 4 m internal diameter (approximately 5.6 m excavated diameter) utility tunnel up to 6 km long. The tunnel will be fitted out to accommodate the nominal 48” internal diameter proposed feed gas pipeline, two 132 kV high voltage electrical circuits for mains electricity supply to the proposed LNG plant (all electrical option), a fibre-optic cable, and water and sewerage services (Figure 7.2).

The depth of the tunnel below the seabed is dictated by geology, which is described in the following section. Latter sections describe the tunnel components and how the tunnel is constructed.

7.5.2 Geology

Selection of the vertical tunnel alignment was based on the compilation of available geotechnical data supported by geotechnical investigations (GHD, 2010b). The alignment has been designed such that the main tunnel will pass though the most geotechnically stable strata, i.e., competent rock. Further geotechnical investigations will be undertaken to inform the detailed design of the tunnel alignment.

Geotechnical site investigations indicate that alluvial deposits at the mainland launch site extend from the surface to a depth of 19 m. Below these alluvial deposits, highly weathered rock extends for a further 4 m to a depth of 23 m, at which point semi-weathered and competent rock is encountered.

The reception shaft site geotechnical investigations on Curtis Island indicate that residual soils and extremely weathered rock extend from the surface to a depth of 24 m. Highly weathered to moderately weathered rock occurs between 24 m and 30 m depth, below which competent rock exists.

A fault line, the Eastern Basin Fault, occurs approximately 3,500 m from the mainland launch site and 2,500 m from the Curtis Island reception shaft. Mixed ground conditions are expected to occur at this inactive geological feature.

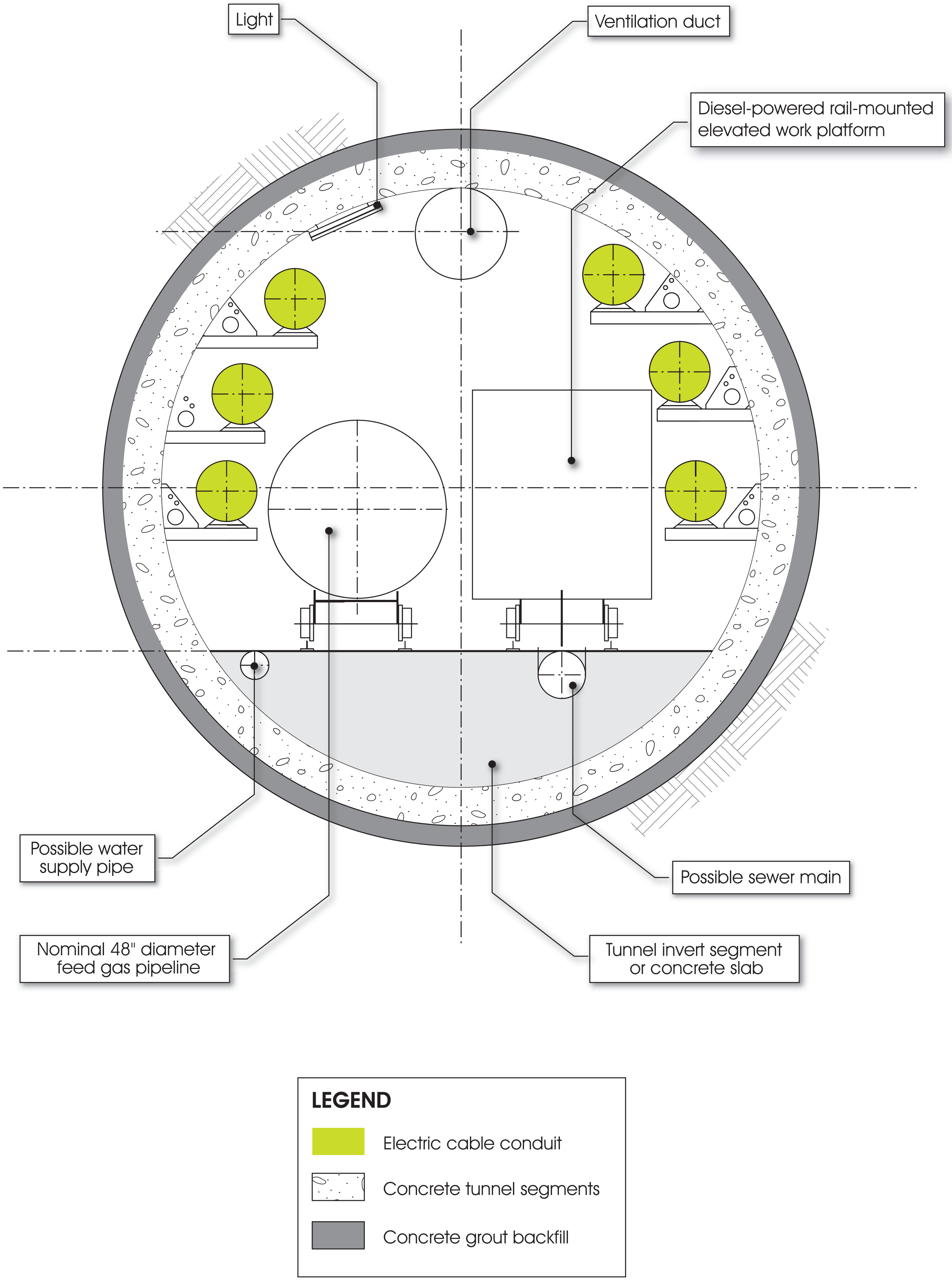
The vertical alignment of the tunnel (Figure 7.3) has been located in the slightly weathered to competent rock west of the Eastern Basin Fault, and in the extremely weathered and more competent rock east of the fault.

7.5.3 Mainland Tunnel Launch Site

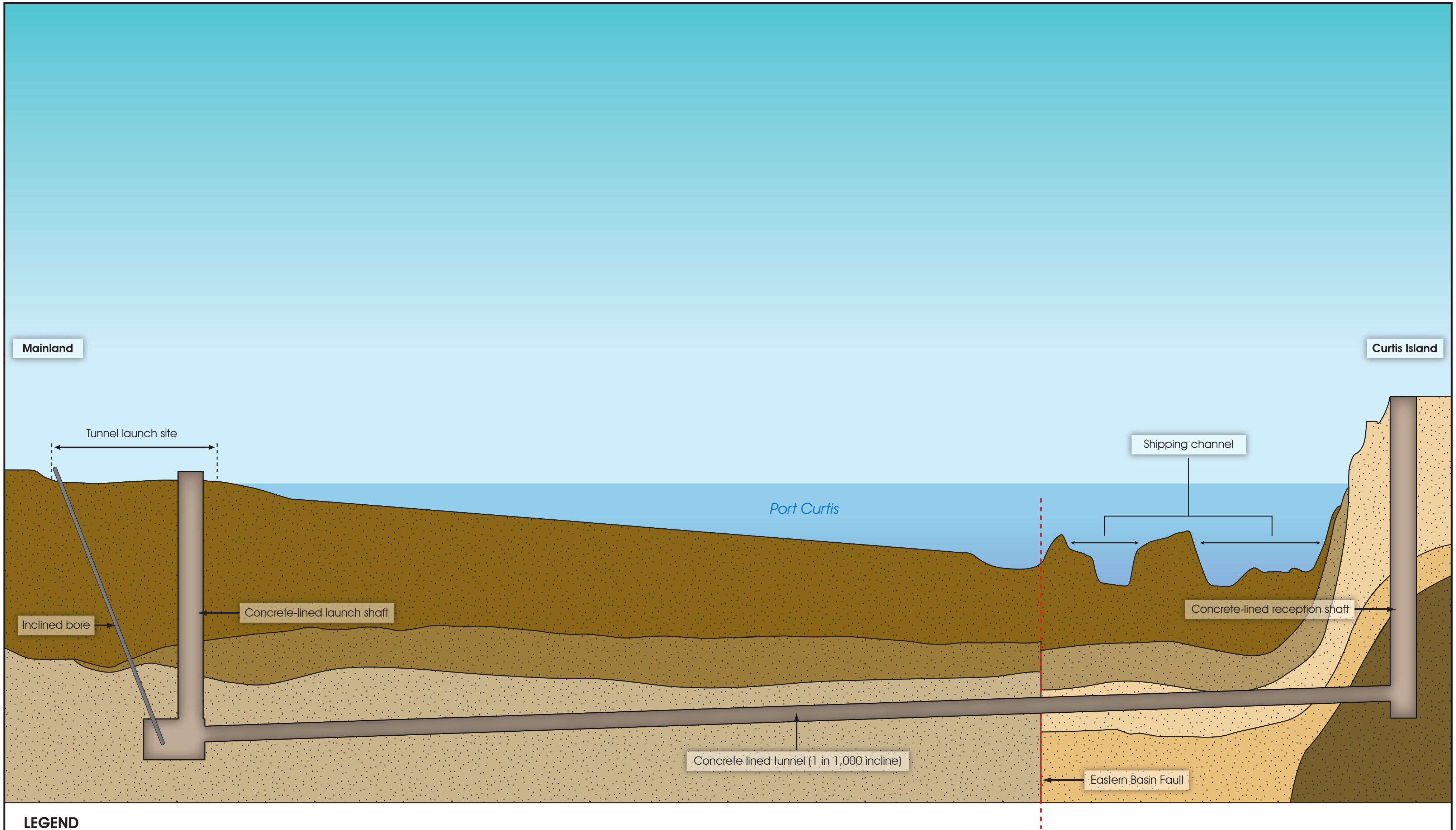
The mainland tunnel launch site will be located on the intertidal mudflats south of Boat Creek and extends from the mainland shoreline to within about 100 m of the mangroves (Figure 7.4). Access to the site will be either from the Gladstone–Mount Larcom Road via the Yarwun Alumina Refinery pipelines access track, which will be upgraded, or via a new 900-m-long access track from the road, as shown in Figure 7.4.

The irregular-shaped, 50-ha site is approximately 900 m long by 700 m wide at the edge of the intertidal mudflats and up to 350 m wide near the tunnel launch shaft and encompasses the tunnel launch shaft site and spoil disposal areas.

The tunnel launch site pad will be constructed from imported fill, which will be contained within an engineered structure. The pad will be shaped to direct stormwater runoff to retention ponds located adjacent to the southern boundary of the site where, if necessary, runoff will be treated before discharge to the intertidal mudflats. This will ensure adequate separation of discharge points from Boat Creek and its associated estuarine ecosystem.



coffey environments	Job No: 7033	Arrow Energy	arrow energy go further	Typical tunnel cross-section all electric option	Figure No: 7.2
	File Name: 7033_07_F07.02_GL	Arrow LNG Plant			



LEGEND

- Alluvial deposits
- Highly weathered to moderately weathered rock
- Slightly weathered to competent rock
- Highly weathered to moderately weathered rock
- Competent rock
- Residual soils and extremely weathered rock

Source:
Coffey Environments
Note:
Not to scale

coffey environments

Job No: 7033	Arrow Energy	Port Curtis feed gas pipeline crossing - tunnel option	Figure No: 7.3
File Name: 7033_07_F07.03_GL	Arrow LNG Plant		

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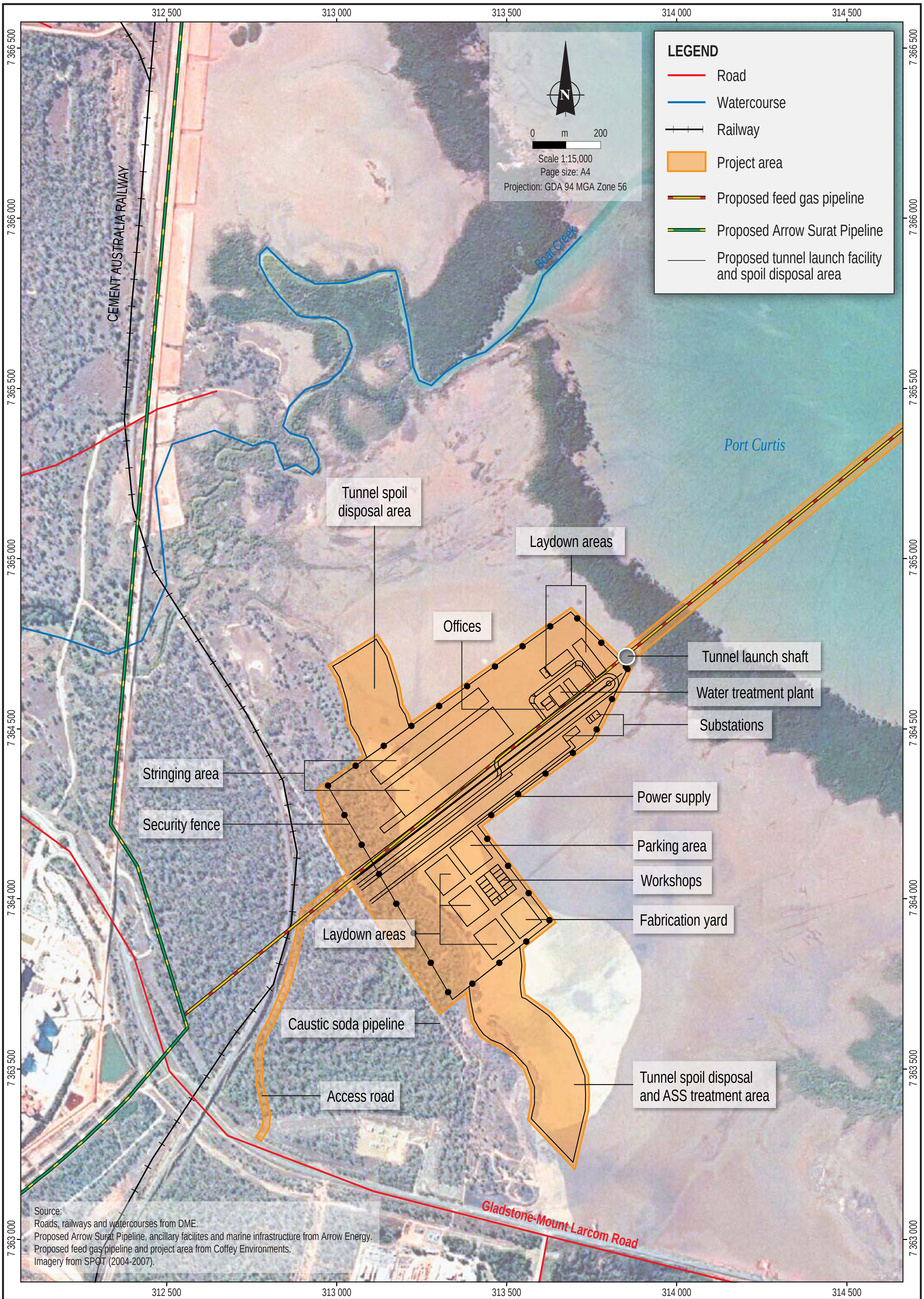


coffey environments

Date: 28.11.2011	Arrow Energy	arrow energy go further	Conceptual layout of tunnel launch site	Figure No: 7.4
MXT: 7033CA_07_GIS137_v1_1	Arrow LNG Plant			
File Name: 7033_07_F07.04_GIS_GL				

The tunnel spoil disposal area will be designed to consider seawater inundation, drainage, management of acid sulfate soils and properties of intertidal mudflat sediments. Further geotechnical and geochemical analysis will inform the design of this area.

Acid sulfate soil treatment pads will be incorporated in the southern tunnel spoil disposal area to treat acid sulfate soil material exposed or excavated during construction of the site formation and launch shaft. Acid sulfate soil material will be treated then disposed in the adjacent tunnel spoil disposal area in accordance with relevant guidelines. It is estimated that up to 450 m^3 of acid sulfate soil material will require treatment and disposal. The tunnel spoil disposal areas have been sized to accept this volume of material and the estimated 223,000 m^3 of weathered and competent rock to be excavated by the TBM. The launch site pad and spoil disposal areas will remain as permanent features after construction.

Vegetation that is cleared and the topsoil removed to establish the site and access track will be stockpiled separately for reuse in rehabilitation of the proposed feed gas pipeline construction right of way (ROW) and non-operational parts of the launch site pad.

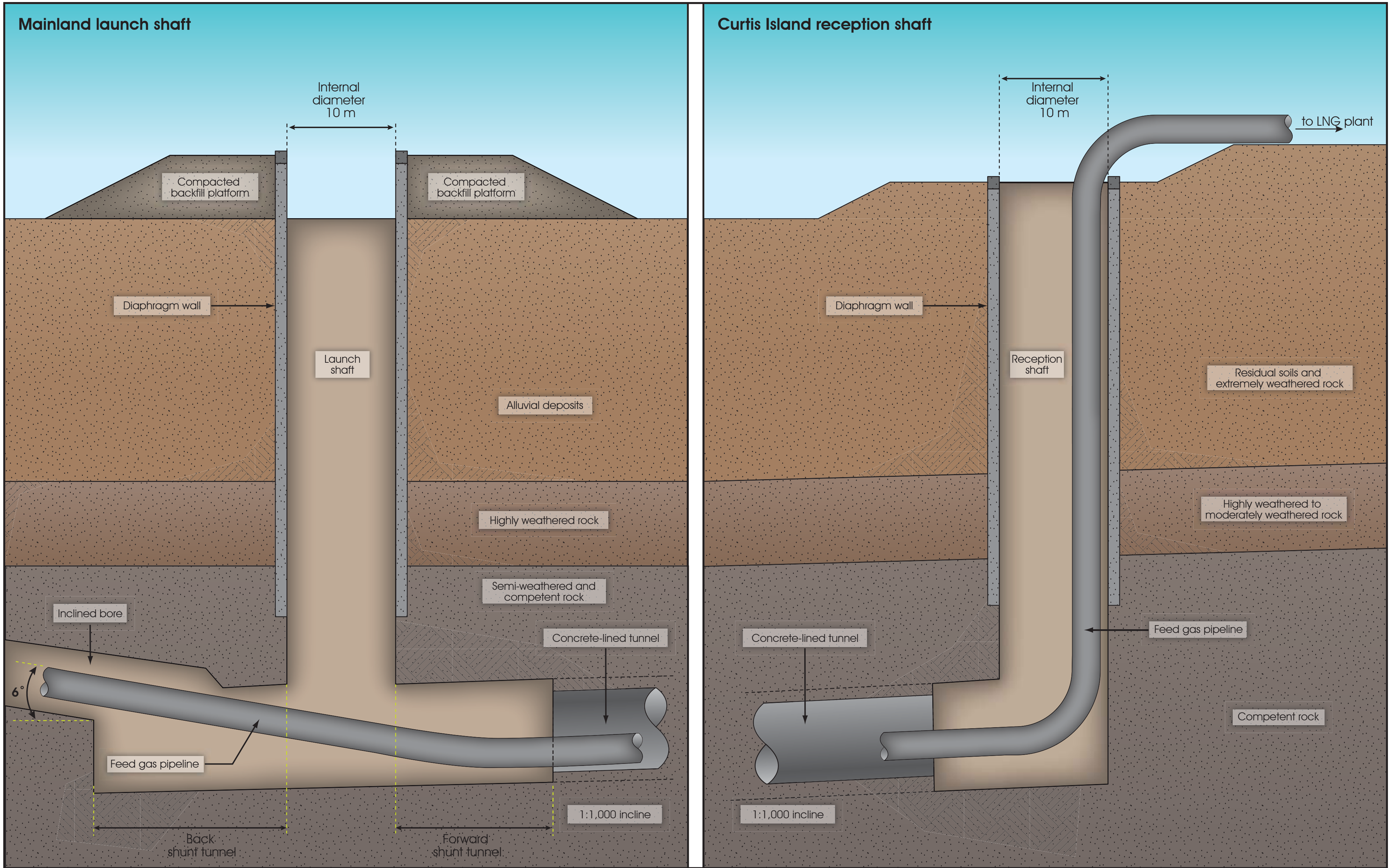
Initial site preparation to establish the required infrastructure will entail connection to the electricity grid for construction power supply; installation of a water supply pipeline; installation of security fencing; pavement works to establish laydown areas, fabrication yards, pipe stringing areas, carparks and internal roads; and building works to establish workshops and offices.

The tunnel launch site facilities will support all launch shaft excavation, incline boring, main tunnel boring, feed gas pipeline installation and high-voltage electricity cable installation activities, including:

- Storage of prefabricated main tunnel components including concrete tunnel segments, invert slabs or segments and low-friction rollers, as well as inclined bore casings.
- Batching and delivery of recyclable bentonite slurry to the tunnel boring machine.
- Processing of tunnel spoil material through a slurry treatment plant prior to placement in the tunnel spoil disposal areas.
- Processing of site construction wastewater through a water treatment plant prior to discharge to Port Curtis.
- Storage of 300-m-long feed gas pipeline sections in the stringing areas prior to installation.
- Welding of feed gas pipeline sections and feeding them via the inclined bore into the main tunnel during feed gas pipeline installation.
- Storage of 132 kV, high voltage electrical cables prior to installation.

7.5.4 Launch Shaft

A 10 m wide (internal diameter) launch shaft will be excavated to a depth of approximately 35 m below ground level to ensure the base of the shaft is located in competent rock, allowing the main tunnel to be bored through competent rock rather than overlying alluvial material (Figure 7.5). The overall depth of the launch shaft will be approximately 41 m. A compacted backfill platform with a reinforced concrete pavement surface will be built around the launch shaft to provide a stable working surface to support tunnel boring activities.



Source: Coffey Environments Note: Not to scale	coffey environments	Job No: 7033 File Name: 7033_07_F07.05_GL	Arrow Energy Arrow LNG Plant	arrow energy go further	Conceptual arrangement of mainland launch shaft and Curtis Island reception shaft	Figure No: 7.5

The top of the launch shaft will sit approximately 6 m above the highest astronomical tide level to ensure it does not flood. The launch shaft will allow TBM components, concrete tunnel segments, invert slabs and low-friction rollers to be lowered to the base of the launch shaft on an as-needed basis.

To maintain integrity of the launch shaft, the upper 32 m of the shaft will be supported by a concrete diaphragm wall, which will pass through the surface alluvial deposits and highly to moderately weathered rock, and penetrate at least 2.5 m into competent rock (see Figure 7.5). The remaining lower section of the launch shaft located in competent rock will be stabilised using traditional rock support methods, e.g., shotcrete and rock bolts.

The base of the launch shaft will be horizontally extended to incorporate a back shunt tunnel and a forward shunt tunnel that will form a chamber in which the TBM will be assembled and from which it will commence boring.

During operations, the top of the launch shaft will be fenced off and covered with a load-bearing steel grate floor supported by cross beams to prevent unauthorised access. An access gate and trapdoor will allow access to the launch shaft and main tunnel for feed gas pipeline inspection and maintenance activities.

7.5.5 Back and Forward Shunt Tunnels

The back and forward shunt tunnels will provide working space for assembly and operation of the TBM and (once construction of the main tunnel is complete) to progressively install the proposed feed gas pipeline.

The back shunt tunnel (excavated with rock cutting tools in the opposite direction from the main tunnel) will be stabilised with traditional rock support methods. The back shunt tunnel will be 20 m long and will be 6 m wide and 7 m high at its largest extent (see Figure 7.5).

The forward shunt tunnel, excavated in the direction of the main tunnel and stabilised using the methods described above, will be approximately 15 m long, 6 m wide and 5.5 m high.

7.5.6 Inclined Bore

An approximately 300 m long, 1.8 m wide (internal diameter) inclined bore, horizontally aligned with the main tunnel, will be driven from the surface at an angle of 6° to the end of the back shunt tunnel (see Figure 7.3 and Figure 7.5). The inclined bore will be lined with concrete. It will allow the proposed feed gas pipeline, fabricated in 300 m long sections, to be progressively fed into the back and forward shunt chamber to be pulled through the main tunnel to the reception shaft.

7.5.7 Reception Shaft

A reception shaft will be excavated at Hamilton Point on Curtis Island, within the proposed common infrastructure corridor (see Figure 6.10). The 10 m wide (internal diameter) reception shaft will connect the main tunnel to the surface. During feed gas pipeline installation, the reception shaft will house the equipment used to pull the proposed feed gas pipeline through the main tunnel to Curtis Island.

Cut and fill earthworks at the entrance to the reception shaft will provide a level working platform at the surface. The upper 31 m of the launch shaft will be reinforced with a concrete diaphragm wall, which will pass through extremely weathered, and highly to moderately weathered rock, and penetrate 2.5 m into competent rock (see Figure 7.5). The lower section of the reception shaft will sit within competent rock and will be supported with traditional rock support methods.

During operations the reception shaft will house the proposed feed gas pipeline and provide access to the main tunnel for inspection and maintenance. A security fence with an access gate will be installed around the shaft opening and a load-bearing steel grate floor supported by cross beams with a trapdoor will cover the opening to limit access to authorised personnel only.

7.5.8 Main Tunnel

Excavation of the main tunnel (up to 6,000 m long) between the launch and reception shafts will commence following excavation of the mainland launch shaft and back and forward shunt tunnels, and completion of ancillary infrastructure including a personnel access stairway and passenger hoist, communications, power, drainage, lighting, water supply and ventilation systems.

TBM components (Plate 7.2) will be lowered with a gantry crane to the base of the launch shaft and assembled in the chamber created by the back and forward shunt tunnels. Power supply and bentonite slurry recirculation and spoil removal lines will be connected from the TBM to the surface.

The tunnel will be inclined upward from the mainland to Curtis Island at a grade of 1 in 1,000 in order to provide gravity drainage to a sump in the base of the launch shaft. Water will be pumped to the surface during construction and operation and discharged to Port Curtis after treatment.

Material cut by the TBM will be mixed with a surface-supplied, bentonite slurry to create a spoil slurry. The spoil slurry will be pumped back along the excavated section of the main tunnel and through the launch shaft to the mainland launch site slurry treatment plant.

The slurry treatment plant will process the spoil slurry to remove the bentonite and water, which will be reused in the slurry feed circuit. The remaining tunnel spoil material will be permanently placed in the tunnel spoil disposal areas adjacent to the mainland launch site. Excess water will be treated by the site water treatment plant prior to discharge to Port Curtis or reuse.

As the boring of the main tunnel advances, the tunnel will be progressively lined with 230 mm thick interlocking concrete segments. The void between the concrete segments and excavated tunnel wall will be backfilled with grout (see Figure 7.2). The resulting concrete-lined main tunnel will have an internal diameter of 4 m. Construction ventilation, lighting, drainage, communications and power services (Plate 7.3) will be sequentially installed as the tunnel advances toward the reception shaft.

Precast invert concrete slabs will be progressively installed in the base of the concrete-lined tunnel. The slabs will be fitted with rail tracks and will provide a 2.6 m wide flat working surface at the bottom of the tunnel. During feed gas pipeline installation, low-friction rollers will run on the rail tracks as the pipeline is pulled through the tunnel.

Concurrent with the main tunnel boring, the inclined bore will be drilled from the surface to the end of the back shunt tunnel and lined with a concrete casing. Construction of the reception shaft will also occur concurrently with tunnel boring activities and will be completed prior to the TBM arriving at the reception shaft.

When the TBM breaks through into the reception shaft, the machine will be disassembled at the base of the reception shaft and raised to the surface in sections using a gantry crane. A winch system will be installed in the reception shaft and wire rope will be extended through the main tunnel to the launch shaft and through the inclined bore to the surface where it will be connected to a tow head.

Source: Arrow Energy

Plate 7.1
Typical tunnel boring machine

Source: Arrow Energy

Plate 7.2
Typical launch shaft and TBM segments ready for lowering down shaft

Source: Arrow Energy

Plate 7.3
Typical TBM-bored concrete-segment-lined tunnel

The 132 kV, high voltage electrical cables (three phases) will be installed on steel support racks in conduits in the tunnel using an automated cable-laying machine. The cables will be supplied in minimum 1 km long lengths to minimise jointing of the cable in the tunnel. Two options are being considered for the electrical cable conduits: a conventional steel duct, and a gas-insulated line. The latter would be filled with an inert gas (e.g., sulfur hexafluoride (SF_6)) to insulate the cables, which would be maintained clear of the duct lining by non-conductive spacers.

The proposed feed gas pipeline will be fabricated by welding together the 300-m-long pre-assembled pipeline lengths at the entrance to the inclined bore. The lead section of the pipeline will be connected to the tow head and pulled through the inclined bore and onto low-friction rollers installed on the rail tracks in the main tunnel.

Feed gas pipeline lengths will be progressively welded to the feed gas pipeline string and pulled through the main tunnel on low-friction rollers until it reaches the reception shaft. The winch system will then be disassembled and removed. The end of the feed gas pipeline at the base of the reception shaft will be welded to a length of feed gas pipeline with pre-formed bends to bring the pipeline to the surface. Expansion joints will be installed at the surface to take up movement in the pipeline from the different temperatures and atmospheric conditions experienced in the main tunnel and reception shaft, and the adjacent underground section of pipeline. The expansion joint will be protected by a security fence to exclude unauthorised access.

Additional services may be installed in the tunnel including communication cables, a water supply pipeline and a sewerage pipeline. These will be installed in ducts mounted on the tunnel wall or in ducts in the precast invert slabs.

A diesel-powered, rail-mounted, elevated work platform will provide access through the tunnel during fit out and for inspection and maintenance of the tunnel, feed gas pipeline and services.

7.6 Pipeline Construction Method

Up to 3.7 km (1.6 km on the mainland and 2.1 km on Curtis Island) of the proposed feed gas pipeline will be constructed using conventional pipe laying techniques. The pipeline will be constructed in accordance with the conditions of the pipeline licence issued to Arrow Energy for the proposed Arrow Surat Pipeline (PPL 144).

Construction activities will be undertaken in accordance with the construction safety management plan and construction environmental management plan required under the *Petroleum and Gas (Production and Safety) Act 2004* (Qld) and *Environmental Protection Act 1994* (Qld). The safety management plan will be prepared in accordance with the requirements of AS 2885. The construction environmental management plan will have regard to the Australian Pipeline Industry Association code of environmental practice for onshore pipelines (APIA, 2009).

Pipeline construction activities are typically carried out by what is known as a spread. A spread is the vehicles, plant, equipment and personnel required to sequentially undertake the activities. Road, railway and watercourse crossings are typically constructed in advance of the main spread to ensure uninterrupted progress.

A typical construction spread will not be required for construction of the proposed feed gas pipeline because of the relatively short lengths involved and because of the constraints posed by existing infrastructure. The equipment required to construct the mainland and Curtis Island sections of the feed gas pipeline will include:

- A bulldozer and grader to clear and prepare the ROW.

- An excavator to dig and backfill the pipe trench.
- All-terrain mobile cranes or side-boom tractors for handling the pipe and pipeline.
- Pipe bending machine and welding rig.
- Grit blasting truck for preparing pipe joints.
- Water cart for dust suppression on the ROW.
- Four wheel drive vehicles and buses.
- Pipe transport trucks.

The construction spread typically progresses at a rate of several kilometres per day, except in steep or difficult terrain where progress may be reduced to several hundred metres per day. It is expected that construction of the onshore sections of the proposed feed gas pipeline would proceed at the slower rate.

A construction depot will be required for the storage of materials and pipe. The depot is expected to be located at the mainland launch site.

The following sections describe pipeline construction activities.

7.6.1 Survey and Access

The centreline of the pipeline and ROW boundaries will be marked out to ensure they are clearly defined. A permanent easement of 40 m will be acquired to protect the pipeline, with a 40-m-wide ROW required for construction of the pipeline. The easement and construction ROW may be reduced in difficult areas, for example at the landfall on Hamilton Point. A typical construction ROW layout is shown in Figure 7.6.

Temporary gates will be inserted in fences where they cross the easement to allow the spread to move along and work on the construction ROW. Temporary fencing or barriers will be erected along the construction ROW to ensure construction activities do not encroach on environmentally and culturally sensitive areas flagged as ‘no go’ areas.

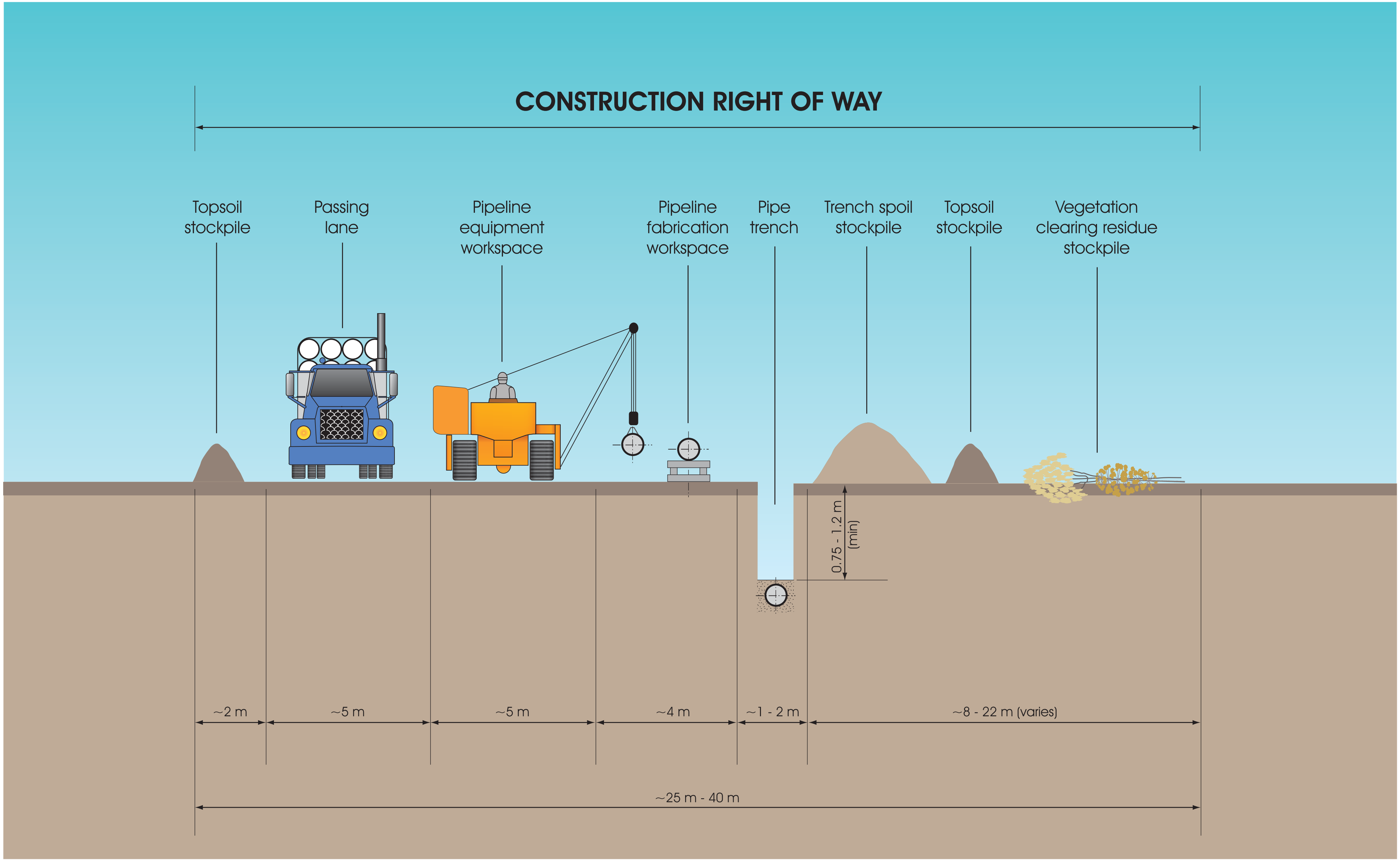
The location and extent of any identified contaminated soils will be marked out to facilitate the management, treatment and disposal or remediation of the soils. Contaminated soils or the potential for such soils to exist has been established through an environmental site (phase 1) assessment undertaken as part of this EIS. Preconstruction flora and fauna surveys and Indigenous cultural heritage surveys will be carried out prior to clear and grade activities.

7.6.2 Clear and Grade

Native vegetation and topsoil will be removed from the construction ROW in this activity. Cleared vegetation will be stockpiled on the construction ROW for reuse in rehabilitation. Millable timber may be set aside for recovery or use by the landowner.

Topsoil will be removed to one or both sides of the construction ROW by a grader and stockpiled separately to the trench spoil to ensure topsoil and subsoils are not mixed. The construction ROW will be levelled to the required gradient using graders, excavators and bulldozers.

During this activity, silt fences and erosion control berms will be established to ensure stormwater runoff from the cleared ROW does not cause erosion and sedimentation of the ephemeral watercourses or intertidal mudflats.



Source: Arrow Energy

coffey environments	Job No: 7033	Arrow Energy	arrow energy go further	Typical construction right of way layout	Figure No: 7.6
	File Name: 7033_07_F07.06_HU	Arrow LNG Plant			

7.6.3 Stringing

Pipe, in 12 m lengths, will be delivered to the construction ROW from a stockpile, most likely at the mainland launch site where construction laydown areas will be established.

Stringing (Plate 7.4) involves laying the pipe lengths end to end along the construction ROW in preparation for welding. Excavators with pipe lifting (vacuum lift) devices will lift the pipe from pipe transport vehicles and place it adjacent to the trench on sandbags or blocks to protect the pipe coating. Where required, pipe lengths will be bent using a hydraulic bending machine to match changes in either the vertical or horizontal alignments of the pipeline.

7.6.4 Pipe Welding, Coating and Testing

Once the pipe is strung, the individual 12 m long sections of pipe will be aligned using internal line-up clamps and welded together to form the pipeline. As each pipe is welded to the pipeline, the joint is tested for structural integrity (using non-destructive methods) and, if it passes, the joint is grit blasted and coated (Plate 7.5). If the joint fails the test, the faulty material is removed and the joint is rewelded before again being tested, prepared and coated. The pipes will be welded into strings of several hundred metres or in shorter lengths where bends are close.

7.6.5 Trenching

The depth of the trench will be determined by a risk assessment conducted in accordance with AS 2885, with the minimum depth of cover being 750 mm and 1,200 mm for creek and infrastructure crossings. The trench depth will depend on the diameter of the pipeline and the current or anticipated use of the land. It is expected it would be at least 2,000 mm to 2,500 mm for the proposed feed gas pipeline.

An excavator will be used to excavate the trench. The length of trench opened will depend on the terrain, weather conditions and workspace constraints. Trench spoil will be stockpiled separately from topsoil on the non-working side of the construction ROW. Acid sulfate material excavated will be treated in situ in accordance with relevant guidelines and used as backfill in the trench.

Breaks in the trench will be left at drainage lines and to facilitate wildlife crossing. Structures to minimise fauna entrapment and mortality (e.g., trench plugs, ramped ends of trench, safe havens including damp sandbags) will be installed in the pipe trench. These fauna egress points will be placed at appropriate distances. Additional breaks in the trench will be left for access tracks, watercourses, drains, roads, railways and buried services crossed by the pipeline.

7.6.6 Cement Australia Railway Crossing

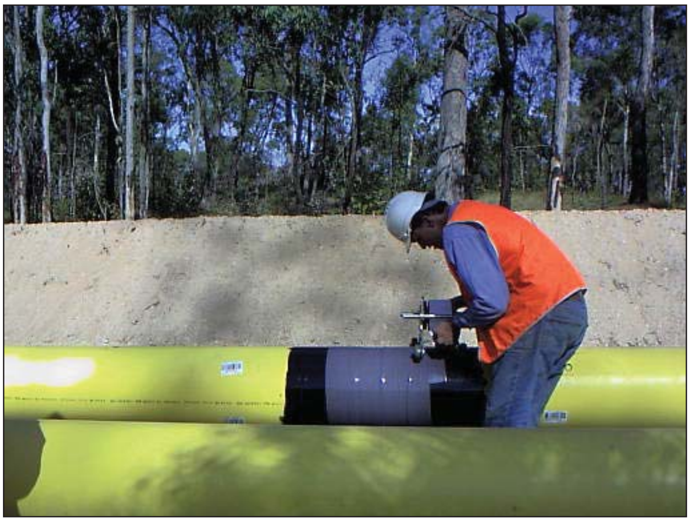
The Cement Australia railway will be crossed by horizontal or thrust boring. Horizontal boring involves drilling a horizontal bore under the railway. To enable a horizontal drill, bell holes will be excavated either side of the railway. The boring machine will be placed in one of the bell holes and it will drill under the railway to the other bell hole. A duct will be installed in the borehole to protect the pipeline. Pipe lengths will be pushed into the duct one length at a time with welding, testing and coating taking place in the bell hole. The inserted pipeline section will be further protected by pumping grout between the duct and pipeline to seal the void.

7.6.7 Lowering In and Backfilling

Prior to lowering the pipeline into the trench, padding material will be placed in the bottom of the trench to protect the pipe coating from damage. Padding material is typically sand or sifted subsoil, which is prepared by a padding machine. Trench spoil (subsoil) is expected to be used for padding.

Source: Arrow Energy

Plate 7.4
Pipeline stringing



Source: Arrow Energy

Plate 7.5
Coating and wrapping of the pipe joint

Source: Arrow Energy

Plate 7.6
Pipeline being lowering into the trench

All-terrain mobile cranes or excavators with pipe laying heads will progressively lower the pipeline into the trench (Plate 7.6). The laid pipeline will be protected with a layer of padding material. The trench will be backfilled with the excavated soil, with the horizons placed in the opposite order to which they were excavated to avoid soil inversion. Any excess material will be disposed of in accordance with landowner requirements.

Excavated material will be bladed into the trench by a grader or bulldozer. The material will be placed in layers and wheel rolled to provide compaction and prevent subsequent settlement. A crown will be formed to allow for settlement.

Where required, impermeable trench blocks known as trench breakers will be installed prior to backfilling of the trench. These will control water movement along the backfilled trench. Trench breakers are commonly installed adjacent to watercourses, on steep slopes or where drainage patterns change.

7.6.8 Hydrostatic Testing

The pipeline will be tested in sections to verify its integrity. Pipeline integrity will be tested using water pumped into the pipeline section; hence, the term hydrostatic testing. Hydrostatic testing will involve pressurising the pipeline to, and above, its nominal maximum allowable operating pressure for a specified period of time. Instruments attached to the pipeline will detect any loss of pressure resulting from a failed weld or defect in the pipeline (Plate 7.7). Failed welds and damaged pipe identified during the hydrostatic testing will be excavated and repaired before the pipeline is tested again.

Hydrostatic test water for the proposed feed gas pipeline will most likely be seawater or fresh water. If biocides or oxygen scavengers are added to the hydrostatic test water, the water will be tested and treated as necessary, prior to discharge. To reduce the volume of water required for hydrostatic testing, the hydrostatic test water can be passed sequentially from one section of the pipeline to the next before it is finally discharged. Hydrostatic testing procedures, including water sourcing and disposal, will be determined during detailed design.

7.6.9 Dewatering and Drying

After satisfactory hydrostatic testing of a pipeline section, it will be dewatered and dried using swabbing or cleaning pigs. A pipeline inspection gauge (pig) is propelled by air or gas pressure between a launcher and receiver station or between hydrostatic test sections to clean pipelines, provide physical barriers between different substances being conveyed in the pipeline during commissioning and to inspect the pipeline for defects.

The swabbing or cleaning pigs will be passed through the test section using oil-free compressed air until the acceptance criteria for dryness and cleanliness are met. The criteria will be set out in the dewatering and drying procedures to be developed and approved prior to the commencement of hydrostatic testing. When clean and dry, the test section will be tied in to any preceding sections and left sealed and full of dry air in readiness for commissioning.

7.6.10 Cathodic Protection System and Pipeline Markers

This activity involves installing and testing the cathodic protection system, and installing pipeline marker posts over the pipeline centreline to alert people to its presence (Plate 7.8). Pipeline marker posts will be installed in accordance with the requirements of AS 2885, which requires the marker posts to be intervisible, i.e., the adjacent marker posts in each direction must be visible from the marker post located and visited by the observer. Marker posts are placed closer together at bends, on either side of road crossings, at fences and at watercourse crossings.

Source: Arrow Energy

Plate 7.7
Leak detected in hydrostatic test of pipeline

Source: Arrow Energy

Plate 7.8
Typical pipeline marker post

Source: Arrow Energy

Plate 7.9
Typical intelligent pig

7.6.11 Rehabilitation

Areas disturbed during construction, including the construction ROW, access tracks and pipe stockpile areas will be cleaned up and rehabilitated as soon as practicable after pipe laying and backfilling the trench. Rehabilitation will involve removal of foreign material (construction material and waste), surface contouring, respreading topsoil, spreading vegetation clearing residue and revegetation.

Stable landforms that reflect the original topographic contours and natural drainage patterns will be reinstated. Erosion control measures (e.g., contour banks, filter strips) will be installed in areas prone to erosion, including adjacent to waterways and drainage lines. To promote vegetation regrowth and protect against the loss of topsoil, the construction ROW surface will normally be lightly scarified prior to respreading of topsoil.

Where native vegetation and fauna habitat has been disturbed, revegetation will be undertaken using clearing residue spread over the construction ROW to assist with natural regeneration. Revegetation will comprise groundcover and shallow-rooted shrub species, as tree roots may interfere with the pipeline coating leading to possible corrosion. Where planting is required, seedlings propagated from seed stock of local provenance will be used.

The success of rehabilitation will be monitored for evidence of subsidence, poor soil management and failed revegetation for up to two years following completion of pipeline construction. Monitoring will be conducted on a quarterly basis and following major storm events and incorporate the use of photo reference points to document rehabilitation progress. Any areas not demonstrating successful rehabilitation will undergo further soil treatment, erosion protection works, weed control and revegetation until the vegetation is self sustaining. Successful rehabilitation will be indicated by measurable growth in the native vegetation communities.

7.7 Associated Pipeline Construction Activities

The following sections describe associated pipeline construction activities.

7.7.1 Construction Water Supply

Water will be required for dust suppression and concrete batching during construction of the proposed feed gas pipeline, and for rehabilitation activities. Access tracks and the construction ROW will be watered to suppress dust using a water truck, with the frequency of watering depending on prevailing weather conditions. Approval will be sought from the relevant authority to source the required water. It is estimated that up to 2 ML of water may be required for dust suppression, revegetation and other construction activities during the pipeline construction period.

7.7.2 Stormwater Management

Stormwater runoff from buildings and roofed areas at the pipeline construction area will be collected in tanks and used for ablutions.

7.7.3 Traffic Management

The proposed feed gas pipeline does not cross any local government or state-controlled roads and consequently, it is anticipated that a traffic management plan will not be required for road crossings. A plan might be required for access off the Gladstone–Mount Larcom Road, as this will be located in a highly trafficked section of that road. The traffic management plan, if required, will be prepared in consultation with the Department of Transport and Main Roads, Gladstone

Regional Council and Queensland Police Service and implemented prior to construction of the feed gas pipeline.

7.7.4 Waste Management

The Environmental Protection Act, Environmental Protection Regulation 2008, Environmental Protection (Waste Management) Regulation 2000 and Environmental Protection (Waste Management) Policy 2000 govern waste management associated with the development, operation and decommissioning of the proposed feed gas pipeline.

Relatively small amounts of domestic and industrial waste will be generated during construction and operation and maintenance of the feed gas pipeline. Waste management will be based on waste avoidance, minimisation and recycling before disposal. A licensed waste disposal contractor will be engaged to remove and dispose of all wastes from the construction site.

Typical construction wastes include:

- Road base for laydown areas and access track crossings.
- Packaging (ropes, cardboard), fibre/nylon rope spacers, drums and scrap metals.
- Used chemicals and oils, e.g., lube oil, spent x-ray film developer chemicals, used tins from solvents, rust proofing agents or primer.
- Discharged abrasive blasting media (garnet).
- Scrap welding rods (stub ends) and grinding discs.
- Horizontal directional drilling cuttings and tailings.
- Hydrostatic test water.
- Construction depot wastes including putrescibles, paper, timber, plastic piping and wastewater.

Typical operation wastes include:

- Sludge from pigging operations.
- Packaging.

7.8 Pipeline Commissioning

The pipeline will be commissioned following completion of hydrostatic testing, cleaning and drying. Commissioning will be in accordance with AS 2885 and a procedure prepared during detailed design. Commissioning activities include testing the cathodic protection, instrumentation and SCADA systems, purging and filling the pipeline with gas, and undertaking performance tests.

Purging involves removing air from the pipeline prior to the introduction of gas to ensure safe entry of the gas. The initial gas purge will be preceded by the introduction of a slug of an inert gas, typically nitrogen. A number of foam pigs will be used to separate the dry air present in the pipeline and the gas, thereby minimising the likelihood of a potential explosion due to the build up of a volatile air/gas mixture.

During purging, air will be discharged from the downstream end of the section being commissioned – typically at an isolating valve – followed by the nitrogen slug, then the gas. As there is some mixing of the slugs, the gas initially contains some nitrogen. Venting will continue until a pure gas stream is detected at the outlet (valve), after which the valve will be closed and the pipeline pressurised to its minimum operating pressure (typically 3,000 kPa).

Volumes of gas discharged at this time are very small, as the mixing occurs over short distances and most of the discharge is at pressures slightly above atmospheric pressure. The low pressure fill enables leak testing at low pressures to be undertaken prior to the pipeline reaching its nominal operating pressure. There are no further gas discharges once the pipeline has been tested for leaks.

7.9 Pipeline Operation and Maintenance

The proposed feed gas pipeline will be operated in accordance with approved documentation, the operation environmental management plan, AS 2885 and the APIA code of environmental practice for onshore pipelines (APIA, 2009).

Operation and maintenance activities include regular inspection, maintenance of aboveground pipeline infrastructure, repairs to the pipeline and cathodic protection system, and remedial works to address unsuccessful rehabilitation.

7.9.1 Inspection

Regular inspections of the proposed feed gas pipeline and ancillary infrastructure, conducted by vehicle and on foot, will ensure:

- There are no unauthorised activities occurring on the easement including construction of buildings, excavation and removal of soil or other activities that might pose a risk to the pipeline.
- There is no erosion, land degradation or weed infestations occurring as a result of construction and maintenance activities.
- Pipeline facilities are secure and operating correctly.

7.9.2 Maintenance Activities

Unsuccessful rehabilitation will be remediated and weeds controlled. Vegetation on the easement will be managed to discourage deep-rooted vegetation directly above the pipeline and encourage grass and shallow-rooted groundcover shrubs elsewhere to maintain a stable landform. The line of sight between pipeline marker posts will be maintained through selective vegetation clearing.

Minor maintenance activities will include servicing the cathodic protection and SCADA systems, and periodically operating valves to ensure their availability in the event of an emergency.

Sacrificial anodes and faulty test points of the cathodic protection system will need replacing periodically. This will involve excavating the pipeline or anode bed to expose the anode or test point connection and replacing the faulty parts.

Corrosion found during internal inspection of the pipeline by using intelligent pigs (Plate 7.9) that detect defects in the pipe wall and/or coating or damage to the pipeline from third parties will be repaired by excavating the affected length of pipe and repairing or replacing it.

The repair and replacement of cathodic protection system components and sections of the gas pipeline will involve similar activities to those undertaken during construction, but with a small workforce and minimal vehicles, plant and equipment. Exposure of the pipeline for repairs or replacement will typically involve excavation of a bell hole in which the works are carried out. Excavation and backfill of the bell hole and pipeline repairs will be conducted in accordance with the requirements of the operation environmental management plan and APIA code of environmental practice for onshore pipelines (APIA, 2009).

7.10 Pipeline Decommissioning

When the pipeline is no longer required, it will be decommissioned in accordance with the regulatory requirements and accepted environmental best practices of the day. Currently, decommissioning procedures require the removal of all aboveground infrastructure and the restoration of associated disturbed areas.

At the time of decommissioning, a decision will be made regarding the opportunities for future use of the pipeline. The following two options will be considered:

- Mothballing – this would involve depressurising the pipeline, capping and filling it with an inert gas (such as nitrogen) or water with corrosion inhibiting chemicals. The cathodic protection would be maintained to prevent the pipeline corroding. A monitoring program would be maintained.
- Abandonment – this could involve purging the pipe of gas, disconnecting it from the manifolds and removing all aboveground facilities. The pipe would then be filled with water and left to corrode in situ. Removing the pipe from the ground is unlikely to be an environmentally or commercially viable option. A detailed rehabilitation program would be developed and implemented in consultation with landholders and the relevant regulatory agencies at the time of abandonment.