4. PRODUCING AND EXPORTING THE LNG

4.1 Overview

The proposed LNG Facilities site for the Papua New Guinea Liquefied Natural Gas Project (PNG LNG Project) is located approximately 20 km northwest of Port Moresby at Caution Bay, on the south coast of PNG's Central Province. The combined area of the facilities is approximately 700 ha.

The LNG Facilities site was selected over alternatives on the north coast of Papua New Guinea and to the west along the shore of the Gulf of Papua (see Section 7.5, LNG Facilities Location Options).

The LNG Project Gas Pipeline will make landfall on the northern part of the facility site. The gas delivered by the pipeline will then be processed, cooled and loaded via the LNG storage tanks and jetty onto LNG carriers and exported to the international market.

The functional and safety objectives for the LNG Facilities are one and the same: a design that is safe and meets environmental, regulatory, constructability and operability requirements.

The main components of the LNG Facilities are:

- A plant to process the gas into LNG (the LNG Plant) with associated utilities and offsites (offsites refers to equipment and facilities that support the LNG processing train(s) and the plant utilities).
- A combined causeway and trestle jetty (the LNG Jetty) with an LNG export berth and a condensate export berth.
- A wharf (the Materials Offloading Facility) at the end of the causeway section of the LNG Jetty to receive materials, equipment and construction machinery delivered by barge.
- A 7,500-person temporary construction camp.
- Upgrading and rerouting an existing public road.
- Desalination facilities to provide water at the site during construction and operations.

ExxonMobil Engineering Practices System (EMEPS) will serve as the basis for project design specifications. The EMEPS is described in Section 2.1, Introduction.

This chapter describes:

- The LNG Plant (Section 4.2), its associated infrastructure (Section 4.4) and the LNG Jetty and Materials Offloading Facility (Section 4.3).
- How construction will be carried out (Sections 4.5 to 4.10).
- How the LNG Facilities will be operated and maintained (Sections 4.11 and 4.12).
- How the various facilities will be decommissioned at the end of the project life (Section 4.13).

4.2 Description of the LNG Facilities

This section describes the natural gas liquefaction plant (LNG Plant), its utilities and offsites, and its future development. The marine facilities portion of the LNG Facilities is described in Section 4.3, Description of the LNG Jetty and Materials Offloading Facility, and supporting infrastructure for the LNG facilities is described in Section 4.4, Description of the LNG Facilities Site Supporting Infrastructure.

4.2.1 Proposed Site and General Arrangement

4.2.1.1 Site

The LNG Facilities site occupies flat land mostly cleared for cattle grazing. Remnant vegetation is largely confined to a coastal mangrove fringe and riparian forest along the banks of the Vaihua River. Apart from the coastal strip, the site is held in freehold title, but grazing has been replaced by the customary and subsistence activities of local people (see Chapter 12, Receiving Onshore Environment: LNG Facilities).

4.2.1.2 Layout Planning and Design Process

The layout of an LNG Facilities site is fundamental to efficiency and safety. In the case of the PNG LNG Project, the layout has been developed by a sequential planning and design process, as follows:

- Pre-FEED (2007): Preparation of a preliminary design, based on analogues from other LNG plants and a review of international standards (principally covering spacing of items within the plant).
- FEED (2008): Refinement of the layout on the basis of a systematic review of PNG, international and company standards and of the results to a risk assessment assuming generic process equipment.
- Engineering, Procurement and Construction (2008 to 2013): Preparation of tenders for the engineering, procurement and construction contract and revision of the layout according to the specified equipment and repetition of the risk assessment (2008 to 2009) and final design adjustment (2009 to 2013) of the layout on the basis of actual equipment and detailed information on site conditions.

4.2.1.3 LNG Facilities Layout

The FEED layout (see above), which is the basis of this EIS, reflects the following functional and safety considerations and the LNG Facilities safety philosophy.

Functional Efficiency

- Constructability (installation of equipment and systems) and alignment with the construction execution plan.
- Access for normal operation and maintenance.
- Isolation of equipment within prescribed isolation boundaries so that maintenance activities can be performed without affecting the parts of the process that remain in operation.

- Protection of critical facilities from damage during normal operations, plant upsets and emergency situations.

Safety

- A project specific Safety Plan to perform risk assessments for various site activities as a means of safeguarding the public from all activities associated with project execution.
- Blast and gas dispersion analysis, to determine separation of employees and of persons and property beyond adjacent property lines from potential environmental or health risks.
- Access for operators to perform emergency shutdowns, fire fighting or other emergency response.
- Facilitate personnel escape and rescue in the event of an emergency.
- Production, storage, venting and flaring facilities to reduce the risk of collateral damage from potential events (e.g., fire and/or explosion).
- Segregate toxic or highly reactive materials and high-risk facilities.
- Separate and place upwind continuous ignition sources (e.g., fired heaters and incinerators, gas turbines and flares) from potential points of release of flammable materials.
- Separate air intakes (building pressurisation, combustion air to turbine, heater, etc.) from potential releases of combustible or toxic vapours.
- Separate equipment to minimise the effects of a fire or explosion on other parts of the plant.
- Site security.

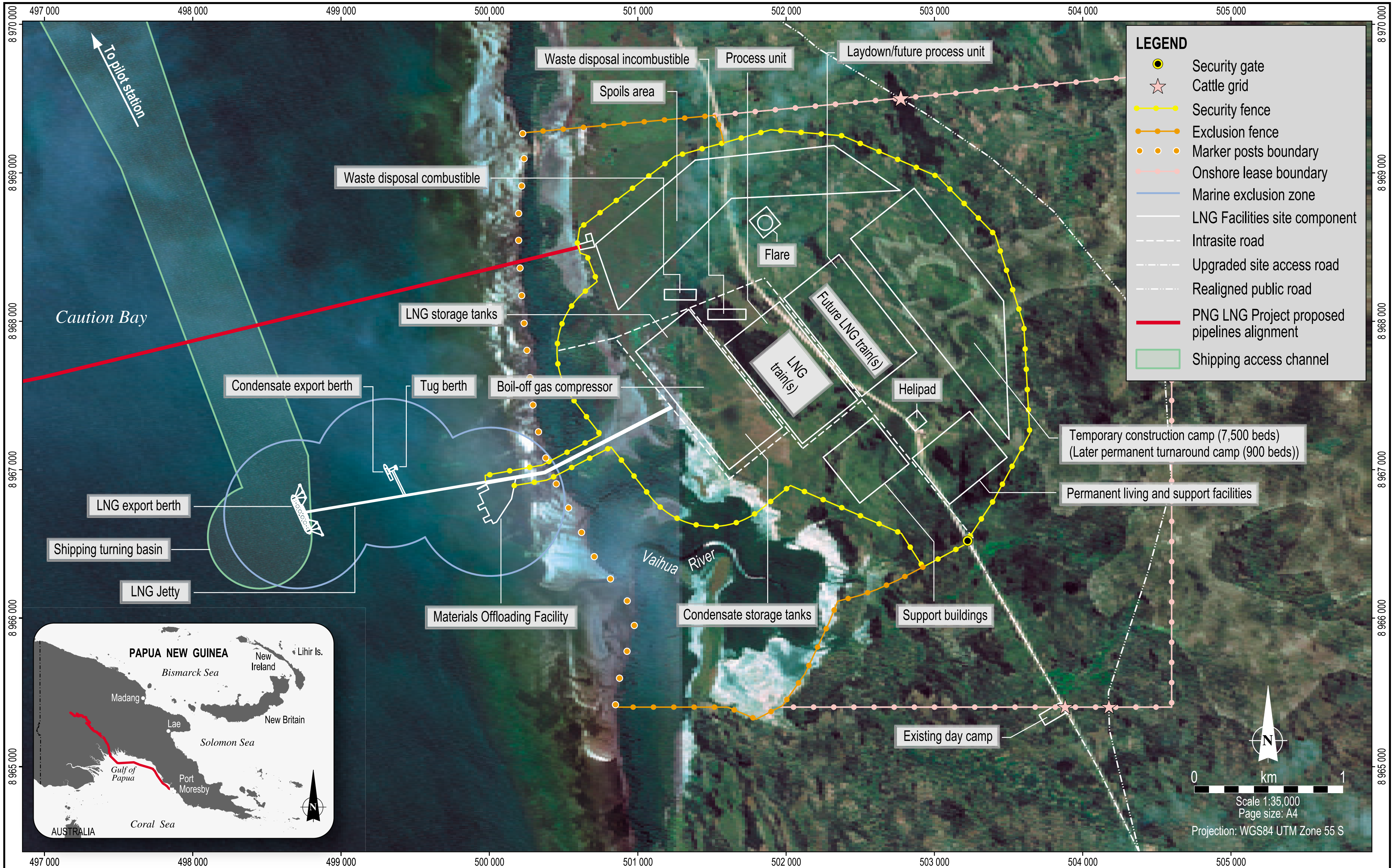
Figure 4.1 shows the FEED site layout, which makes provision for these factors.

LNG Facilities Safety Philosophy

For the PNG LNG Project, Esso has drawn on accident scenario modelling (see Attachment 1, LNG Safety); on the now substantial operating experience of the LNG industry as a whole as embodied in the PNG standards (or surrogates), American Petroleum Institute standards, the US National Fire Protection Association standards, ExxonMobil standards; and on other standards, criteria and guidelines relevant to safe planning, design and operation (see Section 27.3, Project Risk Management Approach and Design Criteria, and Attachment 3, Technical Codes and Standards).

The following multi-layer safety philosophy applies, the objectives of which are loss prevention and, thereby, the protection of workers and the community:

- Incident prevention by planning and design:
  - Primary containment.
  - Spacing between facility components.
  - Isolation systems.
  - Minimise flange connections.



Note:
Layout is indicative only.
Final placement of all components is contingent on pending soil and geological data.
Pipelines approximate the proposed alignment based on engineering data provided up to 1 October 2008.

PNG LNG

Date: 04.09.2008
MXD: PNG_LNG_Project_GIS.mxd
File Name: 1284_09_F04.01_GIS_HB

Esso Highlands Limited

PNG LNG Project

Proposed LNG Facilities site layout

Figure No: 4.1

PGGP-EN-SRENV-000001-001
Rev0

  - Fire-safe valves.
  - Ignition source control.
  - Emergency shutdown and de-pressurisation.
  - Pressure relief, flare and vapour disposal.
  - Air-ingress controls.
  - Vibration and surge monitoring.
  - Equipment health monitoring.
  - Facility data historian.
  - Alarms.
  - Fire proofing of vessel or equipment supports, structural steel, cables instrumentation.
  - Blast and drop protection.

- Fire and gas detection, control, and alarm systems:
  - Combustible or toxic gas.
  - System temperatures and pressures.
  - Status of automatic fire suppression systems.
  - Optical flame detectors.
  - Heat detectors.
  - Manual call points.

- Incident control (fire control systems):
  - Fire hydrants and monitors (manual and remotely operated).
  - Deluge, foam and water mist systems.
  - Buried or protected above-ground fire water piping and isolation valves.
  - Fixed water sprays.
  - In-built, engineered extinguishing systems.
  - Nitrogen snuffing systems.
  - Portable fire extinguishers.

- Incident control (procedures):
  - Depressurisation of vessels.
  - De-inventory of vessels.
  - Isolating fuel flow/limiting fuel availability.
  - Shutting down units.
  - Actuating suppression/exposure cooling systems.
  - Setting up fire fighting operations and evacuation.

- Mitigation measures to prevent escalation and limit the consequences of an incident (spill containment and safety setbacks):
  - Safety zones around LNG ships.
  - Safe setback distances.
  - Secondary containment for leaks and spills.

The latter two mitigation measures are discussed in more detail below.

Setbacks. The LNG Facilities design and its operating systems are intended to prevent unsafe conditions from occurring. In the case of the ‘blast and gas dispersion analysis’ mentioned under ‘Safety’ above, the design and operating systems are backed up by separations, called setbacks, between possible flammable material at an LNG facility and the general public. These setback distances have been determined by modelling the vapour dispersion and pool fire thermal flux (heat radiation) hazards arising from hypothetical LNG release scenarios. The modelling resulted in a safe setback distance of 1 km.

Containment. The plant design also makes provision for reducing the potential of an accidental discharge of LNG endangering adjacent property or important process equipment or reaching waterways. Spill- and leak-containment impoundments (bunds) are located around process areas, vaporisation areas, and transfer and storage areas for LNG, flammable refrigerant and other flammable liquids in line with NFPA Standard 59A (NFPA, 2009). These bunds have been designed to ensure that gas at a dangerous concentration is unlikely to escape the bunds.

4.2.1.4 Fencing and Exclusion Zones

Fencing and exclusion zones are shown in Figure 4.2 and are described below.

Lease Boundary Fencing and Exclusion Fencing

A 10,000-m-long lease boundary fence, constructed of posts and three strands of barbed wire, will be erected along the boundary of Portion 2456 to delineate the lease area under project control. Cattle grids and signage on the realigned public road will indicate when vehicles are entering and leaving the project lease area. This area will not be patrolled regularly, as the intention is to mark the area that is not available for settlement.

A 4,100-m-long exclusion fence, constructed of posts and five strands of barbed wire, will border the intertidal mangrove and saltflat exclusion areas of the coastal strip lease (Portion 2457) to exclude access to this area. Along the shore, this exclusion area will be marked using star pickets or similar. The exclusion area will be regularly patrolled on foot or by boat or vehicle to remove trespassers.

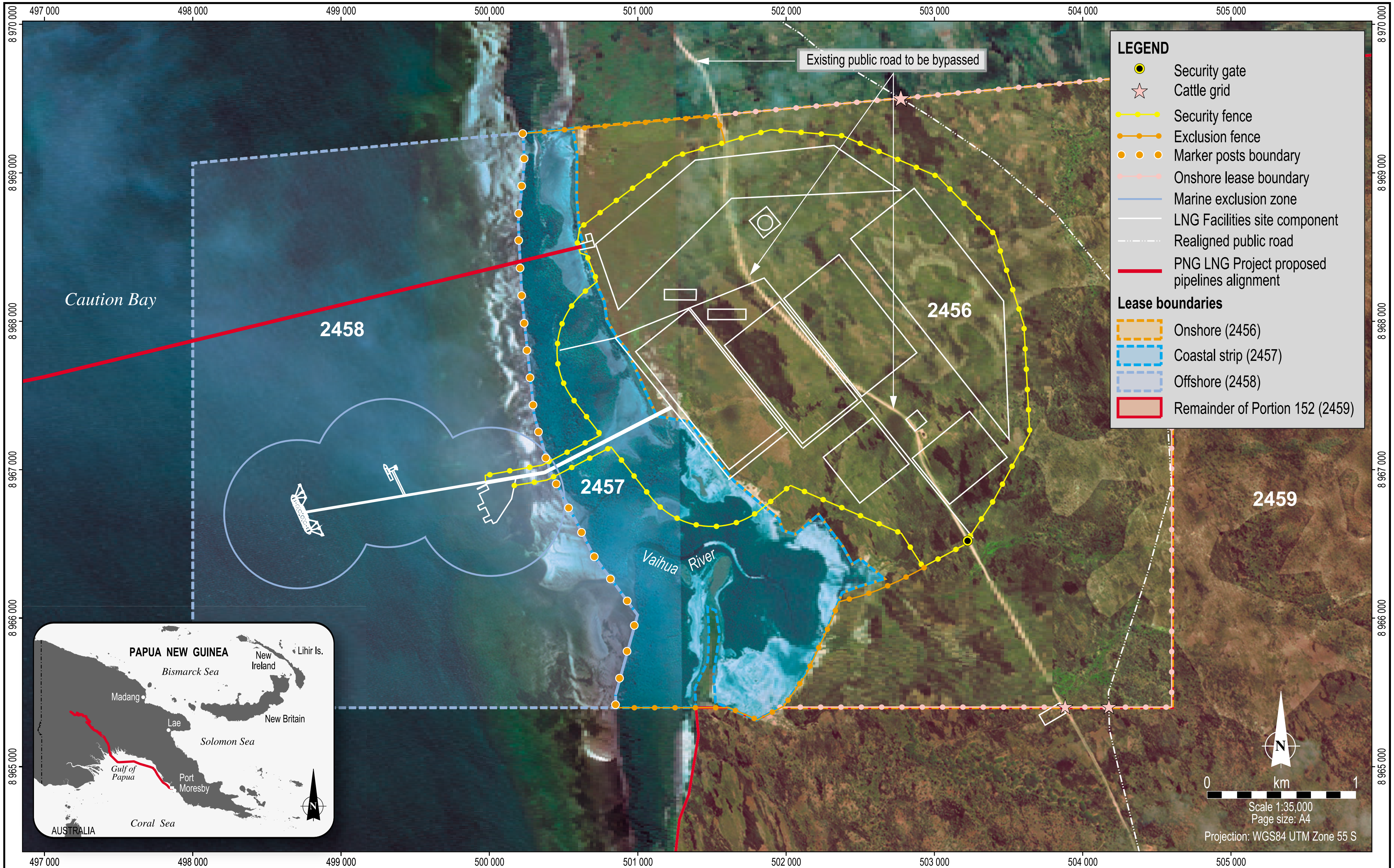
The lease boundary and exclusion fencing have been sited to provide a buffer zone and a margin of confidence that the LNG safety setbacks and guideline noise and air emission values will be met at any dwelling that may be built on land outside of but adjacent to the fencing in the future.

Security Fence

Inside the lease boundary fence, a 1,260-m-long security fence will surround the LNG Facilities site, extending seaward along either side of the earthen causeway to the Materials Offloading Facility. The entire length of the security fence will be equipped with an electronic intrusion detection system. Vehicle gates at the LNG Facilities site entry points will be designed to withstand ramming. The security fence will be 3 m high, topped by coiled razor tape. It will extend below the ground surface to deter tunnelling.

A 6-m-wide road will be constructed along the inside of the security fence for maintenance and security patrols by vehicle or foot. These patrols will occur as often as deemed operationally necessary.

The purpose of the security fence is to prevent access to the LNG Facilities site during construction and operation by all but those persons with appropriate authorisation to enter.



Note:
Layout is indicative only.
Final placement of all components is contingent on pending soil and geological data.

PNG LNG	Date: 22.10.2008 MXD: PNG_LNG_Project_GIS.mxd File Name: 1284_09_F04.02_GIS_HB	Esso Highlands Limited PNG LNG Project	LNG Facilities fencing and exclusion zones

Figure No:
4.2

The approximately 1,000 ha between the security fence and the lease boundary fence will serve as a noise and air quality buffer between the plant and neighbouring receptors (see Section 20.8, Air Quality, and 20.9, Noise).

Marine Exclusion Zones

Consultation will be held with people from the nearby coastal villages prior to and during construction in order to explain the need for (i.e., the safety case) and the procedures for enforcing the marine exclusion zone. A combination of patrol boats and marker buoys will be used to indicate and enforce the 500-m marine exclusion zones around the LNG Jetty (during LNG carrier and condensate loading) and the Materials Offloading Facility (during materials offloading). At other times, visual surveillance, warning sirens and use of patrol boats (if necessary) will be used if small boats enter the marked exclusion zone.

A project security management plan will be developed as part the environmental management plan and will detail how the exclusion zones will be managed.

4.2.1.5 Public Road Upgrade from Port Moresby to the LNG Facilities Site

The existing public road between Port Moresby and the site will be used to transport personnel, equipment and material to the LNG Facilities site from Jacksons International Airport and from the Port of Port Moresby during both construction and operations. Sections of the road will need to be upgraded and/or widened, particularly through Baruni village and leading into Baruni junction, where the surface is poor and buildings crowd the narrow road. There are no bridges between the LNG Facilities site and Port Moresby, but culverts will need to be upgraded.

4.2.1.6 Rerouted Public Road

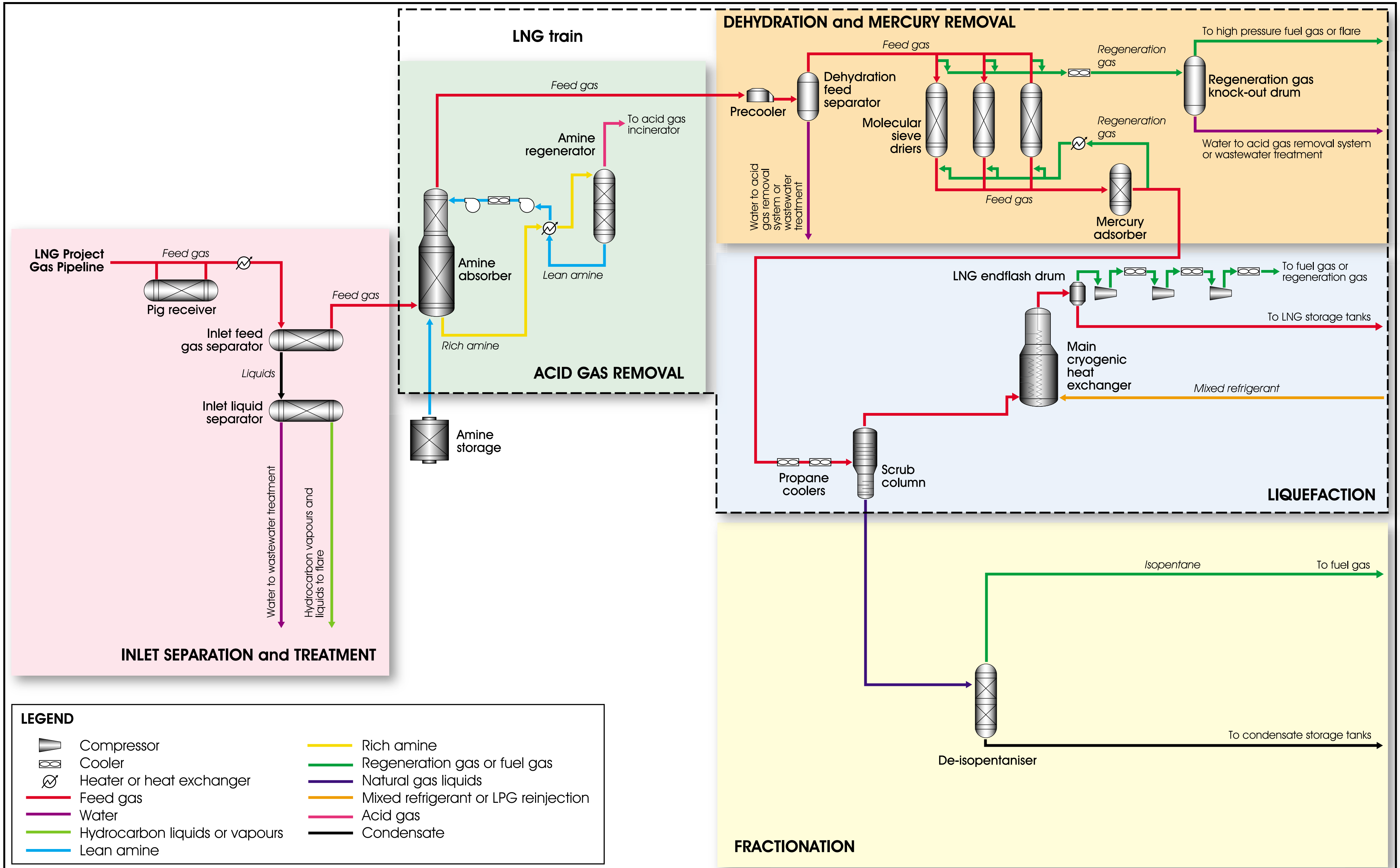
Approximately 8.3 km of the existing public road through the future LNG Facilities site will be rerouted around the security fence (see Figure 4.2) early in the construction process. The rerouted road will be approximately 900 m longer and of at least an equal standard to the existing road.

4.2.1.7 Intrasite Roads and Walkways

Intrasite roads and walkways will link the process, utilities, offsites (e.g., diesel storage and flare), and camp facilities and will be illuminated at night. The portion of the former public road within the site will be widened by 3.6 m and become part of the intrasite roadway network. The portion of the public road from the diverted road turnoff to the security fence will be upgraded as access to the LNG Facilities site.

4.2.2 LNG Plant

The LNG Plant will receive and process 1,133 kSm^3/hr (960 Mscfd) of gas into approximately 6.3 Mtpa of liquefied natural gas. The LNG Plant will receive gas from the LNG Project Gas Pipeline, treat it and then liquefy it using refrigerants. It may produce refrigerant make-up and will produce condensate in a fractionation system. Figure 4.3 is the simplified process flow diagram for the plant.



PNG LNG

Job No: 1284

File Name: 1284_09_F04.03_HB

Esso Highlands Limited

PNG LNG Project

Simplified process flow diagram of the LNG Plant

Figure No: 4.3

PGGP-EN-SRENV-000001-001
Rev0

Plates 4.1 and 4.2 show the SEGAS LNG facility in Egypt as an example of what an LNG facility looks like.

In simple terms, the process removes impurities or hydrocarbons that are heavier than methane from the gas and then cools the gas sufficiently to turn it into a liquid. Specifically, the LNG Plant will:

- Heat the incoming gas from the pipeline, reduce its pressure, and remove any liquids entrained with the gas.
- Remove acid gas, residual moisture and mercury from the feed gas.
- Liquefy the feed gas.
- Fractionate the hydrocarbon liquids produced during the liquefaction process into condensate (pentane and heavier hydrocarbons) for export.

The components and process are described further below.

The LNG train(s) will include a process pipe rack (Plates 4.3 and 4.4). Another 11 pipe racks will interconnect to carry piping around the plant site, the utilities and offsites area, and the marine facilities.

Greenhouse gases from emissions from sources within the LNG facilities are given in Section 26.3.3, Emissions from LNG Facilities Site).

4.2.2.1 Feed Gas Processing

Inlet Separation and Treatment System

The inlet facilities at the LNG Plant will receive a single-phase gas from the LNG Project Gas Pipeline at a pressure of 7,500 kPag and a temperature of between 14°C and 21°C. The gas will have been conditioned to a water and hydrocarbon dewpoint of 5°C at the Hides Gas Conditioning Plant. Preliminary conditioning may also occur in the associated oil fields' modified production facilities (described in Section 2.3, Description of the Gas Processing Facilities) to prevent liquids from forming in the pipeline.

The hot oil system (described in Section 4.2.3, LNG Plant Utilities) will heat the gas to prevent hydrate formation and to meet the amine absorber feed gas temperature requirement. The warmed gas will be depressurised and flow to the inlet feed gas separator, which will remove occasional small liquid slugs. The inlet liquids separator will receive these liquids (if present) and send the hydrocarbons to fractionation for processing into condensate. The produced water stream will be sent to the wastewater treatment system (see Section 4.2.4.5, Wastewater Treatment Systems) for disposal.

Feed gas from the inlet feed gas separator will be metered ahead of final treatment before liquefaction to remove acid gas, residual water and traces of mercury (if any; see Mercury Removal System below).

Plate 4.1
Night view of SEGAS LNG facility in Egypt

Plate 4.2
Close-up of SEGAS LNG facility in Egypt

Plate 4.3
A process pipe rack 70% completed

Plate 4.4
Typical pre-assembled pipe rack

Plate 4.5
LNG jetty at Tangguh LNG

Plate 4.6
Barge-mounted desalination plant

Acid Gas Removal System

Impurities in a gas stream, such as hydrogen sulfide and carbon dioxide, are collectively referred to as acid gases. In this project, the only acid gas expected is low amounts of carbon dioxide, which will freeze at cryogenic liquefaction temperatures and thereby block the natural gas flow path. However, there is a three to fourfold increase in carbon dioxide content over the life of the project, which is accommodated in the design of the acid gas removal system (see Section 4.2.5, LNG Future Plant Development). Other contaminants, such as hydrogen sulfide, sulfur, mercury and mercaptans, do not change over the life of the project.

An amine solvent (amine mixed with water) will be used to remove acid gas, as follows.

Acid Gas Removal. Feed gas warmed to approximately 35°C from the metering station enters the bottom of the amine absorber. The amine solvent enters the absorber near the top and flows counter-current against the gas being treated, so that the freshest solvent contacts the cleanest gas first. The solvent progressively absorbs the acid gases and exits the bottom of the amine absorber.

The treated ('sweetened') feed gas then flows from the top of the amine absorber to the dehydration system. From this point, it can also be vented to the wet flare in the event of an upset or during start up (see Section 4.2.4.3, Flare Systems). Sweetened gas can also be used as high-pressure start-up fuel gas (see Section 4.2.3.3, Low-pressure and High-pressure Fuel Gas Systems).

Solvent Regeneration. The amine solvent containing the absorbed acid gases and traces of hydrocarbons (rich amine) enters the side of the rich amine flash drum, where a pressure drop will separate most of the hydrocarbons and some carbon dioxide, which will exit the top of the flash drum and pass to the low-pressure fuel gas system (see Section 4.2.3.3, Low-pressure and High-pressure Fuel Gas Systems).

The rich amine passes from the bottom of the flash drum through a heat exchanger. Here it is preheated by the regenerated amine (called lean amine) that is being returned to the absorber and then enters the amine regenerator. Hot oil will further heat the rich amine, which, combined with the pressure drop in the regenerator, will release the carbon dioxide, hydrogen sulfide (if any), and hydrocarbon gases from the rich amine (including benzene, toluene, ethylbenzene and xylene (BTEX)). The lean amine exits the bottom of the regenerator and returns to the amine absorber via a cooler and three filters (mechanical, carbon and polishing). The acid gases exit the top of the amine regenerator and pass to the acid gas incinerator. The BTEX will be disposed by thermal destruction or industry best practice.

Acid gas will be sent to either the acid gas incinerator (see Section 4.2.4.4, Acid Gas Incinerator) or the turbine exhaust, where the high temperatures will destroy volatile organic compounds and other pollutants to meet emissions requirements. The acid gas removal system will be sized to handle the higher amine circulation rates required for the higher carbon-dioxide content expected when gas from the Juha field is added to the inlet gas during Phase 4 (approximately Year 10). The impact assessment of air emissions from the plant is provided in Section 20.8, Air Quality. The implications for greenhouse gas emissions of discharging the carbon dioxide is assessed in Chapter 26, Greenhouse Gases and Climate Change.

Amine Storage. An amine storage tank will contain a mixture of fresh amine (delivered by truck) and demineralised water. The tank will have sufficient capacity to hold the normal make-up inventory plus all the solvent in the acid gas removal system (in case this needs to be drained during a process upset or for maintenance).

The acid gas removal system includes provision for collecting and directing solvent drips to a sump for recycling.

Dehydration System

The gas leaving the acid gas removal system will be saturated with water. The dehydration system will dry the gas down to less than 0.1 ppm(v) of water to prevent ice (hydrates) forming in the downstream cryogenic equipment.

A propane refrigerant cools the feed gas to 25°C (approximately 5°C above the hydrate formation temperature) and condenses most of the water vapour. The dehydration feed separator returns the condensed water and solvent carryover to the acid gas removal system as make-up (or to the wastewater treatment system, if necessary).

Molecular sieve driers will then adsorb the remaining water in the feed gas onto an inert zeolite (clay) bed.

Regeneration (drying of the molecular sieve adsorbent) will be achieved with a gas stream. This regeneration gas will be heated by the hot oil system to approximately 230°C. When a bed is regenerating, the hot regeneration gas stream enters at the bottom of the drier and exits at the top. The water released during regeneration will normally be directed to the wastewater treatment system or used as make-up water for the acid gas removal system.

The molecular sieve adsorbent typically has a life of three years. The spent adsorbent will be analysed to confirm that no controlled substance (special wastes, restricted substances, metals, sulfur, nitrogen compounds) has adhered to the adsorbent and is then disposed of as an non-restricted waste (see Chapter 25, Waste Management).

Mercury Removal System

Elemental mercury corrodes aluminium, and even very low traces must be removed to prevent damage to the cryogenic heat exchangers.

The mercury removal system will pass gas from the dehydration system through an adsorber of non-regenerative, sulfur-impregnated, activated carbon, which will chemically fix elemental mercury as a non-volatile mercury sulfide.

As operationally necessary, the adsorbent will be sent off site for mercury recovery and recycling and incineration of the stripped carbon. However, mercury levels in the feed gas are so low that the adsorbent may not need to be replaced during the life of the project. Management of non-restricted and restricted wastes generated during LNG Plant operations is described in Section 25.2.3, Operations.

4.2.2.2 Liquefaction

Liquefaction uses the same principle as a household refrigerator to cool the feed gas to below the methane boiling point of around -161°C. At this temperature, the gas liquefies to 1/600th of its original volume.

Liquefaction System. The liquefaction system in an LNG train comprises propane coolers, a heavy-hydrocarbon removal column, and cryogenic heat exchangers.

The feed gas from the mercury removal system will be cooled by propane coolers. The coolers liquefy the heavier hydrocarbons, which then flow to a heavy-hydrocarbon removal column. Heat and pressure will be used to separate the heavier hydrocarbons from the feed gas stream in the column. These heavier hydrocarbons (ethane, propane, butane and heavier components) will exit the bottom of the column and be sent to the common fractionation system (described in Section 4.2.2.3, Fractionation, below). The vapours will exit the top of the column and flow to the main cryogenic heat exchanger. The column will be designed to ensure that, as the composition of the feed gas changes over the life of the project, the concentration of the pentane and heavier hydrocarbons (C5+) in the feed gas of the cryogenic heat exchanger will not exceed 0.10 molar percentage. This is done to control the BTEX levels in the feed gas supplied to the cryogenic heat exchangers.

The main cryogenic heat exchanger is similar to the evaporator plate inside a refrigerator. It provides a sufficiently large surface area to efficiently transfer heat from the feed gas to the refrigerant. In the cryogenic heat exchanger, the feed gas will be further cooled and condensed by the refrigerant stream from the refrigeration system.

The cold natural gas will exit the liquefaction process at near atmospheric pressure and -161°C. The LNG will be produced at approximately 800 t/hr.

The flashing process loses some of the LNG as a vapour, which will be warmed and then compressed. Some of this gas will be used to regenerate the molecular sieve driers in the dehydration system before being sent to the high-pressure fuel gas system (see above and Section 4.2.3.3, Low-pressure and High-pressure Fuel Gas Systems); the remainder will be sent directly to the high-pressure fuel gas system. It can also be sent to the dry flare system if required, for example, for pressure relief (see Section 4.2.4.3, Flare Systems). The LNG from the liquefaction system will be pumped to the LNG storage tanks.

Refrigeration System. The refrigeration system cools and pressurises the refrigerants used in the liquefaction system. The refrigeration system will use closed-loop, refrigerant circuits to provide the low-temperature refrigerants. The refrigerants will be used to liquefy and subcool the feed gas in the cryogenic heat exchangers.

Turbines for the Refrigeration System Compressors. The refrigerant circuits will require gas turbine generators to drive the compressors. Two options were considered for this: frame turbine technology and aero-derivative technology (see Section 7.8.3, Refrigeration Circuit Compressors). A comparison of the emissions from the two technologies is provided in Chapter 26, Greenhouse Gases and Climate Change, where it is shown that aero-derivative technology emits less greenhouse gases. The base case for the refrigeration system compressor turbines is the aero-derivative technology.

4.2.2.3 Fractionation

The hydrocarbon liquids recovered in the heavy-hydrocarbon removal column of the liquefaction system will be sent to the fractionation system to separate the liquids into high-purity hydrocarbon products.

The fractionation system will be operated to meet the specification of the condensation product by removing an isopentane-rich pentane product (which will be directed to the fuel gas system) from the condensate. The bottoms product (the condensate) will be sent to the condensate storage tank. Condensate will be produced at an approximate rate of 7.2 t/hr, or 270 m^3/day.

Additionally, refrigerant-grade ethane and propane may be produced in the fractionation system.

4.2.3 LNG Plant Utilities

The LNG Plant utilities (Figure 4.4) comprise various systems that store or produce inputs required by the plant:

- Hot oil system.
- Utility and instrument air system.
- Low-pressure and high-pressure fuel gas system.
- Power generation and distribution systems.
- Water systems.
- Nitrogen system.
- Cooling system.

The contribution to greenhouse gas from fuel use from these facilities is included in Chapter 26, Greenhouse Gases and Climate Change.

4.2.3.1 Hot Oil System

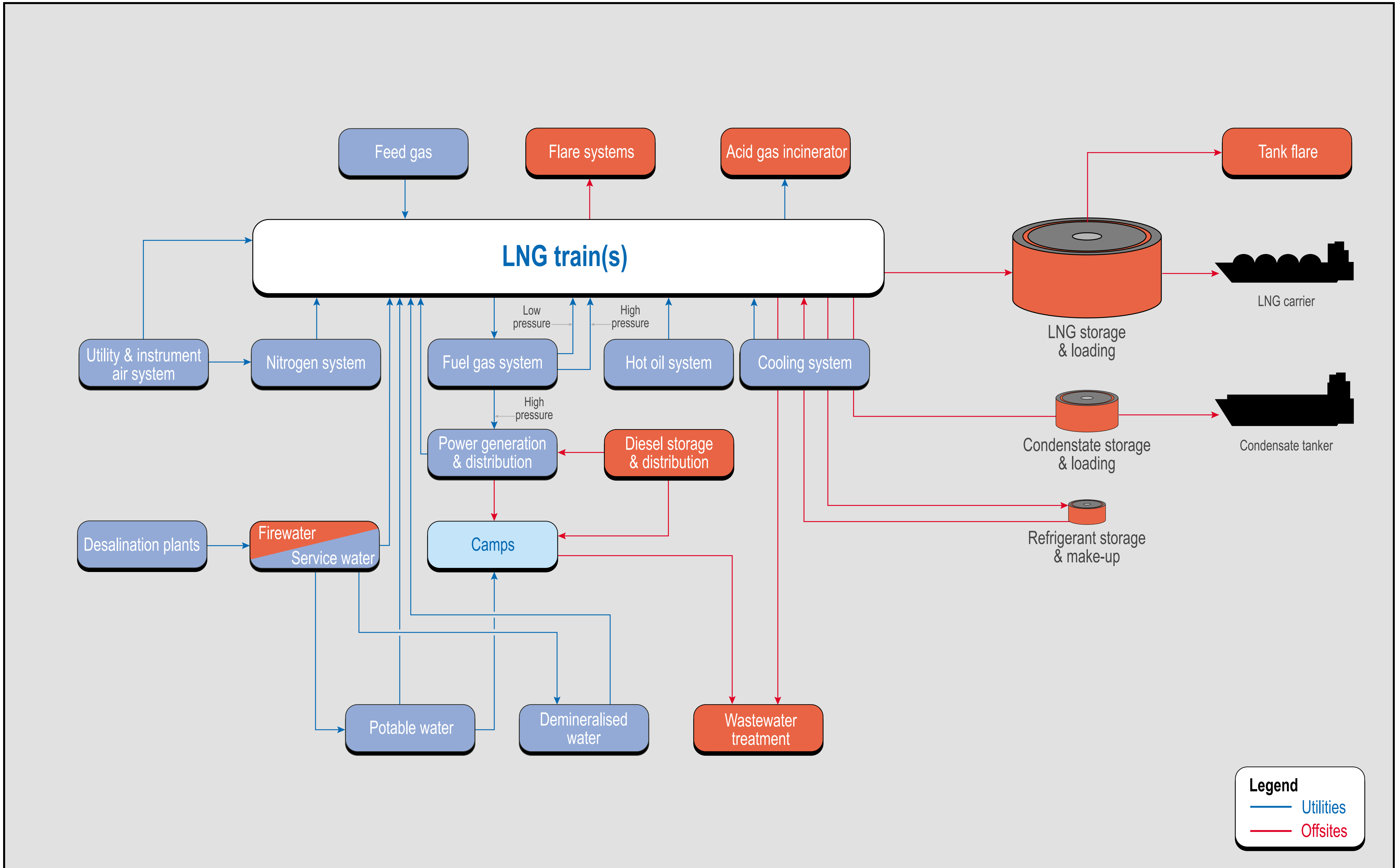
The hot oil system will provide the process heat required for the LNG Plant. The system will circulate a thermal-fluid-based oil (Therminol 66) heated via exchangers using the heat exhaust from the gas turbines.

In addition to the waste heat recovery units, the system comprises:

- Hot oil pumps.
- A slipstream filter.
- Surge drum.
- Fired heater for start-up, fuelled by the low-pressure fuel gas system.
- Hot oil trim cooler to reduce the temperature of the hot oil for certain uses.
- Bunded storage tank for the Therminol 66, which will be delivered by truck.

4.2.3.2 Utility and Instrument Air System

The utility and instrument air system will supply clean wet compressed air for pneumatic tools and other utility needs. In addition, clean dry compressed air for plant instruments will feed to the nitrogen system (described in Section 4.2.3.6. Nitrogen System). The air will be compressed by



PNG LNG	Job No: 1284	PNG LNG Project	Block diagram of the LNG Plant utilities and offsites
	File Name: 1284_09_F04.4_KB	Esso Highlands Limited	Figure No: 4.4

PGGP-EN-SRENV-000001-001
Rev0

compressor packages. The air required for the plant instrumentation will be dried by air dryer packages designed to produce approximately 2,600m^3/hr of dry compressed air. The instrument air-dryer packages will emit wet air to the atmosphere.

The utility and instrument air system will be sized to handle current and future compressed air demand requirements.

4.2.3.3 Low-pressure and High-pressure Fuel Gas Systems

The high-pressure fuel gas system supplies fuel at the appropriate design pressure (estimated at 4,000 kPag) to the gas turbines that will drive the refrigerant compressors and the power generation gas turbines. Fuel usage will be equivalent to approximately 7% to 10% (on an energy value basis) of the inlet feed gas.

The low-pressure fuel gas system will supply the start-up hot oil heater, flare purges and pilots, the acid gas incinerator, and some blanket gas requirements. The low-pressure fuel gas pressure will be approximately 700 kPag.

Normal supply of fuel gas will be from process, boil-off gases and heavier hydrocarbons from the fractionation system. The make-up fuel will be obtained from downstream of the dehydration system. The high-pressure fuel system mixing drum will combine these fuel sources and direct the high-pressure fuel gas to the compressor turbines, the high- and low-pressure fuel gas headers and the LNG storage tanks (for vacuum prevention).

Start-up and back-up fuel gas will be supplied from the high-pressure inlet piping before the inlet pressure control station or downstream of the amine absorber.

4.2.3.4 Power Generation and Distribution Systems

Power Generation System

The power generation system will supply electricity for LNG processing and the common utility and offsites areas, such as the LNG and condensate storage tanks, LNG Jetty, Materials Offloading Facility and camps.

Primary Power. A number of gas turbine generators (one of which will be in standby mode) will produce electrical power to meet an estimated base load of 44,000 kW (Table 4.1), with an allowance for future load growth. The turbine generators will be fuelled by the high-pressure fuel gas system (see Section 4.2.3.3, Low-pressure and High-pressure Fuel Gas Systems, above). Dry low emissions technology has been proposed to maintain nitrous oxide concentrations at less than 25 ppm (assessment of air quality and greenhouse gas emissions is provided in Section 20.8.2, Air Quality, and Chapter 26, Greenhouse Gases and Climate Change).

Table 4.1 LNG Facilities electrical power base load, growth and contingency estimates

Load	Kilowatts
LNG train(s)	20,060
Product storage	10,847
Utilities	5,782
Offsites	3,753

Table 4.1 LNG Facilities electrical power base load, growth and contingency estimates (cont'd)

Load	Kilowatts
Operations camps	3,825
Total LNG Plant facilities base load	**44,267**
Growth (20%)	8,853
Contingency (15%)	6,640
Total	**59,760**

Essential and Black Start Power. Diesel-engine–driven generators will be provided for the LNG Plant to facilitate a 'black start' of the LNG Plant. These generators will also be used to provide essential power for selected loads that may be required in the event of an extended outage of the primary power generation system.

Power Distribution System

The plant site will have a power distribution system serving all areas of the site, including the marine facilities (Figure 4.5).

Batteries will provide uninterruptible back-up power for the following:

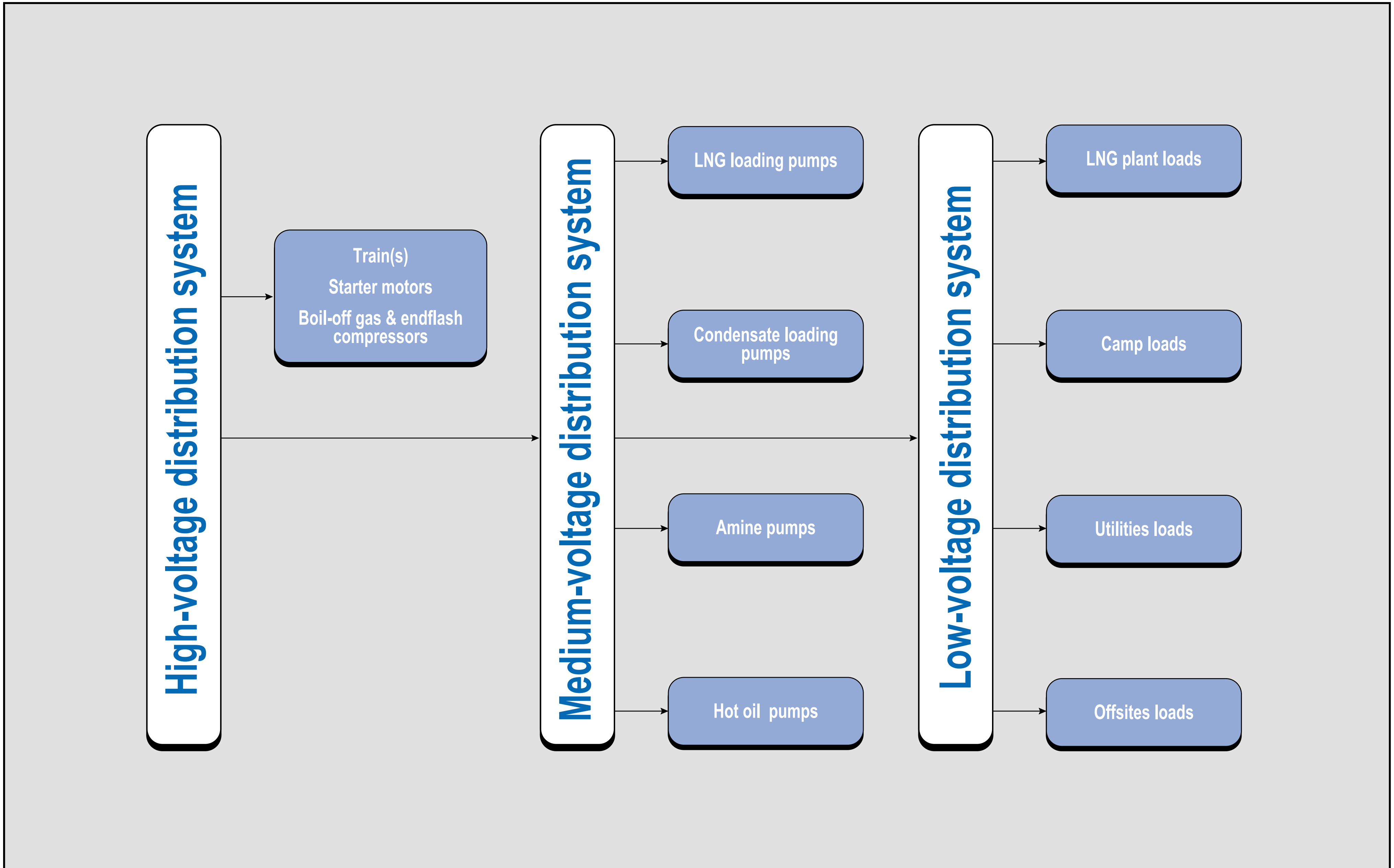
- Critical instrumentation.
- Controls.
- The telecommunication systems.
- Fire and gas detection.
- Emergency shutdown systems.
- Emergency lighting.

4.2.3.5 Water Systems

Water sourced from Caution Bay and treated in desalinisation units will generate water for the freshwater system, which will provide fresh water to the service water reticulation system (discussed below) and the fire-protection system (discussed in Section 4.2.4.6, Fire-protection System). The service water system will provide water for the demineralised and potable water systems.

Freshwater System

Groundwater in the vicinity of the LNG Facilities site is limited, and seawater desalination by reverse osmosis is proposed to supply fresh water during operations. Average salinities in Caution Bay of around 32 g/L are expected to enable a freshwater recovery rate of approximately 50%.



PNG LNG	Job No: 1284 File Name: 1284_09_F04.05_KB	PNG LNG Project Esso Highlands Limited	Block diagram of the site power distribution system

Figure No: 4.5

During operations, one onshore desalination system will be located within the LNG Plant, and a second system will supply the permanent operations camp and turnaround camp with potable water. The design water demand during operations is estimated to be 2,160 m^3/day for the LNG Plant and 420 m^3/day for the permanent operations camp.

The proposed seawater intake in Caution Bay will be located on the LNG Jetty with sufficient separation from the brine outfall to avoid recycling of brine. The brine outfall will be located at the head of the LNG Jetty at a depth of approximately 12 m. Initially, and until the LNG Jetty is completed, the brine will be discharged at the end of the Materials Offloading Facility.

A number of standard water treatment measures will be required:

- Solids removal. Seawater will be dosed with ferric chloride (flocculant) and cationic polymer (coagulant) and the solids filtered out.
- Biocide. Intake seawater will be chlorinated to inhibit biological growths from obstructing the intake system.
- Chlorine removal. Membranes are sensitive to oxidising chemicals (such as chlorine) and so the biocidal chlorine will be scavenged by sodium metabisulfite before the treated seawater enters the reverse osmosis system.
- Membrane descaling. Salts can precipitate and reduce membrane efficiency, and so a proprietary anti-scalant may be added to the intake water.
- Final polishing of the freshwater before dispatch to the reticulation system.

The seawater intake filter backwash and membrane rinse water, which may contain traces of the chemical additives, will, if necessary, be sent to the site wastewater retention pond for final settling to meet environment (waste discharge) permit conditions before discharge. As the process chlorine is removed from intake seawater prior to the reverse osmosis system, reject brine will be discharged directly to the sea (see 'Discharge of Brine from Desalination Plant Processing' in Section 21.3.1.2, Operations, for details of the assessment of the impacts of brine discharge).

Service Water System

The service water system will include a 5,000-m^3 (5-ML) freshwater tank (supplied by the freshwater system and shared with the fire-protection system), two 100-m^3/hour pumps, a potable water treatment plant, and make-up water pretreatment for the demineralised water system. The effluent generated by the service water system will be treated prior to release into Caution Bay in accordance with discharge criteria of the relevant environment (waste discharge) permit issued by the DEC.

Demineralised Water System. Service water will be treated in the reverse osmosis demineralisation package and then sent to the 150-m^3 (150,000-L) demineralised water storage tank. Demineralised water will be used to wash the blades of the gas turbines and to provide make-up water and wash water for the acid gas removal system.

Potable Water System. Service water will be treated to potable standards in a plant with a capacity of 7 m^3/hour to meet operations requirements of 360 L/day per person. Treated water will be stored in a 170-m^3 buffer tank prior to distribution via potable water distribution piping.

4.2.3.6 Nitrogen System

The LNG Plant requires nitrogen gas for the following process and maintenance purposes:

- To purge equipment on start-up and shutdown.
- As make-up to refrigerant circuits of the LNG train(s).
- To maintain inert atmospheres (e.g., blanket gas in hydrocarbon storage tanks).
- To purge miscellaneous analytical equipment.
- To purge tanker-loading arms after use.

Nitrogen may also be used as a separation gas for dry gas seal systems. Ways to reduce or eliminate nitrogen consumption are currently being investigated.

Two nitrogen generation packages (plus a third standby package) will produce approximately 450 m^3/hr of nitrogen each. Nitrogen will be distributed to the flare systems, the inlet receiving and treatment system, the acid gas removal system, the refrigeration system, the LNG Plant utilities area and the offsites and loading areas. The system will have the capability to fill nitrogen bottles for use in areas not serviced by the distribution system.

Imported liquid nitrogen storage and vaporisation will provide additional capacity and back up during plant start up, during intermittent peak demand or when the nitrogen generation packages are out of service.

During start up of the LNG train(s), the system will be purged with nitrogen to remove the oxygen (atmospheric air) prior to introducing the feed gas. During maintenance shutdown, the vessel and piping systems will be purged with nitrogen gas to remove the hydrocarbons in the system prior to opening the system for inspection or maintenance. Purged gas will be vented to flare (see Section 4.2.4.3, Flare Systems).

4.2.3.7 Cooling System

Process heat from the LNG Plant will be offloaded to ambient air via air coolers. These coolers will be located within the LNG Plant in locations that avoid recirculation of turbine exhaust or interference from other air coolers. The coolers are often installed straddling plant piping between operational areas. Low-noise coolers will be specified in detailed design planning.

4.2.4 LNG Plant Offsites

The term ‘offsites’ refers to equipment and facilities that support the LNG processing train(s) and the plant utilities (see Figure 4.4). The offsites for the PNG LNG Plant are:

- LNG storage and loading system and boil-off gas system.
- Condensate storage and loading system.
- Flare systems.
- Acid gas incinerator.
- Wastewater treatment system.
- Fire-protection system.

- Diesel storage and distribution system.
- Refrigerant storage and make-up system.
- Waste management system.

4.2.4.1 LNG Storage and Loading System

The LNG storage and loading system provides the facilities needed to store the LNG until the next LNG carrier arrives. Then the system loads the carriers, freeing up capacity. Associated with the system is a closed circuit that captures LNG that boils off the storage facility and loading facilities and returns it to the system.[1]

The LNG will be stored in two 165,000-m^3-capacity, single-containment tanks. The tank size is based on 220,000-m^3-capacity LNG carriers and will store approximately three days of LNG production. The LNG storage tanks will operate at a pressure of approximately 105 kPa and a temperature of -161°C. Tanks will be filled and discharged from the top, in order to reduce the risk of a leak. The tanks will be enclosed within bunds that are capable of containing 110% of the storage tank volume.

Boil-off compressors control the pressure in the storage tanks. When outside of the boil-off gas control range, other process control and safety systems will be used to protect the tanks. Some of these include:

- Vacuum breakers on the tanks, which will open to control the maximum vacuum in the tank.
- Dry, high-pressure feed gas from the LNG Plant, which will be introduced into the tank on pressure control to prevent pulling a vacuum on the tank.
- The staging control of the boil-off compressors, which will keep the pressure in the storage tank at the desired operating pressure range.
- The tank venting control valve, which will open on high pressure, sending tank vapour to the low-pressure flare system (see Section 4.2.4.3, Flare Systems).

Each LNG storage tank will be provided with four in-tank LNG loading pumps (one of which will normally be in standby mode).

When the storage and loading system is not loading LNG, a small quantity of LNG will circulate through the insulated LNG loading lines to maintain cryogenic temperatures.

LNG will be pumped at 12,000 m^3/hr through the two LNG loading lines to the LNG carrier. A return line will send vapour generated at the jetty during the loading to the LNG storage tanks to replace the liquid volume being loaded, with excess gas sent to the low-pressure flare only if the boil-off gas compressors are not operating (see Section 4.2.4.3, Flare Systems).

---

[1] Boil-off gas occurs when heat is transferred to the stored LNG via, for example, the walls of the storage tanks or the operation of the loading pumps. The term also refers to the vapours generated at the jetty during the carrier-loading operation.

LNG loading arms are described in Section 4.12.3.1, LNG and Condensate Loading.

4.2.4.2 Condensate Storage and Loading System

Hydrocarbon condensate from the bottom of the de-isopentaniser will be delivered to two 8,500-m^3-capacity, floating-roof storage tanks. The tanks will operate at atmospheric pressure and provide approximately 30 days of storage each. Condensate will be pumped via a loading line to export tankers at the nominal loading rate of 750 m^3/hr (see Section 4.12.3.1, LNG and Condensate Loading).

4.2.4.3 Flare Systems

The cold (dry), hot (wet) and low-pressure flare systems will provide for the safe disposal of hydrocarbon fluids (gases and liquids) from pressure safety valves and blowdown valves during process upsets, emergencies, maintenance activities and shutdown conditions. It is likely that some flaring will occur during commissioning and start up; however, it is not anticipated that flaring will be necessary during routine operations.

Flare systems are sized to accommodate what is expected to be the largest single event requiring gas release. For an LNG plant, this is typically the discharge from a blocked refrigerant compressor. The flares will be designed to provide smokeless flaring over a maximum range of operation, and all flare headers will be continuously purged with low-pressure fuel gas.

Cold Flare. The cold flare will dispose of moisture-free vapour and liquid hydrocarbons from relief valves, vents and drains throughout the process areas. The cold flare will be sized to handle relief and blowdown streams from the liquefaction, refrigeration and fractionation systems for both the design case and the future rich-gas scenario, with an estimated capacity of 1,701,000 kg/hr. The gas will flow through the cold flare knock-out drum, where the hydrocarbon liquids will be collected. Liquids will be stored in the knock-out drum until they vaporise, with any liquids remaining transferred to the hot gas flare knock-out drum.

Hot Flare. The hot flare will collect vapours and liquids that are susceptible to freezing (and hence not compatible with the cold, dry gas flare system). The hot flare will be sized to handle liquid relief and blowdown streams from the inlet area, the inlet gas treating systems, the hot oil system and the fuel gas system. Liquids collected in the hot flare knock-out drum will be heated and the volatile components sent to the flare stack. Remaining liquids will be transferred to a slop oil storage tank.

Low-Pressure Flare. The low-pressure flare will provide pressure relief for the LNG storage and loading system and the boil-off gas system. A dedicated flare is required for these systems because the LNG storage tanks would not be able to handle backpressures from the cold flare system.

4.2.4.4 Acid Gas Incinerator

Acid gas from the amine regenerator will be sent to the acid gas incinerator for destruction of volatile organic compounds and other pollutants to meet emissions requirements. Acid gas will be produced at approximately 11 t/hr.

Plant design provisions will ensure that the liquid effluents are minimised and that effluent discharges are within the limits set out by international effluent standards (see Chapter 25, Waste Management).

4.2.4.5 Wastewater Treatment Systems

The LNG Plant and associated facilities will generate various kinds of wastewater, including oily water, clean water, chemically contaminated water and sanitary sewage. The wastewater treatment system will include:

- Liquid effluent collection via a system of drains segregated by effluent source.
- Routing and treatment through a retention pond.
- Effluent discharge monitoring for compliance with discharge limits.

A system of open and closed drains, connecting to appropriate retention and treatment ponds will be constructed to separate clean from potentially contaminated surface water. Open drains will direct surface water to stormwater retention ponds for settlement. Oily wastewater drains will direct potentially contaminated runoff, washdown, spillage and fire water from sealed (bunded) process areas to a corrugated-plate interceptor, which will separate the oil and water. The oil will be sent to a slop oil storage tank, and the water will be sent to the retention pond. Each sealed area will have a water-sealed pit to prevent the migration of flammable vapours.

The chemically contaminated wastewater drains will collect effluent associated with:

- Compressor and lube oil consoles.
- Acid gas removal system.
- Electrical transformers.
- Emergency generators.
- Chemical injection packages.
- Pump base plates.

This chemically contaminated runoff will be sent to the retention pond, where trace hydrocarbons will separate and be skimmed and sent to the oily water treatment system.

Sanitary wastewater will flow by an underground sewer network to sanitary lift stations for pumping to a single wastewater and sewage treatment facility for biological oxidation, clarification and chlorination. Treated effluent will be sent to the retention pond for final polishing.

Process waste streams, such as filter backwash and membrane rinse water from the desalination process will also be sent to the appropriate treatment stream subject to optimisation studies during detailed design.

Water from the retention pond will be discharged into Caution Bay in accordance with the required environment (waste discharge) permit conditions, and in accordance with a surface water and stormwater management plan, developed as part of the water management plan for the project. Impacts of this discharge are assessed in Section 21.3, Sea Water Quality.

The wastewater treatment system will be designed for the greater of a six-hour, one-in-ten-year storm or firewater deluge.

4.2.4.6 Fire-protection System

The fire-protection system will provide full fire-fighting capabilities, with firewater ring mains incorporated into the LNG Plant, marine facilities, operations camp and turnaround camp.

Fire hydrants will be located so that at least two hose streams can reach any point in the facilities area. Water spray systems will be installed to cover potential sources of flammable liquid release in the process and offsite storage areas.

The 5-ML freshwater tank will store both service water and firewater and is sufficient for four hours of firewater supply at a rate of approximately 1,135 m^3/hr.

Two freshwater main firewater pumps (one electric and one diesel) will be provided along with two freshwater jockey pumps. In case of a prolonged fire incident where the firewater requirement exceeds the design storage capacity, two diesel-powered seawater pumps will provide additional fire-fighting capability.

A high-expansion foam system will be used to control fires inside the LNG spill containment areas (at the LNG storage tanks and LNG process sump). Selection of foam system is yet to be made but will take into consideration the potential environmental implications.

4.2.4.7 Diesel Storage and Distribution System

The LNG Facilities will include a system for receipt, storage and distribution of diesel fuel for use in the LNG Plant and by tugs. The diesel system will not be used to refuel the LNG carriers.

The diesel storage tank, approximately 160-m^3 (160,000-L) and associated transfer pumps will provide low-sulfur diesel fuel where practicable, during construction of the LNG Facilities site to various users. Diesel filter coalescers will be provided to ensure particulates and water are removed. Diesel fuel day tanks will be strategically located throughout the facility, near clusters of users to enhance distribution. All tanks will have appropriately designed secondary containment.

4.2.4.8 Refrigerant Storage and Distribution System

The refrigerant process uses light hydrocarbons for the liquefaction of natural gas. The light hydrocarbons will be stored in tanks outside of the process area. Approximately 300 m^3 and 1,600 m^3 of ethane and propane respectively will be held in storage tanks.

Transfer pumps will be used to supply make-up refrigerant to the system. The system is usually designed to store one complete inventory of refrigerant, with additional capacity for another should the circuit require draining. If operational requirements trigger the need for additional light hydrocarbons, they will be imported.

The refrigerant fuel will be stored in appropriately designed and sized designated areas and containers.

4.2.4.9 Waste Management System

A number of waste streams will be generated during construction and operation of the LNG Facilities. The proposed management system for solid and liquid restricted and non-restricted waste at the LNG Facilities site is described in Chapter 25, Waste Management.

Other waste types are described elsewhere in the EIS as follows:

- Acid gas will be disposed of in the acid gas incinerator, as described in Section 4.2.4.4, Acid Gas Incinerator.
- Management of wastewater discharges are described Section 4.2.4.5, Wastewater Treatment Systems, above.
- Emissions to air during construction will include dust from earthworks, together with exhaust emissions from construction vehicles and earthmoving equipment and the high-temperature waste incinerator. These are described in Section 20.8, Air Quality.
- During operations, emissions to air will occur from gas-fired equipment, i.e., the LNG plant (Section 4.2.2, LNG Plant), the utilities (Section 4.2.3, LNG Plant Utilities) and the high-temperature waste incinerator (Section 25.4.2.2, High-temperature Incinerator), LNG carriers, condensate tankers, tugs and project vehicles. These are detailed in Section 20.8, Air Quality.
- Domestic sewage from the construction and operations camps will be discharge to Caution Bay after treatment to meet requirements set out in the environment (waste discharge) permit issued at the time of project approvals. Sewage treatment is described in Section 4.2.4.5, Wastewater Treatment Systems, and discharge in Section 21.3, Sea Water Quality.
- Management of materials dredged from within Caution Bay for construction of the Materials Offloading Facility is described in Section 21.3, Sea Water Quality.

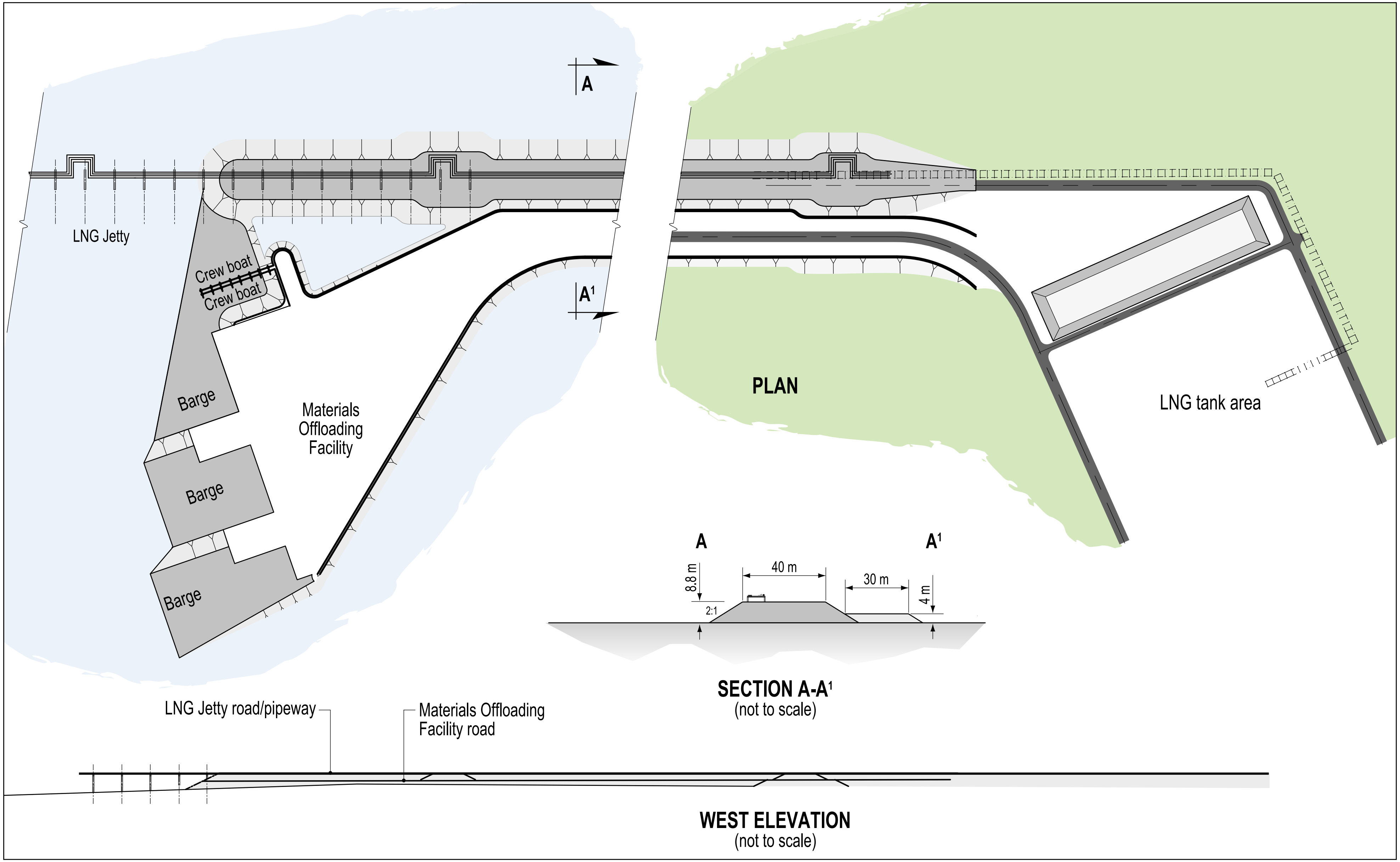
Waste management strategies to be adopted by the project are described in Section 25.1, Relevant Legislation, Guidelines and Policies, and address waste avoidance and mitigation, recycling and reuse, treatment and disposal, restricted waste management, waste storage, transportation and monitoring.

4.2.5 LNG Plant Future Development

The project will be developed in five phases (see Section 1.2.2, Project Development Schedule and Project Phases), and the LNG Plant will be designed to handle the variations in gas composition through the different phases over the life of the development. The project will pre-invest in an acid gas removal system to handle the higher carbon dioxide concentrations in Phase 4 when the Juha field is developed. No modifications to the LNG Plant are currently planned for future phases.

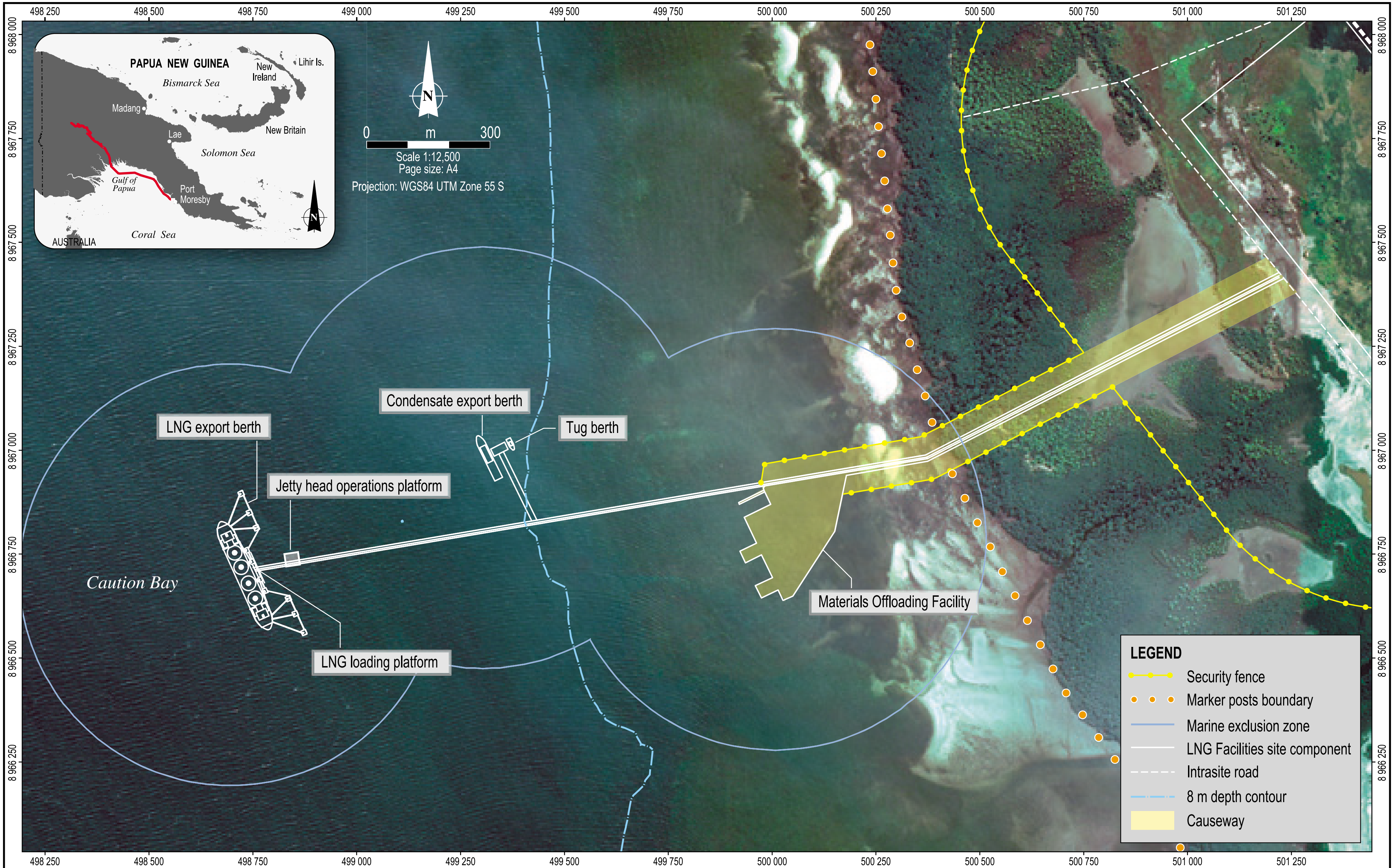
4.3 Description of the LNG Jetty and Materials Offloading Facility

The marine facilities will consist of two structures, the LNG Jetty and the Materials Offloading Facility, which will provide four berthing areas. These two structures will share a two-level earthen causeway (105 m wide at the base) and then diverge as shown in Figures 4.6 and 4.7 into separate structures. An analysis of proposed designs associated with the size and engineering of the causeway and jetty has resulted in shortening the causeway by approximately 500 m to reduce impacts to the Vaihua River (see Section 7.7.4, Materials Offloading Facility). Figures 4.6 and 4.7 show this proposed configuration, which is described below.



PNG LNG	Job No: 1284	Esso Highlands Limited	Integrated LNG Jetty and Materials Offloading Facility causeway (indicative orientation)
	File Name: 1284_09_F04.06_HB	PNG LNG Project	Figure No: 4.6

PGGP-EN-SRENV-000001-001
Rev0



Note:
Layout is indicative only.
Final placement of all components is contingent upon pending soil and geological data.

PNG LNG

Date: 20.08.2008
MXD: PNG_LNG_Project_GIS.mxd
File Name: 1284_09_F04.07_GIS_HB

Esso Highlands Limited

PNG LNG Project

Materials Offloading Facility and LNG, condensate and tug berths

Figure No: 4.7

The LNG Jetty will link the LNG storage tanks and condensate storage tanks with the LNG and condensate export berths. It will extend to a water depth of 14 m below lowest astronomical tide (LAT), which is reached approximately 2.9 km from the coast, and the elevation of the loading platform deck will be set at about 11 m above LAT.

The LNG Jetty will begin with a 40-m-wide, earth-filled causeway north of but parallel to and adjoining the causeway for the Materials Offloading Facility until the two causeways diverge. At the end of the causeway, a trestle will continue on subsea piles. The piles will be embedded in the seafloor to a depth of 15 to 20 m, and approximately a third of the piles will have tension anchors.

The Materials Offloading Facility will begin as a 30-m-wide, earth-filled causeway, rising from ground level at the shoreward end to approximately 4 m above LAT at the seaward end.

The causeway and trestle will be designed to support the following:

- LNG loading and vapour return lines.
- Condensate loading lines.
- Utilities.
- Jetty head operations platform.
- A roadway capable of accommodating trucks carrying heavy loads, ambulances, small cranes, and pedestrian traffic.

Systems for berthing aid, mooring load monitoring, metocean monitoring and navigation will be provided.

The LNG Jetty will be designed to withstand weather and sea conditions with an average recurrence interval of 500 years under AS 4997, Guidelines for the design of maritime structures, in Australian Standards 2005. The navigation aids will be sited in accordance with International Association of Lighthouse Authorities (IALA, 2006).

Impacts from construction and operation of the LNG Jetty and Materials Offloading Facilities, including preliminary analyses of the impacts from dredging required for the shortened earthen causeway, are assessed in Section 21.3, Sea Water Quality.

4.3.1 LNG Export Berth

The LNG export berth will be constructed at the seaward end of the main LNG Jetty trestle (see Figure 4.7). The berth concept consists of two breasting dolphins and three mooring dolphins installed on each side of the LNG loading platform. These structures will be supported on piles, and access to the dolphins will be provided by catwalks. Plate 4.5 shows an example of an LNG jetty at Tangguh, Indonesia.

The LNG export berth will be able to load LNG carriers in the size range of 125,000 to 220,000 m³, corresponding respectively to approximate loading frequencies of 3.5 and 6 days. Table 4.2 presents LNG carrier dimensions.

Table 4.2 LNG carrier dimensions

Carrier Size	Length Overall	Beam	Draft
125,000 m^3	285 m	44 m	11.5 m
220,000 m^3	315 m	50 m	12.2 m

The minimum water depth at the LNG export berth will allow a 0.5-m under-keel clearance for the deepest draft LNG carrier. No dredging is expected to be required during construction of the LNG Jetty (except possibly for isolated points in the turning basin), and maintaining this water depth at the LNG export berth and in the shipping access channel is not expected to require any maintenance dredging (assessment of potential water quality impacts is provided in 'Increased Suspended Sediment and Sedimentation Rates' in Section 21.3.3.2, Operations).

The final approach of the shipping access channel (see Figure 4.1) will be 500 m wide, with a turning basin in front of the LNG export berth that will have a minimum diameter of two times the overall length of the longest LNG carrier.

The roadway on the LNG causeway will continue onto the main LNG Jetty trestle and end at the LNG loading platform. The LNG loading platform will support the LNG loading operation. The loading platform will include:

- Four 16-inch (200-mm) LNG loading arms (two liquid service, one vapour return, and one liquid or vapour return) and associated pipework support systems.
- Personnel gangway tower.
- Berth operator shelter.
- Piping and pipe racks.
- Fire monitors.
- Control panels.
- Dry chemical fire extinguishers.
- Hydraulic power pack skid.
- Fire and gas monitoring system.
- Utility stations.
- Backup firewater supply to vessel.
- Navigation lights.
- Area lighting to allow 24-hour operation.
- Catwalk access to adjoining breasting and mooring dolphins.
- Steel ladder access from water.
- LNG spill protection for the supporting piles.
- LNG spill containment kerbs and trough on the loading platform.

The loading arms support and direct the vapour return or the loading lines. The two liquid service loading arms and the dual-purpose liquids or vapour return loading arm will each have a capacity of 5,000 m^3/hour. The vapour return loading arm will have a capacity of 20,350 m^3/hr. The loading arms will be fitted with an emergency shutdown system and powered emergency-release couplings.

A berth operations shelter or building will be located shoreward of the LNG loading area. Visual and audible signals for berth operations and emergency alarms will be connected to the berth operations shelter.

A seawater pumping system will be located on a small platform cantilevered from the trestle.

4.3.2 Condensate Export Berth

The condensate export berth will be constructed at the end of a spur trestle extending at a right angle from the main LNG Jetty trestle (see Figure 4.7). The spur trestle will extend northwest for approximately 200 m. A berthing and mooring dolphin will be located at the southwest side of the seaward end of the spur trestle, with a tug berth on the northeast side.

The spur trestle will carry the condensate loading lines on a pipe rack to a single condensate loading arm at the seaward end of the spur trestle.

Initial bathymetric survey indicates that the condensate export berth will not require initial dredging to accommodate 7,000 deadweight tonnage condensate tankers. These vessels will arrive approximately every 30 days.

The minimum water depth at the condensate export berth of 10 m at LAT is not expected to require maintenance dredging (see Section 4.6.1.9, Dredging for the Marine Facilities).

4.3.3 Materials Offloading Facility

At approximately 250 m offshore of the seaward edge of the mangroves, the causeway widens into a triangular dock with three barge berths at the seaward end and two crew boat berths and a parking area for crew boat passengers on the north side (see Figure 4.6).

The dock will be located in approximately 8 m water depth at LAT and will be sheet-piled, edged with a concrete beam and surfaced with crushed rock. The sides of the causeway will be rock armoured. A roadway will run from shore to the end of the causeway. It will be necessary to dredge in the order of 150,000 to 200,000 m^3 of the seafloor immediately seaward of the Materials Offloading Facility to meet the 8 m below LAT navigation depth limit for vessels making deliveries (see Section 7.7.4, Materials Offloading Facility, for a description of the rationale for dredging and Section 21.3, Sea Water Quality, for an assessment of residual impacts to the marine environment from dredging).

The Materials Offloading Facility will accommodate shipping associated with delivery of equipment and materials during construction, and typical vessel specifications are given in Table 4.3 below.

Table 4.3 Materials Offloading Facility vessel specifications

Vessel	Length (m)	Width (m)	Depth (m)	Draft (m)
Two 9,000-t barges	90	28	6.1	4
Two 5,000-t barges	75	24	4.8	3
One 2,500-t barge	60	21	3.7	2
Crew boats	60			2

The dock and causeway at the Materials Offloading Facility needs to be low enough for barges to offload and so have been designed to reduce overtopping by waves.

4.3.4 Mooring Structures and Mooring Load Monitoring System

Breasting and mooring structures either side of the centreline of the loading arms will allow both port-side-to and starboard-side-to berthing. The mooring structures will be lit and equipped with the following:

- Guard rails.
- Quick-release mooring hooks.
- Capstan and controls.
- System to monitor the load on each mooring connection.
- Line chafing guards.
- Ladder access from water.

4.3.5 Marine Operations and Metocean Monitoring System

The marine facilities will be equipped with a marine operations and metocean monitoring system to display wind speed and direction, water level and current speed and direction in real time.

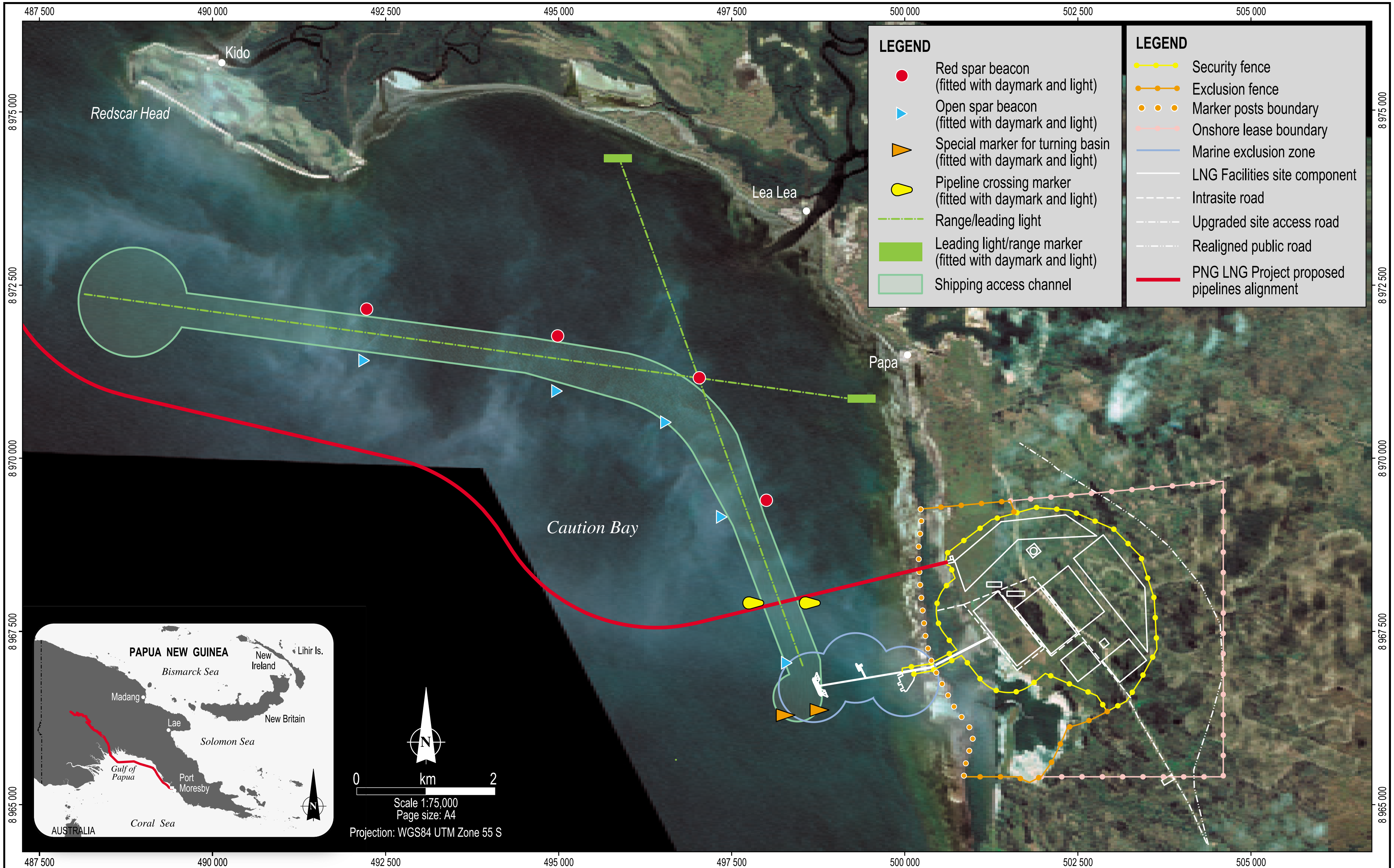
4.3.6 Navigation Aids and Pilot Station

LNG carriers and condensate tankers will first arrive at a pilot station at the northern end of Caution Bay, near Redscar Head. From here, tugs will escort vessels to the LNG Jetty.

The draft of the vessels requires fixed navigational aids to delineate the channel boundaries and to mark shallow areas to be avoided. A combination of lighted buoys and fixed bridge lights are proposed for marking of adjacent navigation hazards, the pilot station, approach channel and turning basin (Figure 4.8). The lights will be solar powered.

4.3.7 Tug Berthing

Four 80-t bollard-pull tugs are provisionally proposed to aid in mooring the carriers and tankers (see also Section 4.12.3.2, Operations Environmental Safety Limits). Permanent mooring for the tugs will be provided at either the combined LNG Jetty and Materials Offloading Facility or at an offsite location.



Note:
Layout is indicative only.
Final placement of all components is contingent on pending soil and geological data.
Pipelines approximate the proposed alignment based on engineering data provided up to 1 October 2008.

PNG LNG

Date: 20.08.2008
MXD: PNG_LNG_Project_GIS.mxd
File Name: 1284_09_F04.08_GIS_HB

Esso Highlands Limited

PNG LNG Project

Notional navigation channel and turning basins

Figure No: 4.8

PGGP-EN-SRENV-000001-001
Rev0

The tugs will provisionally have a draft of 6.4 m and be some 30 m long and 12.2 m wide. They will have fire-fighting capability.

The feasibility of using a permanent tug moorage facility owned and operated by a third party at an offsite location (such as Motukea Island near Port Moresby) will be considered further during FEED.

4.4 Description of the LNG Facilities Site Supporting Infrastructure

This section describes the various facilities and infrastructure that will be required to support the LNG Facilities during operations.

Camps will be designed and constructed to comply with the relevant aspects of the codes and standards described in Attachment 3, Technical Codes and Standards. Permanent camps are described below and temporary camps associated with construction are described in Section 4.6.4, Constructing the Temporary Construction Camp.

4.4.1 Permanent Operations Camp

The permanent camp for the operations workforce will be located to the southeast of the LNG Plant (labelled ‘Permanent living and support facilities’ on Figure 4.1) and provide accommodation for 270 people. The camp will be operational at least six months prior to LNG production start-up. Facilities and buildings at the operations camp are anticipated to include the following:

- Accommodation.
- Commercial kitchen.
- Dining area.
- Laundry.
- Convenience store.
- Lounge area and TV rooms.
- Game rooms.
- Fitness centre.
- Medical clinic.
- Combined basketball/volleyball courts.
- Squash/racquet ball courts.
- Soccer field.
- Jogging trail.
- Camp office and reception.
- Camp maintenance workshop.
- Training centre.
- Warehousing.
- Guard house.
- Staff house.

4.4.2 Permanent Turnaround Camp

A permanent, but intermittently used turnaround camp (see Figure 4.1) will provide contractor workforce housing during plant turnarounds (planned maintenance activities that last for several months). Approximately 300 beds of the construction camp and the associated support facilities, located at the eastern end of the facility site, will be designed for a 30-year life and will remain in place after construction to serve as the turnaround camp. The diesel generators used during construction will remain at the camp to meet the back-up power requirements.

4.4.3 Utilities for Permanent Camps

The operations camp and turnaround camp utilities will be sized to handle the expected peak loading during turn around.

Electricity. The LNG Plant power system will supply electricity to the operations and turnaround camp via buried distribution cables (see Section 4.2.3.4, Power Generation and Distribution Systems). The camps will each be equipped with three back-up diesel generators.

Potable Water. The LNG Plant service water system will provide potable water to the operations and turnaround camps (see Section 4.2.3.5, Water Systems) to meet an assumed daily requirement of 360 L/person. The desalination plants will be sized appropriately for the requirements during construction and operation. The assessment of impacts of discharge of reject brine over the life of the project (see Sections 21.3.2, Mitigation and Management Measures and 21.3.3, Residual Impact Assessment), is based on modelling of the peak daily requirement of 2,500 m^3 per day, which occurs during years 3 and 4 of construction).

Wastewater and Sewage Treatment. One plant will treat wastewater and sewage from the operations and turnaround camps to meet an assumed daily load of 360 L/person. This wastewater will be treated to meet the relevant environment (waste discharge) permit conditions of quality before being discharged to Caution Bay via the LNG Jetty. Sewage sludge will be compressed and incinerated prior to disposal in the onsite engineered landfill (see Section 25.4.2, Waste Management Area Infrastructure – LNG Facilities).

Firewater. A dedicated storage tank and distribution system will provide firewater to both the permanent camps. The LNG Plant firewater tank (see Section 4.2.4.6, Fire-protection System) will back up the camp system.

4.4.4 Telecommunications

A link between the LNG Plant and Port Moresby will provide internal voice, data, control and security telecommunication and access to external networks, such as the public switched telephone network, operator voice and data network and the Internet.

A tower at least 50 m high at the LNG Plant will provide a microwave link between the LNG Plant and a PNG Telikom tower. The tower will also support other local services, including VHF FM mobile radio, AM marine and AM aviation radio antennas.

Access to the public switched telephone network will be via the Esso Port Moresby Office.

A 12-channel, portable radio system will be provided for operational use. Marine radio systems will be provided for carrier, tanker, tug and supply boat communications.

4.4.5 Plant Support Buildings

The main plant support buildings will include:

- Plant operations administrative office.
- Warehouse.
- Chemical, restricted materials and insulation storage building.
- Fire station and medical clinic.
- Maintenance workshop.
- Laboratory.
- Equipment shelters.
- Analyser building.
- Safety and security building.
- Electrical and instrumentation shop.
- Paint shop.
- Vehicle refuelling station.
- Communications building.
- Guard houses.
- Marine terminal control shelter.
- Fire-fighting training building.
- Training centre.

4.5 Construction Overview

4.5.1 Scheduling and Sequencing

The indicative schedule for completion of construction of the LNG Facilities, from the award of the engineering procurement and construction contract to the first LNG shipment, is 49 months. See Figure 1.3 for the overall indicative project development schedule.

4.5.2 Construction Workforce

Estimated peak full-time equivalent (FTE) positions required for Phase 1 construction of the LNG Facilities are estimated at 7,500 (see Table 1.1 in Section 1.2.6, Project Staffing). Construction positions involve working a rotational shift, and these will be filled on an as-needs basis (see Section 1.2.6, Project Staffing). The social and economic assessment of the project’s staffing and employment effects are discussed in Chapter 23, Project-wide Socio-economic and Cultural Impacts and Mitigation Measures.

International personnel will be mobilised to the site via the existing Jacksons International Airport and then bussed to site. Construction workforce accommodation is covered in Section 4.6.4, Constructing the Temporary Construction Camp.

4.5.3 Transport, Shipping and Laydown

Table 4.4 gives an estimate of the freight required during construction of the LNG Plant. Preference will be given to sourcing materials and equipment locally where economically and technically practicable. Local procurement contractors will need to abide by relevant components of the project-wide codes and standards (see Attachment 3, Technical Codes and Standards). Details on delivery and transport of freight are given in Chapter 5, Project Logistics.

Table 4.4 Current freight estimates

Project Freight	Tonnes
Direct LNG Facilities equipment and bulk materials	250,000
Construction camp, temporary facilities and consumables and supplies	350,000
Construction equipment	100,000
Sand, aggregate, gravel and cement materials	400,000
Fuel	90,000

4.5.4 Safeguards

Standard industry practice will be implemented to reduce environmental effects during construction. The main measures are described below. A summary of the mitigation and management measures adopted by the project, including those relevant to LNG Facilities construction, is given in Chapter 29, Summary of Mitigation and Management Commitments, and Chapter 30, Environmental Management, Monitoring and Reporting.

The main construction environmental safeguards include:

- **Sediment Control and Management.** The proposed management strategy for sediment control, including such measures as use of fabric silt fences downstream of flow paths and channels to intercept sediment generated during construction, is given in Sections 20.5.3 and 20.6.2, Mitigation and Management Measures, for water quality and aquatic ecology respectively. See also Section 21.3, Sea Water Quality, for discussion of control of sedimentation in Caution Bay.
- **Management of Other Construction Wastes.** The proposed project construction waste management system is described in Chapter 25, Waste Management.
- **Management of Soil Contamination.** The proposed management strategy for soil contamination is described in Section 20.2.2, Mitigation and Management Measures.
- **Management of Hazard and Risk.** The proposed approach to managing safety, security and emergency response is described in Chapter 27, Environmental Hazard Assessment.
- **Management of Emissions.** The proposed management and mitigation measures for air (including dust control), noise and lighting emissions are described in Sections 20.8.3, 20.9.3 and 20.10.3, Mitigation and Management Measures, for air, noise and visual amenity respectively.
- **Management of Traffic.** Traffic management issues and mitigation measures are discussed in Chapter 23, Project-wide Socio-economic Impacts and Measures.
- **Management of Chemical and Fuel Storage.** The proposed approach to managing chemical and fuel storage is described in Sections 20.2.2, 20.4.3, and 20.5.3, Mitigation and Management Measures, for soils, hydrological processes and water quality respectively.

- **Environmental Monitoring.** The environmental management and monitoring system that will be implemented to limit environmental and social impacts during project constriction and operations is described in Chapter 30, Environmental Management, Monitoring and Reporting.

4.5.5 Training

The project will build a construction training facility at the Port Moresby Technical College to provide training, primarily for LNG Facility construction trades and to be used during construction. A second one will be built near the LNG Plant for use during operations.

4.6 Constructing the Initial Infrastructure

Initial infrastructure construction activities will include:

- Construction of the bypass road.
- Installation of the lease boundary, exclusion and security fences (see Section 4.2.1.4, Fencing and Exclusion Zones).
- Site preparation and watercourse diversion.
- Upgrading (see Section 4.2.1.5, Public Road Upgrade from Port Moresby to the LNG Facilities Site) and rerouting (see Section 4.2.1.6, Rerouted Public Road) of Lea Lea Road between Port Moresby and the site.
- Construction of the Materials Offloading Facility.
- Construction of the temporary construction camp.
- Foundation construction for major infrastructure items.

Site preparation and civil works will start soon after the award of the LNG Facilities engineering, procurement and construction contract. The first 12 to 18 months of field construction activities will focus on site clearance and overall site preparation for the major facilities construction effort to follow. Site-specific security and execution methods will be considered and applied as appropriate to areas of excavation including security (watchmen) active dewatering, provision of a physical barrier, community awareness programs and signage.

Access to the site at this stage of construction will be via the existing Lea Lea Road from Port Moresby to the LNG Facilities site.

The LNG Facilities site will be patrolled from the time that construction work begins. Once the security fence is complete, access will be controlled through manned security gates.

Until the Materials Offloading Facility is operational, construction equipment will be transported to the LNG Facilities site either by landing craft or shallow-draft barges or will be shipped to Motukea Island or Port Moresby and trucked to site.

4.6.1 Site Preparation

Site preparation includes:

- Unexploded ordnance clearance.
- Fence installation.
- Ground survey.
- Archaeological clearance.
- Installation of a surface water drainage system.
- Vegetation clearance and storage.
- Topsoil removal and storage.
- Rehabilitation.
- Earthworks.
- Dredging for the marine facilities (see Section 4.3.3, Materials Offloading Facility).

4.6.1.1 Unexploded Ordnance Clearance

The LNG Facilities site and surrounding environment were used as an artillery firing range during World War II, and unexploded ordnance is known to be present on the site.

Specialist unexploded ordnance clearance teams have cleared parts of the site to enable environmental and engineering studies to be carried out, and this clearing process will be completed for the entire LNG Facilities site. Clearance involves magnetic detection and probing to locate buried metallic objects that could be unexploded ordnance and then excavating, identifying and disposing of the objects.

With the exception of unexploded ordnance clearance personnel, no one will be allowed to access any area of the LNG Facilities site without an escort until the area has been signed off as cleared and classified as ‘subsurface safe’.

4.6.1.2 Fence Installation

The lease boundary fence, exclusion fence and security fence (see Figure 4.2 and Section 4.2.1.4, Fencing and Exclusion Zones) will be installed by the normal method of excavating foundations for the posts, lodging the posts in concrete footings, securing the fencing wire (and razor tape for the security fence) and fitting the gates and surveillance systems. The exclusion fence sections located in the mangrove area will require vegetation clearance of approximately 5 m width to allow fence installation The exclusion fence and lease boundary fence will be erected immediately after leases over Portions 2456 and 2457 are granted to the project.

4.6.1.3 Ground Survey

All areas proposed for construction activities will be surveyed and pegged. The extent of site clearing and incidental site disturbance will be minimised by the demarcation of areas that require clearing and by confining traffic to designated tracks and laydown areas.

4.6.1.4 Archaeological Clearance

The LNG Facilities site and surrounds have a long history of human occupation and are important locations for the *hiri*[2] pottery trade that occurred along the gulf coast of Papua New Guinea for over 500 years (see Chapter 16, Cultural Heritage Environment: LNG and Marine Facilities). Numerous artefact sites and foundations of former village settlements have been found at or close to the site; and archaeological site clearance, including selective salvage of artefact material, will be required prior to ground disturbance.

Archaeological clearance of the areas within the LNG Facilities site perimeter fence will be conducted as described in Chapter 22, Project-wide Cultural Heritage Impacts and Mitigation Measures.

4.6.1.5 Installation of Surface Water Drainage Systems

A site surface water drainage system will be constructed to reduce the potential for soil erosion and discharge of sediment-laden water to local drainage lines and creeks and the marine environment during construction. The surface water drainage system will divert clean surface-water runoff away from areas to be disturbed and will collect sediment-laden water from disturbed areas in sediment traps, settlement ponds or similar structures prior to discharge in accordance with requirements detailed in the relevant environment (waste discharge) permit. As far as practicable, any existing small watercourse diverted within the LNG Facilities site will discharge at approximately the same location as they do currently once they reach the edge of the LNG Facilities site. Further details of management strategies are given in Sections 20.4, Hydrology and Sediment Transport, and 20.6, Aquatic Ecology, for water quality and aquatic ecology respectively.

4.6.1.6 Vegetation Clearance and Storage

Clearing of vegetation for construction will be undertaken so as to minimise the potential for soil erosion from exposed surfaces. Vegetation will be cut as close as possible to the ground without striking the earth. Cut vegetation will be carried to a designated stockpile area for later reuse for soil stabilisation and rehabilitation works and will not infringe upon areas required for maintenance and operations.

4.6.1.7 Topsoil Removal and Storage

Topsoil is generally defined as the top layer of fertile soil, including all plant matter that has not been cleared. Following vegetation clearance, topsoil will be progressively stripped and either used in rehabilitation works or stockpiled in spoil areas on the site. Topsoil will be respread over the final surfaces of areas designated for rehabilitation and landscaping to support regrowth.

---

[2] The English translation of *hiri* is 'trading voyage'.

Topsoil stockpiles will be stabilised, and erosion control measures will be implemented as appropriate (see Section 18.2, Landform and Soils, for the proposed mitigation and management measures).

4.6.1.8 Rehabilitation

Following construction and startup, the site will be cleaned up and rehabilitated. This will involve the removal of construction waste materials, surplus material and scrap, temporary buildings and construction equipment. Where practicable, areas no longer required for construction or support services will be revegetated promptly (e.g., the area set aside for future LNG train(s)). A reclamation plan will be developed that will prioritise erosion control (particularly of black cracking clays) by the regeneration of natural vegetation communities, wetland substrates and savanna as close to natural levels as possible through seed collection and/or use of topsoil as a seed resource. However, for safety and security reasons, within the LNG Facilities, site grass will be kept down through regular mowing.

4.6.1.9 Earthworks

Major earthworks (earthmoving and levelling activities) will provide a base for roads, accommodation camps, the LNG Plant and other site infrastructure. These activities will be undertaken using front-end loaders, backhoes, dozers, motor graders, rollers, and dump trucks. No drilling or blasting is expected to be required. Appropriate management measures will be adopted to restrict soil erosion and dispersion (see Section 20.2.2, Mitigation and Management Measures). Water trucks, water sprays or dust suppressants will be used as necessary to manage dust. Areas requiring undercut to remove poor soils will be backfilled with appropriate quality fill as needed. Areas will be trimmed to final grade and compacted on completion of major earthworks.

Cut and fill volumes are estimated at approximately 2 million m^3 each. Excavated cut material will be used for fill where suitable, and any surplus will be deposited in the spoils area at the northern end on the site (see Figure 4.1).

If material suitable for fill is not available in sufficient quantities on site, it will be sourced from in-country quarries or imported from overseas sources and delivered to site via the port facilities in Port Moresby. Road base and foundation aggregate material sourced from in-country quarries that are not developed by the project will be in accordance with the requirements of Land and Community Affairs guidelines and procedures that provide controls for the amount of gravel extracted from quarries. A sufficient quantity of aggregate suitable for concrete production will be produced (or trucked in) by the earthworks crew and stockpiled for use in foundation construction.

4.6.1.10 Dredging for the Marine Facilities

A bathymetric survey indicated that initial dredging of between 150,000 and 200,000 m^3 will be required to construct the access to the Materials Offloading Facility with sufficient draft of 8 m below LAT (see Section 7.7.4, Materials Offloading Facility, for a description of the rationale for dredging and Section 21.3 Water Quality, for a preliminary assessment of the impacts to the marine environment from dredging and dredge spoil disposal).

A small amount of dredging may also be required in the LNG carrier turning basin to remove any localised areas of seabed raised above the minimum required depth (subject to geotechnical survey); otherwise, the turning basin and the shipping access channel have sufficient under-keel clearance without dredging. The type of dredging equipment is not yet defined but will be appropriate for the operating depths and types of material to be dredged. It is not expected that maintenance dredging will be required during operation of the Materials Offloading Facility, which can be allowed to silt up naturally on completion of construction. The need for maintenance dredging of the LNG Jetty export berth, condensate export berth and turning basin is not anticipated during operations but could be required if silting is heavier than predicted.

4.6.2 Constructing or Upgrading Roads

The upgrade and realignment of Lea Lea Road from Port Moresby to and around the LNG Facilities site and the intrasite roads will be completed by conventional road-building plant (e.g., front-end loaders, backhoes, graders, rollers, dump trucks and water carts). The road base will be constructed of crushed stone. Bitumen from the asphalt plant will then be laid onto the base to seal the road, followed by road markings, signs, safety barriers, lighting and other ancillary works.

Road construction, upgrade and realignment will meet the design criteria for roadways as shown in Section 5.2.3.1, Roadway Design Criteria.

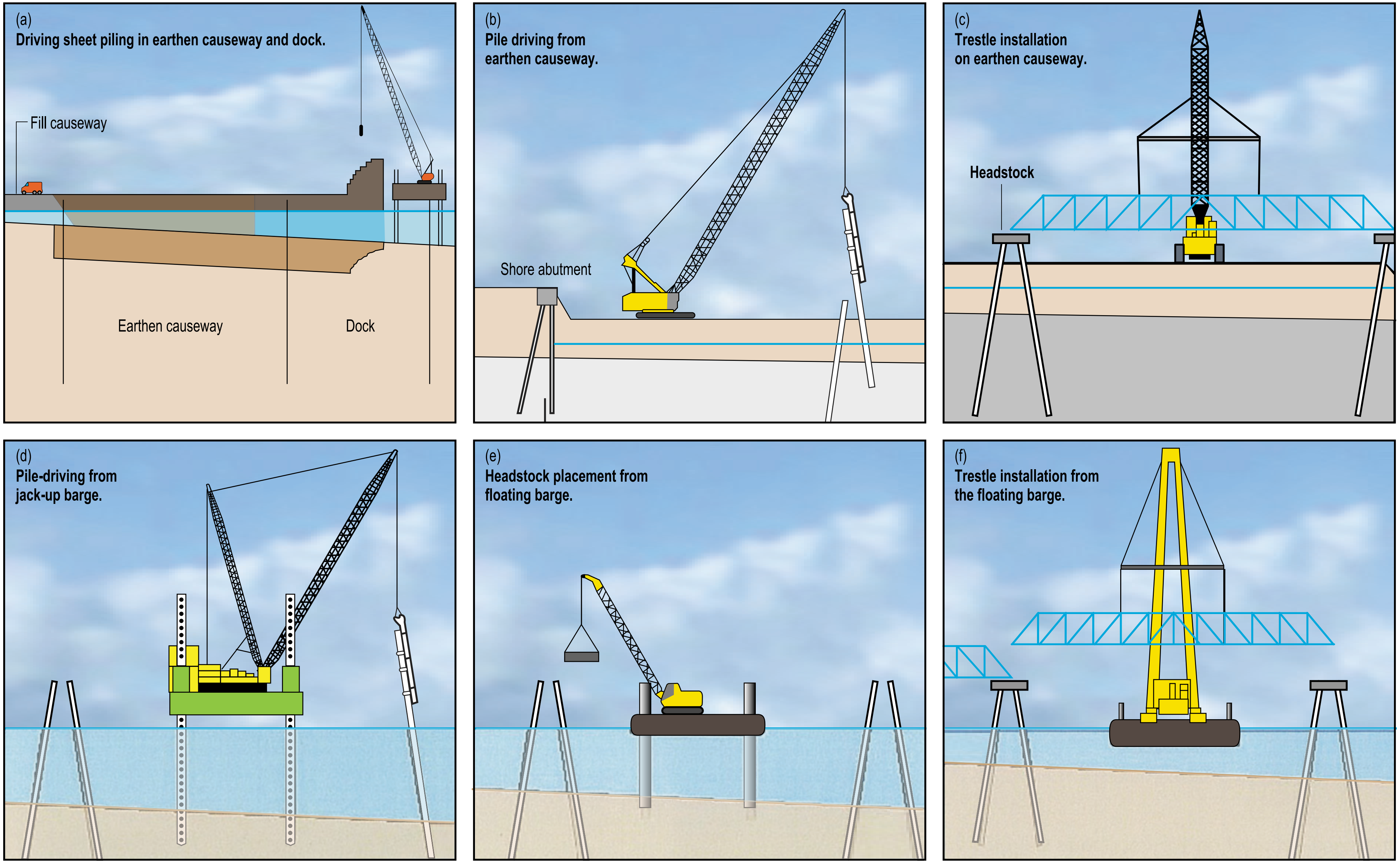
4.6.3 Constructing the Causeway and the Materials Offloading Facility

The Materials Offloading Facility will avoid the need to transport heavy, large or unwieldy loads by road. It will be an extension of the shared earthen causeway to be constructed for the marine facilities (see Figure 4.6).

The shared earthen causeway will be 105 m wide at the base and will be constructed seaward from shore, using conventional earthmoving equipment, such as excavators, bulldozers, dump trucks, graders, rollers, and concrete trucks. A rock containment bund will define the perimeter of the causeway, and sediment control measures will be employed to limit the release of fines into the marine environment. Examples of sediment control measures include the use of silt curtains or the placement of lining between the causeway and the seafloor interface either with geotextile or with a gravel having a small proportion of fines (see Section 21.3, Sea Water Quality). Fill will be end-dumped on the internal slopes of the containment bund perimeter and progressively compacted.

The sheet piles used in the construction of the dock (and the final section of the causeway) will be brought to site via barge. Conventional pile-drivers (impact or vibratory) will be used to drive sheet piles into the seafloor (Figure 4.9a). The dock area will then be pumped out and filled by end-tipped and compacted material, surfaced with crushed rock and topped with concrete beams to form the working surface.

As described in Section 4.3.3, Materials Offloading Facility, dredging of up to 200,000 m^3 material may be required to achieve the required depth of 8 m below LAT at the wharf. The type of dredging equipment is not yet determined and will be optimised during detailed design. Dredged rock and sand will be used in construction and foundations wherever practicable. However, some offshore disposal will be required, and thus will be disposed of to deep water (beyond the 450-m contour) with sufficient separation to avoid additional turbidity and sedimentation on the barrier reef or within the coastal lagoon.



Source: PGLN-SW-JRZZZ-820001.

PNG LNG	Job No: 1284	Esso Highlands Limited	Materials Offloading Facility and LNG Jetty construction
	File Name: 1284_09_F04.09_HB	PNG LNG Project	Figure No: 4.9

PGGP-EN-SRENV-000001-001
Rev0

More discussion of dredging and an assessment of the impacts of dredging, including the potential dredge spoil disposal locations, are given in Chapter 21, Environmental Impacts and Mitigation Measures: Marine Facilities. Procedures of the National Dredging Guidelines (Environment Australia, 2002)[3] will be followed, including consideration of reuse potential for dredged spoil. Since the area has not been developed for industrial activities or shipping, it is considered unlikely that sediment in Caution Bay is contaminated; however, dredging guidelines for testing will be followed to allow for safe handling in the event of dredging any contaminated material.

Impacts from sedimentation during construction are assessed in Section 21.3, Sea Water Quality. Impacts of noise from pile driving are assessed in Section 21.5, Marine Fish and Other Marine Fauna.

Construction of the Materials Offloading Facility is expected to take around 6 to 8 months.

4.6.4 Constructing the Temporary Construction Camp

A temporary construction camp will be set up to house the construction workers building the LNG Facilities (Figure 4.10). The construction contractors will be required to follow the relevant project design philosophies, standards and codes given in Attachment 3, Technical Codes and Standards. The temporary camp will be self-sufficient in power, communications, water treatment, sewage treatment and domestic incineration (see Chapter 25, Waste Management).

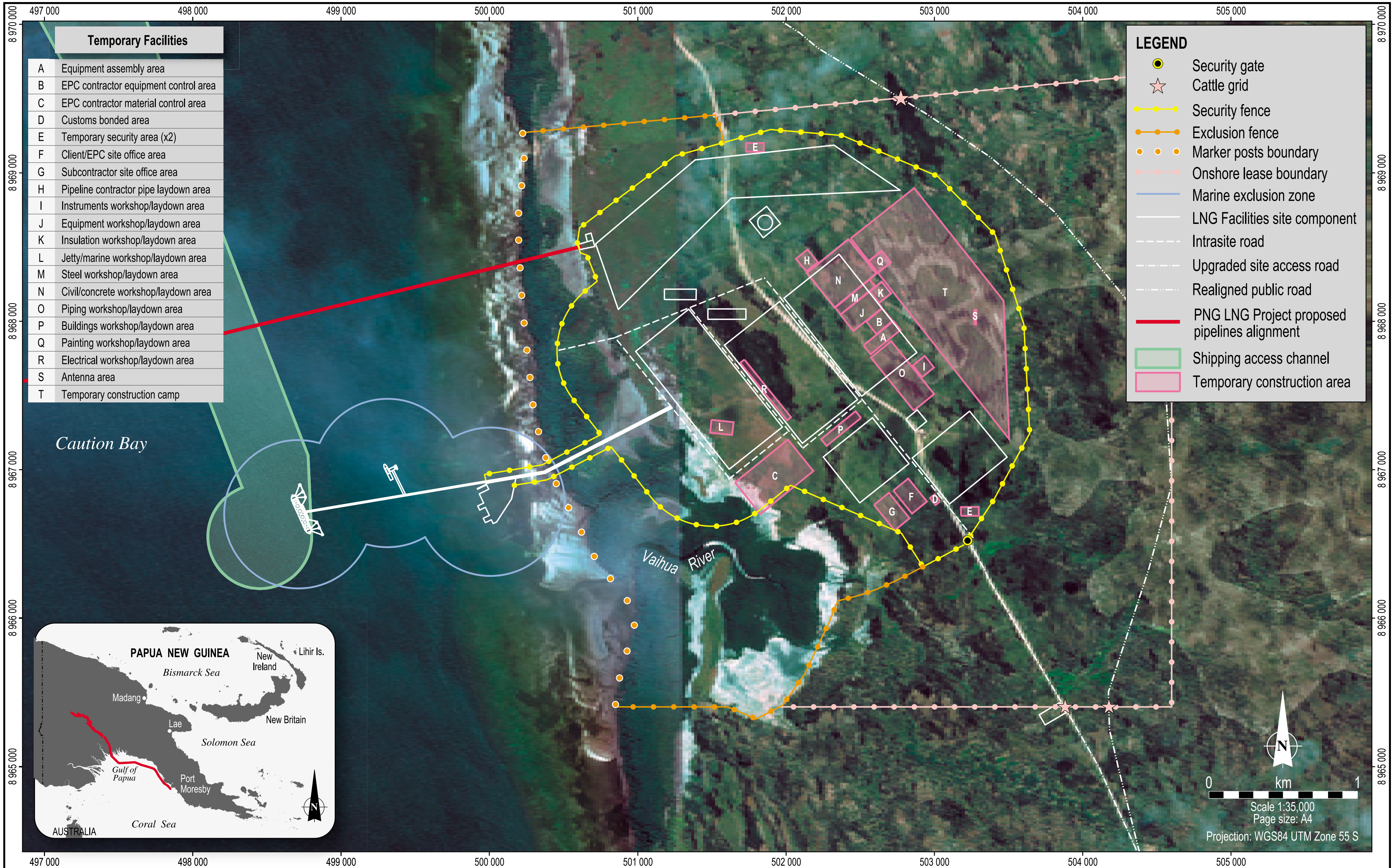
For the initial 200-bed stage of the construction camp, water will be trucked in from Port Moresby or Curtain Brothers. Barge-mounted desalination systems moored near shore in Caution Bay will be installed to provide water during the second stage of the construction camp development (Plate 4.6).

Accommodation and other buildings for the construction camp will be prefabricated of modularised wood around a metal frame and stressed membrane structure. They will be transported to site initially by road and then by barge and truck when the Materials Offloading Facility is operational. The buildings will be lifted off the trucks by a crane, set into place on prepared foundations and connected to services (electricity, water, sewage and telecommunications) as required.

The construction camp is programmed to be built in eight separate stages. Stage 1 will be the pioneer camp of 200 beds. From this stage forward, each stage will include beds in the following cumulative quantities:

---

[3] This is consistent with, and anticipates the introduction of the proposed Marine Pollution (Sea Dumping) Bill, currently under consideration by the PNG Government, and which will bring into effect the provisions of the London Convention (1996 Protocol) on the prevention of marine pollution by dumping of wastes and other matter, 1972.



Note:
Layout is indicative only.
Final placement of all components is contingent on pending soil and geological data.
Pipelines approximate the proposed alignment based on engineering data provided up to 1 October 2008.

PNG LNG

Date: 25.08.2008
MXD: PNG_LNG_Project_GIS.mxd
File Name: 1284_09_F04.10_GIS_HB

Esso Highlands Limited

PNG LNG Project

Indicative temporary facilities and laydown areas

Figure No: 4.10

PGGP-EN-SRENV-000001-**001**
Rev0

- Stage 2: 400 beds.
- Stage 3: 600 beds.
- Stage 4: 1,200 beds.
- Stage 5: 2,800 beds.
- Stage 6: 4,400 beds.
- Stage 7: 6,000 beds.
- Stage 8: 7,500 beds.

The first construction workforce will initially be accommodated in Port Moresby until the accommodation modules are ready.

The temporary construction camp will be sited on approximately 75 ha on the northeast side of the LNG Facilities site (see Figure 4.10) and provide accommodation, services and messing, with facilities including:

- First aid and clinic.
- Maintenance workshop.
- Security office and guardhouse.
- Safety training and orientation office.
- Commissary, bank and post office.
- Sports and recreation areas.
- Fire station.
- Fuel filling station.
- Place of worship.

4.6.5 Constructing the Foundations for Major Infrastructure Items

The LNG and condensate storage tank piling (if required) and foundation construction will begin shortly after early site development. The concrete batching plant will supply the concrete mixing trucks that will pour the foundations.

Construction of the LNG train(s) piperack foundations will follow the installation of the LNG and condensate storage tank foundations. Construction of both the above-ground foundations and the underground utilities will support the installation of the pre-assembled piperack assemblies.

4.7 Constructing the LNG Plant

Construction of the LNG Plant will follow the site preparation and civil works. Essentially, all major construction equipment required for the construction work at the LNG Facilities site will be imported into Papua New Guinea.

LNG Plant permanent facilities, including instrumentation, accommodation systems and mechanical equipment, will be world open-market sourced and delivered to the site.

Activities during construction of the LNG Plant will include steel and piping erection, equipment setting, welding, and electrical and instrument installation, insulation and coating. Various laydown areas, workshops and other temporary buildings, such as offices and warehouses, will be required. Temporary facilities will be dismantled either before or after the facility begins operations. Figure 4.10 lists the temporary facilities and laydown areas. Laydown areas will store plant components and other materials delivered by barges at the Materials Offloading Facility (see Figure 4.6).

Large cranes will be used to offload and assemble large equipment items on site. Tower cranes will be assembled on site for erection of various facility items, particularly piping erection and equipment setting. Smaller cranes will move construction materials and equipment around the site.

The main activities in constructing the LNG Plant are:

- **Piling (if required) and foundation installation.**
- **Steel installation.** Structural steel will be installed once the foundations are in place using two crawler-mounted, 150-t cranes.

  Most structural steel needed for the construction of the LNG processing facilities will be prefabricated in overseas workshops before being shipped to the LNG Facilities site.
- **Equipment setting.** Equipment items arriving throughout construction will require setting onto their permanent foundations. After their delivery at the Materials Offloading Facility, heavy equipment items requiring heavy-haul transport may be delivered to their foundations or to laydown areas. At the laydown area, large crawler-mounted cranes will transport the equipment items to their permanent position. Once in position, those items will be lifted into place and bolted to the foundations (Figure 4.11).
- **Welding, radiography and pressure testing.** Once the structural steel and equipment erection has taken place, the piping assembles will be welded together. Crews will perform tie-in welds, weld inspection and repair, coating, coating inspections and coating repairs. Welds will predominantly be inspected by radiography. Other inspection methods (e.g., magnetic particle, ultrasonic testing) may also be employed.
- **Electrical and instrumentation installation.** Once equipment has been set and the piping assembled into position, finishing works will include electrical and instrumentation installation. This will include some cables and the earthing grid being installed underground within the camp and buildings and in some plant areas.
- **Insulation and application of coating materials.** Equipment and piping and structural steel, where appropriate, will be coated in the field if not coated by the suppliers. If major vessels are not insulated prior to delivery, they will be insulated in the horizontal position at the appropriate laydown area before lifting into position. Insulation of piping will follow pressure testing, along with touch-up painting and fireproofing.

4.8 Constructing the LNG Plant Utilities and Offsites

The LNG Plant utilities store or produce inputs required by the plant, such as hot oil, electricity and water (for more detail, see Section 4.2.4, LNG Plant Offsites).

Job No: 1284	Esso Highlands Limited	LNG process equipment setting	Figure No: 4.11
File Name: 1284_09_F04.11_KB	PNG LNG Project		

Construction of the LNG Plant utilities and offsites will commence in parallel with LNG train construction. The main construction activities will include:

- Field erected tanks, such as the LNG storage tanks.
- Pipe rack erection.
- Equipment rig out and setting.
- Piping assembly, inspection and testing.
- Building erection.
- Electrical equipment and instrumentation installation and hookup.
- Final grading.

4.8.1 LNG Storage Tanks and Loading System and Boil-off Gas System

Construction of the two LNG storage tanks and loading facilities, boil-off gas system and interconnecting pipeways will begin in parallel with LNG train construction (see Figure 1.3).

The material and equipment required to construct the LNG storage tanks, loading systems and boil-off gas system will be shipped to the Materials Offloading Facility and transported to their respective laydown areas.

The LNG storage tank walls will be constructed of precast concrete sections by the climbing in-situ method and will involve slip-forming construction methods combined with post-tensioning (Figure 4.12). Steel tendons will be inserted horizontally and vertically through each concrete section as it is placed by crane. Once the sections are in position, the vertical and horizontal steel tendons will be tightened to tension the structure. The LNG storage tank roof will be constructed at ground level inside the storage tank walls and then lifted into position by compressed air. Bridging sections will then be inserted between the main body of the roof and the outer cylindrical wall, in order to lock the roof in place. Tank filling and carrier loading systems will be installed on top of the tanks, and the tanks will be enclosed within bunds.

4.8.2 Condensate Storage and Loading System

The two 8,500-m^3-capacity, floating-roof condensate storage tanks will be of welded steel construction. Material and equipment will arrive via the Materials Offloading Facility before being transported to a specific laydown area. The condensate tank construction will follow similar construction methods as for the LNG storage tank (see Section 4.8.1, LNG Storage Tanks and Loading System and Boil-off Gas System).

4.8.3 Flare Systems

Flare systems will be constructed after the construction of the fuel gas system and prior to the introduction of fuel gas.

The flare stack components will arrive prefabricated for assembly on site.

	Job No: 1284	Esso Highlands Limited	LNG storage tank construction	Figure No: 4.12
PNG LNG	File Name: 1284_09_F04.12_KB	PNG LNG Project		

PGGP-EN-SRENV-000001-**001**
Rev0

4.8.4 Utilities

The utilities' components will arrive at the Materials Offloading Facility in prefabricated modules and will be taken by truck to their respective locations for final assembly and erection.

4.9 Constructing the LNG Jetty

4.9.1 Causeway Construction

The causeway construction method has been described in Section 4.6.3, Constructing the Causeway and the Materials Offloading Facility, above.

4.9.2 LNG Jetty Construction

The landward section of the LNG Jetty will comprise the combined LNG Jetty and Materials Offloading Facility causeway and will be erected by equipment operating on the causeway at a water depth of approximately 8 m.

Pile driving will move progressively seawards from the causeway (see Figure 4.9b). Precast headstock systems will then be lifted into place and secured on the apex of each pile. Prefabricated trestle sections will then be lifted from barges and attached to brace the structure (see Figure 4.9c).

Jack-up barges and floating cranes will take over construction from the end of the causeway.

A jack-up barge will be used for pile driving (Figure 4.9d) with conventional hydraulic or diesel hammers. This is expected to be a relatively straightforward and repetitive process.

The piles requiring anchors will be secured and tensioned once the anchor piles are in place.

A barge-mounted crane (Figure 4.9e) will then place precast headstock systems on the apex of the piles, where they will be welded into position. This minimises the amount of in situ installation work to be completed over the water.

A barge-mounted crane will then lift the trestle sections into position (Figure 4.9f).

Impacts to the marine environment from these activities, particularly underwater noise and sedimentation are discussed in Chapter 21, Environmental Impacts and Mitigation Measures: Marine Facilities.

4.9.3 Export Berth Construction

4.9.3.1 LNG Export Berth Construction

The LNG export berth will be built at the seaward end of the main LNG Jetty trestle once the trestle is complete. The breasting and mooring dolphins will also built at this time (see Figure 4.7). A jack-up barge will drive piles.

The work at the LNG export berth is likely to warrant a temporary tower crane, which would be erected on the first completed dolphin.

The jack-up barge will drive piles; install precast headstock systems, decking and catwalks; and erect the tower crane. The tower crane will then complete the remainder of the export berth construction. On completion, the tower crane would be available to assist with the installation of mechanical and electrical works, as well as the LNG loading arms and associated export berth utilities.

A small amount of localised dredging may be required to provide sufficient under-keel clearance in the turning circle; otherwise, no dredging will be required during construction to obtain the required minimum water depth at the LNG export berth or in the shipping access channel.

4.9.3.2 Condensate Export Berth Construction

The condensate export berth (see Figure 4.7) will be constructed generally by methods similar to those used for the trestle and LNG export berth.

No dredging will be required during construction to obtain the required minimum water depth at the condensate export berth.

4.9.4 Jetty Road and Auxiliaries

4.9.4.1 Road

A conventional two-lane roadway will be constructed of crushed rock with a bitumen seal along the causeway to the Materials Offloading Facility and then along the trestle section of the LNG Jetty to the LNG loading platform. The LNG loading platform will be sufficiently sized to support the LNG loading operation.

Construction of the road will begin as soon as the first jetty trestle section is in position. In the first few trestle spans over shallow water, an all-terrain, 60-t crane will place precast concrete road panels from the earthen causeway, with barge-mounted cranes taking over in deeper waters.

4.9.4.2 Topside Equipment and Electrical and Piping Works

Topside equipment includes:

- Loading arms.
- Pipe racks.
- Transformer station.
- Pumps.
- Control room building.
- Fenders.
- Mooring hooks.

The marine equipment (especially the jack-up barge) used to build the jetty and export berths will be able to install most of these items. This avoids the need to offload materials to shore first and transport them back along the trestle - a reduction in double handling and the construction hazard of moving heavy equipment along the trestle.

Air, water, nitrogen, fire water and power will all be installed on the LNG Jetty. Most of the piping will be pre-installed on the trestle sections, while some, including electrical systems, will be installed following the completion of the roadway.

4.9.5 Shipping Access Channel Construction and Turning Basin

The bathymetry of Caution Bay shows sufficient under-keel clearance in the LNG carrier shipping access channel and at the LNG berth to avoid the need for dredging (see Figure 4.1 and Section 4.3.1, LNG Export Berth) described in Section 21.3, Sea Water Quality. It is possible that some dredging may be required to achieve the uniform required depth throughout the turning circle, but if so, equipment such as a backhoe dredge and trailer will be considered, and volumes would be small. It is not anticipated that any maintenance dredging will be required, as there will be no artificial deepening within the shipping access channel.

4.10 Constructing the LNG Facilities Site Supporting Infrastructure

The permanent operations camp, camp utilities, telecommunications infrastructure and plant support buildings will be delivered prefabricated for installation on preconstructed foundations.

4.11 Operating and Maintaining the LNG Facilities

LNG production over the life of the project will include:

- Operation of the LNG processing and loading equipment and of the supporting power, water and waste management facilities.
- Operation of infrastructure sized to handle expected peak load during turnaround (including electricity generated from the LNG Plant with diesel backup).
- Management of the permanent operations camp (270 beds and support facilities) and the turnaround camp (300 contractor beds).
- Waste and wastewater management.
- Operation of the desalinisation plant to supply fresh water to the plant and camps.
- Management of security.
- Management of traffic to and from the LNG Facilities site.
- Dealing with unplanned events, for example, liquids in the gas pipeline, the late arrival of an LNG carrier or condensate tanker, interruptions to gas supply or an accident in the production sequence.

Esso will operate the LNG Facilities under an integrated control, safety and information management system designed for safe, reliable and efficient performance. Standards to which the plant will be operated will be in line with good industry practice and are outlined in Chapter 30, Environmental Management, Monitoring and Reporting.

4.11.1 Management of Environmental, Safety and Social Issues

LNG Facilities will be in operation 24 hours a day for 30 years or more, and a hazard and operability study will be undertaken to identify, define and manage operational, social, environmental and other risks. A series of activity-specific environmental management and protection measures will be developed and performance monitored against targets.

The primary LNG Plant environmental and social management issues are:

- Air emissions (gas turbines, back-up generators, flares) (see Section 20.8.4, Residual Impact Assessment, for air quality and Chapter 26, Greenhouse Gases and Climate Change).
- Wastewater or stormwater discharges (see Section 4.2.4.5, Wastewater Treatment Systems).
- Solid and restricted waste management and disposal (see Chapter 25, Waste Management).
- Noise emissions and exclusion zone protection of local community (see Section 20.9.4, Residual Impact Assessment, for noise and Chapter 27, Environmental Hazard Assessment).
- Traffic (see Chapter 23, Project-wide Socio-economic Impacts and Mitigation Measures).

4.11.2 Staffing

Experienced expatriates and PNG nationals will provide the core team for initial operations. PNG nationals will progressively replace expatriates over time as they achieve the required competency levels and gain sufficient experience.

A month-on, month-off (28/28) rotation with 12-hour shifts is the current planning basis for most LNG Plant operations, maintenance, and key logistics positions. Proximity to Port Moresby means that some positions at the LNG Plant will be non-rotational, with personnel living in their own accommodation. The approximate total staffing requirements (including contractors) for steady state operations is identified in Table 1.2 in Section 1.2.6, Project Staffing.

The project will be managed from Port Moresby. The Port Moresby office will be staffed by up to 300 people. Housing for 190 residents will be required in 100 residences in Port Moresby: 30 for family occupancy and 70 for single occupancy. These facilities will be sited and designed according to National Capital District Commission town planning requirements for Port Moresby (see Section 8.2.4, Project Urban Planning Context), and approvals to develop the facilities will be sought under the appropriate planning regulations. The issues and implications are discussed in Chapter 24, Cumulative and Associated Impacts.

4.11.3 Commissioning

Startup and commissioning activities will test the components of the LNG Plant and associated utilities and offsites for correct operation, for example, by safety checks on electrical instrumentation and valves and by pneumatic and hydraulic pressure testing. From both operational and environmental perspectives, the most significant of these tests will be hydrotesting of the process system to ensure that vessels and pipes can contain the design pressures and safety valves do not leak.

Hydrotesting of LNG Plant facilities is similar in concept to the process described for pipelines (see Section 3.4.6.4, Hydrotesting). LNG and condensate storage tanks, facility piping systems, transmission pipeline connections and other pressure equipment will be subjected to water pressures in excess of normal operating limits, so that leaks can be identified and repaired.

At least 80,000 m^3 (one half the volume of one LNG storage tank) of fresh water will be required for hydrotesting.

Hydrotest water sources and disposal methods will be investigated during detailed design. Water may be supplied from the LNG Facilities onshore desalination plant, or it may be possible to reuse the hydrotest water used in the offshore section of the LNG Project Gas Pipeline. Discharge will be conducted under the appropriate PNG environment (waste discharge) permit, and the potential issues and impacts associated with hydrotest water disposal are set out in Chapter 21, Environmental Impacts and Mitigation Measures: Marine Facilities.

It is likely that some flaring will occur during commissioning and start up. The potential issues and impacts associated with flaring are set out in Section 20.10, Visual, and Section 21.5, Marine Fish and Other Marine Fauna.

4.11.4 Control Centre

A single LNG Plant control centre will monitor and control the operation of the plant and loading of LNG and condensate. The LNG Plant will be as fully automated as practical.

The control centre will also oversee the metering of inlet gas from the LNG Project Gas Pipeline. Custody transfer of LNG and condensate will be measured by the respective carriers or tankers and verified by meters at the LNG Plant.

The LNG Plant will be designed to respond automatically to an emergency, backed up by specific procedures for such situations as gas leaks, fire, or liquid spills. Emergency response equipment (e.g., spill booms and dispersant) will be acquired prior to startup.

4.11.5 Maintenance

Planned maintenance shutdowns (turnarounds) will be scheduled and coordinated to achieve a combined field (upstream gas field and gas processing infrastructure) and LNG Plant availability of 94%. The LNG Plant itself will be designed and operated to achieve an availability of 96% to 97%.

Piping, valving, and equipment will be designed so that sections of the plant can be isolated for maintenance work. Vents and drains will allow for safe and effective depressurising, draining, and purging of equipment. Where possible, common equipment will be considered across upstream and LNG Facilities (e.g., gas turbines, valves, instrumentation, etc.), in order to minimise spares holdings and personnel competency requirements.

Plant data and equipment performance monitoring systems will collect and plot data, monitor critical rotating equipment, and process data so that it can be accessed locally and remotely for troubleshooting and predictive maintenance. The system will be capable of being accessed in Papua New Guinea and remotely.

4.12 Operating and Maintaining the Marine Facilities

4.12.1 Staffing

Marine facilities operations staffing numbers are included in Table 1.2 in Section 1.2.6, Project Staffing.

4.12.2 Materials Offloading Facility Operations

During construction of the LNG Facilities, two 300-t crawler cranes at the Materials Offloading Facility will transfer equipment and material from the barges onto trucks or low loaders for transport to locations across the LNG Facilities site. Among the largest loads will be the amine absorbers (430 t each; Plate 4.7), the main cryogenic heat exchangers (each 60 m long; Plate 4.8) and the mixed-refrigerant compressor knock-out drums and high-pressure propane knock-out drums (each 8 m wide).

Most cargo will be transported in 40-foot containers. Large loads will be transported on multi-wheeled transporters carried on the barges themselves and then simply driven onto the dock. General cargo vessels will typically berth in Port Moresby and transfer cargo to barges, which will in turn steam the short distance to Caution Bay.

During operation of the LNG Facilities, the Materials Offloading Facility will be used only occasionally to unload equipment and materials. Normal quarantine and customs procedures will apply. Dedicated patrol boats will enforce a 500-m moving exclusion zone around vessels during the time that they are under pilot control.

The dock and causeway will be inspected and repaired if there is a sufficiently severe storm for waves to overtop structure.

4.12.3 LNG Jetty Operations

The PNG LNG Project will control ship movements at the LNG Jetty, including safety and operability vetting of LNG carriers and condensate carriers.

4.12.3.1 LNG and Condensate Loading

LNG carriers and condensate tankers will take on pilots before entering Caution Bay and proceeding to their respective berths, where tugs will manoeuvre the vessels into position for mooring. Dedicated patrol boats will enforce a 500-m moving exclusion zone around ships during the time that they are under pilot control.

LNG and condensate loading operations will include storage tank product level measurements, loading arm connection, product transfer activation from the central control room, monitoring of loading rates and confirmation of product transfer close.

Maintenance dredging is not anticipated to be required for the LNG export berth, condensate export berth or the shipping access channel (see Chapter 21, Environmental Impacts and Mitigation Measures: Marine Facilities.).

4.12.3.2 Operations Environmental Safety Limits

A marine operations and environmental monitoring system at the LNG Jetty will monitor wind

Plate 4.7
Amine absorber being unloaded

Plate 4.8
A cryogenic heat exchanger being unloaded

speeds, tide levels and current speeds. Typical operations environmental safety limits are given in Table 4.5.

Table 4.5 Operations environmental safety limits

Operation	Maximum Wind Speed	Maximum Wave Condition
Berthing with tug assist	25 knots	2 m
LNG transfer	35 knots	3 m bow/stern 0.7 m, 9 sec. beam
LNG loading arm disconnection and vessel to remain at berth	40 knots	3.5 m bow/stern 1 m, 9 sec. beam
Condensate berthing	20 knots	1.5 m
Condensate transfer	25 knots	2 m
Condensate loading arm disconnection and vessel to remain at berth	35 knots	2.5 m

The maximum current speed for LNG carrier manoeuvring will be 2 knots.

The 80-t tugs have been selected to cope with the following case:

- LNG carrier of 220,000-m^3 capacity.
- 25-knot wind.
- 1.5-m swell.
- Less than 0.5-knot current.

A marine operations risk assessment (inbound and outbound vessel movement, berthing and cargo transfer) has identified operations scenarios for more detailed analysis and specific risk management, including:

- Vessel grounding between the Gulf of Papua and the marine terminal.
- Subsea gas pipeline rupture from dropped anchor.
- Tanker collision with fishing boat.
- Mechanical failure of critical ship equipment during inbound or outbound transits.
- Vessel fire while berthed.
- Release of LNG vapour cloud while loading.
- Vessel drift from high winds at jetty while loading.

The risk management process is designed to reduce risks for these and other scenarios (see Chapter 27, Environmental Hazard Assessment).

Detailed vessel manoeuvring simulations to confirm tug requirements and environmental operation criteria are planned once specific metocean data and specific vessel characteristics have been better defined.

4.12.4 Marine Exclusion Zone

There will be a marine exclusion zone with its boundary formed by radii of 500 m cented at the LNG and condensate loading manifold connections and on the Materials Offloading Facility (see

Figure 4.1) and also surrounding the LNG carriers and condensate tankers as they move from the pilot station to the jetty. Non-project vessels will be prohibited from entering marine exclusion zones or performing any operations within this zone, including locally owned fishing boats. More details on how the exclusion zone was determined are provided in Chapter 27, Environmental Hazard Assessment. Impacts on subsistence fishing are described in Section 21.6, Subsistence Fisheries and Marine Traffic.

4.13 Decommissioning

4.13.1 LNG Facilities

The decommissioning of the LNG Facilities will be completed to standards that reflect community expectations and good industry practices at that time. Current expectations are that equipment that can be salvaged will be reused or resold, and any facilities of use to the local community will be left in place (e.g., roads). Where feasible, material that cannot be used for its original purpose will be recycled or scrapped. The aim will be to minimise the amount of waste requiring disposal during decommissioning.

Prior to the removal of any equipment, it will be depressurised, purged and flushed of hydrocarbons to ensure that the removal process does not result in adverse hydrocarbon releases. Any advances in the management of the decommissioning process during the life of the facility will be utilised.

The hydrocarbon product to be processed will be predominantly gaseous; therefore, soil contamination is not expected to be an issue. However, a soil contamination survey will be conducted to determine if there has been any inadvertent contamination (e.g., diesel fuel). If any contamination is discovered, a soil remediation program will be instigated and will be consistent with good industry practice environmental management as it stands at the time of decommissioning.

Once LNG processing facility equipment has been removed from the site, the land will be rehabilitated to a condition that is consistent with the surrounding environment and local community and PNG Government expectations at the time. Appropriate funds will be made available for rehabilitation and maintenance. The overall aim of the decommissioning process will be to obtain agreement from the PNG Government that the site has been decommissioned to agreed standards, which will mean that the site poses negligible risk to public safety and the environment and fulfils community expectations.

4.13.2 Marine Facilities

The decommissioning of the marine facilities will be completed to standards that reflect community expectations and good industry practice at that time. It is anticipated that the facilities associated with loading LNG onto ships will be decommissioned in a similar fashion to the onshore LNG processing facilities, whereas decommissioning the pipelines will follow the steps most appropriate for the environment in which they were placed.

The causeway for the Materials Offloading Facility and the beginning of the LNG Jetty itself will be left in place. This is because the local benthic habitat and the associated flora and fauna will have adapted to its presence over the 30-year operational life of the project. In addition, the removal of these facilities is a major operation and would result in a greater environmental disturbance than leaving them in place. In addition, the causeway will probably be of value to the local community.

The section of the LNG Jetty that continues past the causeway and is mounted on subsea piles will be dismantled, the piles cut off at the mud-line and the debris removed for disposal on land.

The dredged access channel to the Materials Offloading Facility will not be refilled as the resulting environmental impact would be greater than leaving the channel to reach a natural equilibrium. The same is true for any areas where maintenance dredging is required during operations, although this is not expected to be necessary. At the Materials Offloading Facility, this equilibrium will most likely be reached well before decommissioning.

As is the case with all these procedures, should advancing technology and techniques over the life of the project bring to light improved methods for decommissioning, they will be adopted for the marine facilities.