ATTACHMENT 3

ARROW LNG PLANT

Environmental Management Plan Update

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ARROW LNG PLANT

STRATEGIC ENVIRONMENTAL MANAGEMENT PLAN

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FEBRUARY 2013

Arrow CSG (Australia) Pty Ltd

Arrow LNG Plant

Strategic Environmental Management Plan

February 2013

CR 7033_16_v3

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Project Director	Barton Napier		
Project Manager	Christopher Doig		
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CR 7033_16_v2	Draft to Queensland Government	Barton Napier	December 2012
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1. INTRODUCTION

This Strategic Environmental Management Plan (Strategic EMP) has been prepared in support of the Supplementary Report to the Environmental Impact Statement (SREIS) for the Arrow LNG Plant. It provides strategic and specific commitments that will inform the development of detailed and specific issue EMPs to be subsequently developed for the project and is intended to support the Queensland Coordinator General's determination and conditioning of the project.

1.1 Project Description

Arrow CSG (Australia) Pty Ltd (Arrow Energy) proposes to develop a liquefied natural gas (LNG) plant on Curtis Island on the central Queensland coast, near Gladstone (Figure 1.1). The project, known as the Arrow LNG Plant, is a component of the larger Arrow LNG Project. The project's aim is to meet growing export gas market opportunities.

The project comprises three components: the LNG plant and ancillary infrastructure (including marine and logistics support facilities), a feed gas pipeline and tunnel, and dredging and disposal works. A detailed description of these key components is provided in Chapter 2 of this Strategic EMP, Description of Petroleum Activities. This Strategic EMP does not apply to upstream coal seam or natural gas fields or the transmission pipelines that transport gas to the Gladstone area which are subject to separate environmental impact statements. The delineation between this strategic EMP and plans for any other aspects that are further upstream will be the pipeline manifold adjacent to the Yarwun Alumina Refinery.

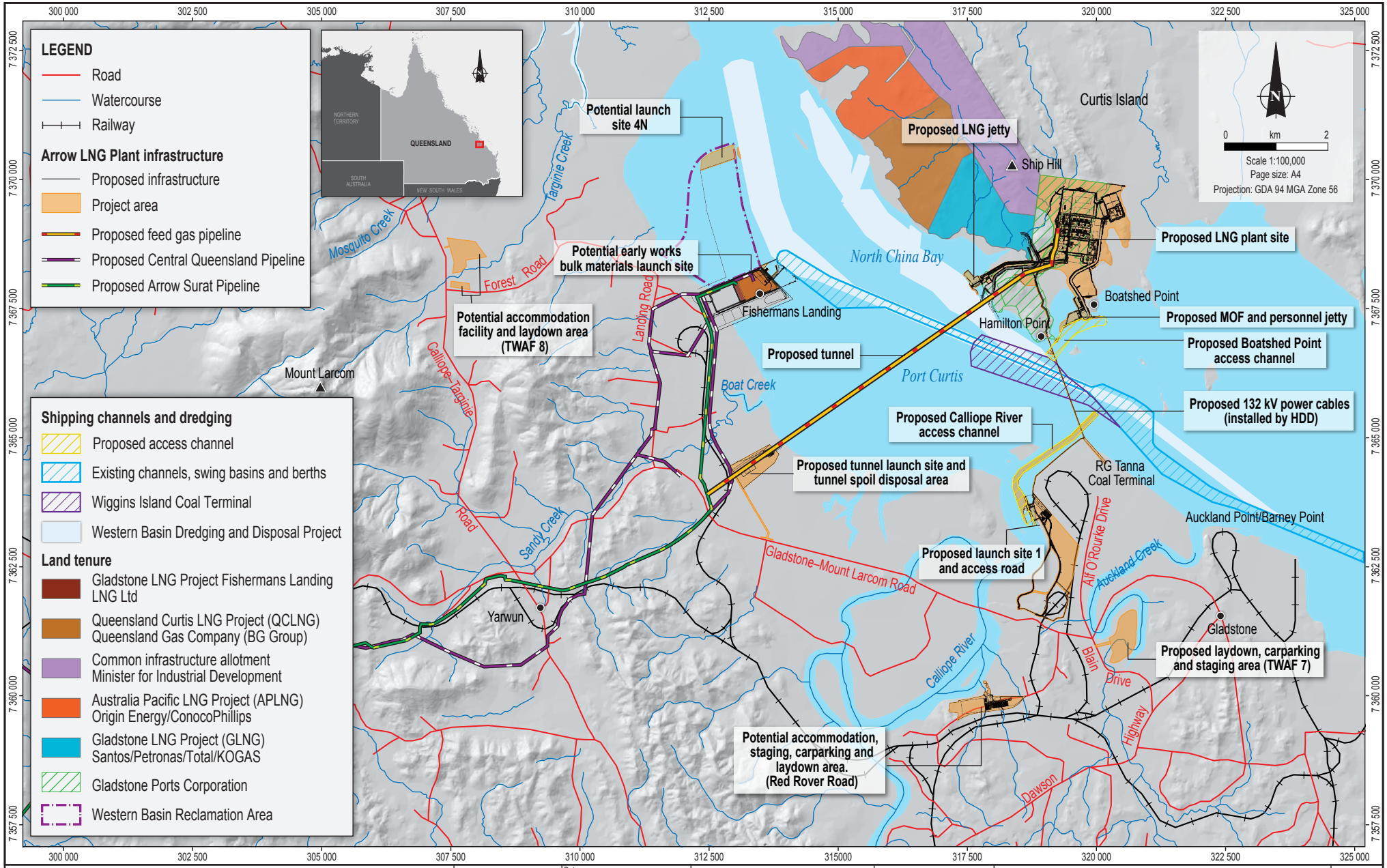
The project site forms part of the 1,500 ha Curtis Island Industry Precinct of the Gladstone State Development Area (GSDA), which extends over the southwest of Curtis Island. Arrow Energy has been granted an exclusive right by the Queensland Government to investigate the project site for the development of the project.

An environmental impact statement (EIS) has been prepared for the project. Coffey Environments Australia Pty Ltd (Coffey Environments) was commissioned to assist Arrow Energy in preparing the Arrow LNG Plant EIS (Coffey Environments, 2012).

The EIS was placed on public exhibition by the Queensland Coordinator-General from 14 April 2012 to 28 May 2012. Twenty-nine submissions relating to the EIS were received from government agencies and the public by the Coordinator-General during this time.

In addition, following the finalisation and exhibition of the EIS, Arrow Energy has completed the front end engineering design (FEED) study for the Arrow LNG Plant. The FEED study resulted in changes to the description of the LNG plant and ancillary infrastructure presented in the EIS. These changes are shown on Figure 1.2.

The Arrow LNG Plant SREIS has been prepared in order to respond to the Coordinator-General's request to provide additional information and to address comments about the EIS and project, as well as reflect the changes from the FEED study.



Source:
Place names and roads from DME. Watercourses from Alluvium.
Project area from Coffey Environments, pipelines, proposed auxiliary facilities and marine infrastructure from Arrow Energy.
Launch site 1 access route, proposed feed gas pipeline, proponents and DEM from Coffey Environments.
Western Basin Dredging Master Plan from Gladstone Ports Corporation.

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Date: 10.12.2012
MXD: 7033CB_16_GIS002_v1_9
File Name: 7033_EMP_F01.01_GIS_GL

Arrow Energy

Arrow LNG Plant

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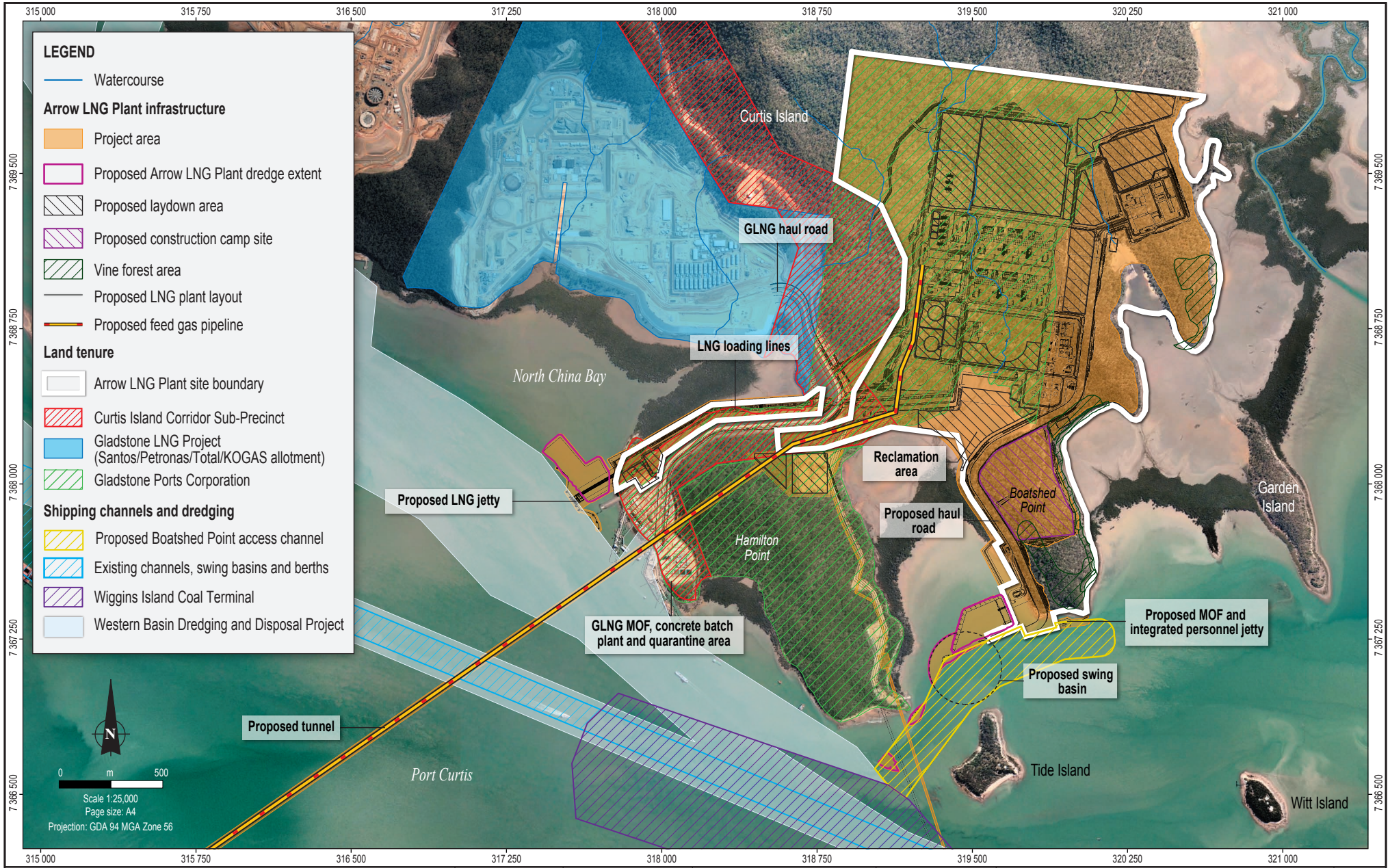
Site locality

Figure No: 1.1



Source:
Place names and roads from DME. Watercourses from Alluvium
Study area, proposed auxiliary facilities, marine infrastructure and vine forest areas from Arrow Energy.
Western Basin Dredging Master Plan and Disposal Project from Gladstone Ports Corporation.
Study area and proposed feed gas pipeline from Coffey Environments.
Imagery from Nearmap (captured 7 August 2012).

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Date: 10.12.2012
MXD: 7033CB_16_GIS001_v1_11
File Name: 7033_16_F01.02_GIS_GL

Arrow Energy

Arrow LNG Plant

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LNG plant and ancillary facilities

Figure No: 1.2

An environmental management plan (EMP) was submitted as an attachment to the (EIS) to Commonwealth and State Governments for project approval. This revised Strategic EMP has been prepared as an attachment to the SREIS to reflect the additional information now available. The revised Strategic EMP has been prepared entirely for the purposes of informing the determination on the EIS and initial conditioning of the project. Detailed statutory EMP(s) will be prepared for the purposes of application(s) for environmental authority in advance of the commencement of any level 1 environmentally relevant activity.

Following the state election in March 2012, the Queensland Government announced machinery-of-government changes for departments directly associated with this project. The key functions of the former Department of Environment and Resource Management (DERM) relating to the project are now delivered by the following departments:

- Department of Environment and Heritage Protection (EHP).
- Department of Natural Resources and Mines (DNRM).

Similarly, key functions of the former Department of Employment, Economic Development and Innovation (DEEDI) relating to the project are now administered by the following departments:

- Department of State Development, Infrastructure and Planning (DSDIP).
- Department of Education, Training and Employment (DETE).
- Department of Agriculture, Fisheries and Forestry (DAFF).

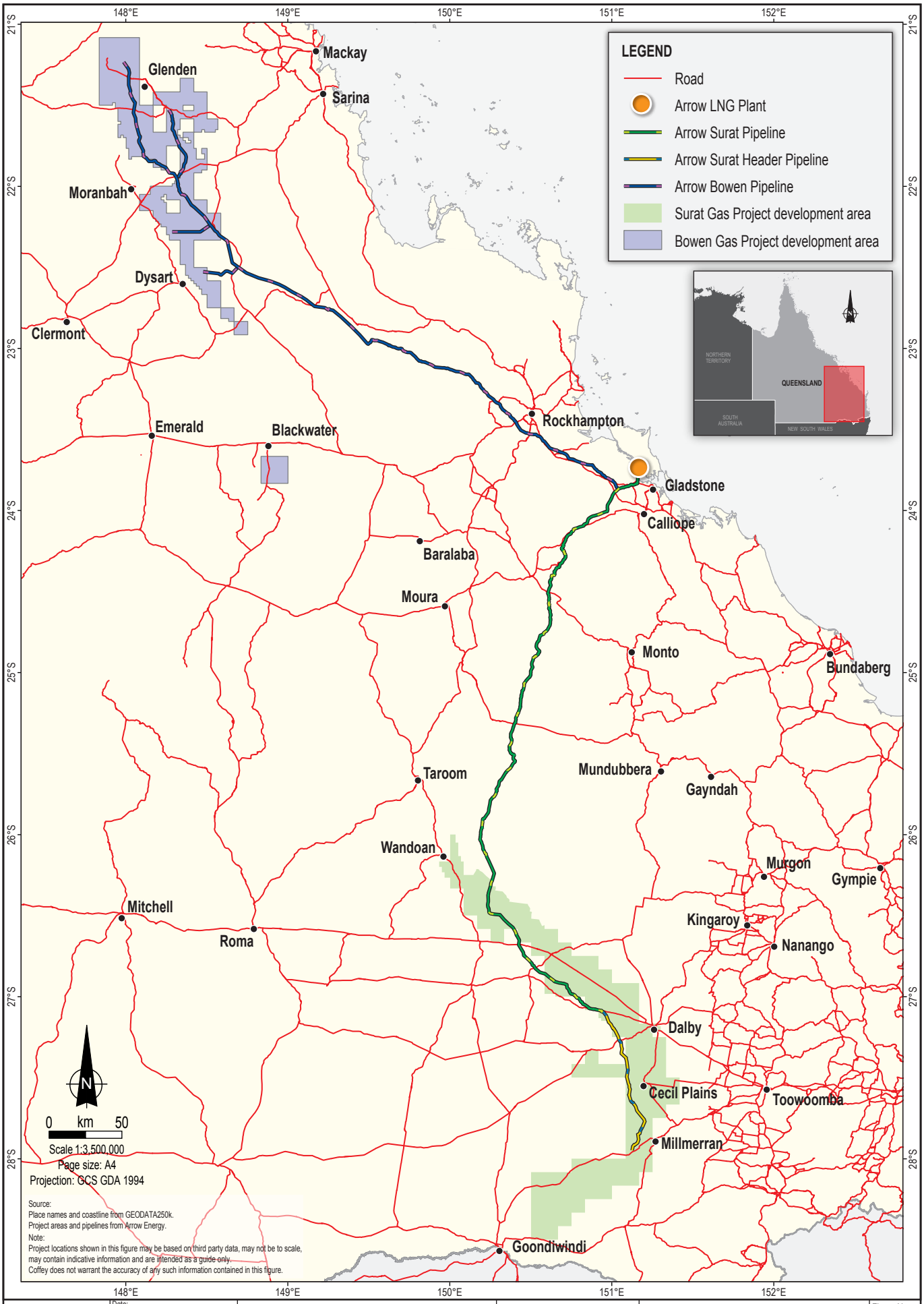
1.2 Project Proponent

Arrow Energy is a Queensland based company owned by Arrow Energy Holdings Pty Ltd (Arrow), a joint venture between subsidiaries of Royal Dutch Shell plc (Shell) and PetroChina Company Limited (Petrochina). The joint venture took ownership of Arrow Energy on 23 August 2010. Arrow Energy is an integrated energy company with interests in coal seam gas field developments, pipeline infrastructure, electricity generation and the proposed LNG plant.

Arrow Energy has interests in more than 56,000 km^2 of petroleum tenures, mostly within Queensland's Surat and Bowen Basins (Figure 1.3). Other areas include the Clarence-Moreton, Coastal Tertiary, Ipswich, Styx and Nagoorin Graben Basins. It is estimated that Arrow Energy's exploration portfolio contains at least 70,000 petajoules of gas.

Arrow Energy's Queensland petroleum tenures are located close to the state's three key energy markets: Townsville, Gladstone and Brisbane. The Moranbah Gas Project in the Bowen Basin and the Tipton West, Daandine, Kogan North and Stratheden projects in the Surat Basin near Dalby comprise Arrow Energy's existing coal seam gas production operations. These existing operations currently contain approximately 1,200 gas wells, and account for approximately 20% of Queensland's overall gas production.

Arrow Energy supplies gas to the Daandine, Braemar 1 and 2, Townsville and Swanbank E power stations, which participate in the National Electricity Market. With Arrow Energy's ownership of Braemar 2 and the commercial arrangements in place for Daandine and Townsville power stations, Arrow Energy has access to over 700 MW of power generation capacity.



coffey environments	Date: 17.11.2011 MXT: 7033CA_16_GIS129_v1_1 File Name: 7033_EMP_F01.03_GIS_FT	Arrow Energy Arrow LNG Plant	arrow energy go further	Arrow LNG Project	Figure No: 1.3

Arrow Energy and its equity partner AGL Energy have access rights to the North Queensland Pipeline which supplies gas to Townsville from the Moranbah Gas Project. They also hold the pipeline licence for the proposed Central Queensland Gas Pipeline between Moranbah and Gladstone.

1.3 Purpose of the Strategic Environmental Management Plan

The purpose of this Strategic EMP is to detail the environmental values in the project area and vicinity, issues and impacts associated with the project, and management measures that Arrow Energy will implement during construction, operation and decommissioning. The environmental protection commitments of the Strategic EMP are based on preferred project options, derived from research, environmental best practice and the site specific environmental assessments that support the EIS. They represent Arrow Energy's commitment to avoid, minimise, mitigate and manage or offset impacts to as low as reasonably practical.

There are many different types of EMP that are used to manage environmental impacts during the course of a major development such as the Arrow LNG Plant. These include Construction EMPs, Operations EMPs, Decommissioning EMPs, Rehabilitation EMPs, EMPs that address specific issues, and statutory EMPs (known as EM Plans under the Queensland Environment Protection Act 1994) that are developed expressly for the purpose of supporting an application for an environmental authority. To avoid any confusion in this regard, this document, which is presented as an attachment to the Arrow LNG Plant SREIS, is referred to as a Strategic EMP. It provides strategic and specific commitments that will inform the development of all EMPs to be subsequently developed for the project.

The Strategic EMP has been developed in accordance with the Coordinator General's terms of reference for the project's environmental impact statement (see Attachment 3 of the EIS). It is aligned with the requirements defined in the Queensland Department of Environment and Resource Management's (DERM) "Preparing Environmental Management Plans". While the Strategic EMP is attached to the Arrow LNG Plant SREIS, it is designed as a stand-alone document for reference and use during the project's phases. As such, the Strategic EMP is a 'living' document intended to be updated as the project proceeds and will inform detailed plans developed through design, construction, operation and decommissioning.

Arrow will prepare statutory EMPs to be submitted in support of applications for the level 1 environmental authorities required for the project to proceed under the Environmental Protection Act 1994 (Qld). The statutory EMPs will:

- Be completed in accordance with EHP guidance.
- Comply with the requirements of S. 310D of the Environment Protection Act 1994 (Qld).
- Be presented in a documentary form that is compliant with EHP requirements.
- Contain all of the detail and data required for EHP to condition the environmental authority.

Further information regarding statutory EMPs has been provided in Section 1.6, Environmentally Relevant Activities.

The key objectives of this Strategic EMP are:

- To document acceptable environmental management strategies and environmental protection commitments from the EIS and SREIS to manage identified potential impacts on the environment as a result of proposed activities.
- To guide the development of the project with minimal adverse impacts on the environment by presenting mitigation measures that reduce impacts to levels that are as low as reasonably practical.
- To ensure best practice environmental management for proposed activities is achieved where practical.
- To address any other matters required under a local, state or federal environmental protection policy or regulation.
- To provide a document that can be referred to during the design of the LNG plant and ancillary facilities, and form a basis for preparing subsequent detailed environmental management plans and support construction planning and the development of standard operating procedures.
- To provide the community with details of the proposed environmental management measures for the project.

It is acknowledged that some of the detail necessary for the statutory EMPs to fulfil the requirements of Section 310D of the Environmental Protection Act will only be available after the completion of detailed engineering design that will be completed by an EPC Contractor that at the time of writing had yet to be commissioned. Through detailed engineering design, the EPC Contractor may also design out much of the current optionality that is being carried forward.

The terms of reference require the EMP to be developed in accordance with the requirements of Section 310D. While it is acknowledged that additional detail will be presented in subsequent statutory EMP(s) this document has been prepared to, as far as practicable, achieve the requirements of Section 310D. Table 1.1 identifies the relevant sections in this Strategic EMP where each requirement of the Environmental Protection Act is addressed.

Table 1.1 Environment Protection Act EMP Requirements

EMP requirement	Chapter/section reference in Strategic EMP
Description of expected relevant resource authority.	Section 1.7
Description of all relevant activities that are the subject of the project.	Chapter 2
Description of the land on which the activities are to be carried out.	Chapter 4
Description of the environmental values likely to be affected by the activities.	Chapter 4
Description of the potential adverse and beneficial impacts of the activities on the environmental values.	Chapter 4
State environmental protection commitments for activities to protect or enhance the environmental values under best practice environmental management.	Chapter 4
Present enough other information to allow administering authority to decide the application.	Chapters 1-4

Table 1.1 Environment Protection Act EMP Requirements (cont'd)

EMP requirement	Chapter/section reference in Strategic EMP
Address any other matter prescribed under an environmental protection policy or regulation.	Chapters 1-4
Include a rehabilitation program for land proposed to be disturbed under each relevant resource authority for the application.	Chapter 5
Financial assurance.	Section 1.8

1.4 Strategic Environmental Management Plan Scope

This Strategic EMP describes Arrow Energy's approach to the management of environmental impacts associated with the planning, design, construction, operation and decommissioning / rehabilitation of the project. Broadly the Strategic EMP describes the following:

- Proposed project activities.
- An overview of Arrow Energy's Health, Safety and Environmental Management System (HSEMS).
- A summary of the existing environment of the project area and surrounds, including relevant environmental values.
- Potential impacts of project activities on identified environmental values.
- Environmental management measures for each of the following environmental elements to minimise the identified potential environmental impacts:
  - Climate and climate change adaptation.
  - Greenhouse gas.
  - Geology, landform and soils.
  - Land contamination and acid sulfate soils.
  - Surface water hydrology and water quality.
  - Groundwater.
  - Coastal processes.
  - Marine water quality and sediment.
  - Terrestrial ecology.
  - Freshwater ecology.
  - Marine and estuarine ecology.
  - Air quality.
  - Noise and vibration.
  - Landscape and visual.
  - Indigenous cultural heritage.
  - Non-Indigenous cultural heritage.
  - Social.
  - Economics.
  - Traffic and transport.
  - Hazard and risk.
  - Land use and planning.

  - Waste management.
- Proposed decommissioning and rehabilitation activities.

1.5 Project Stakeholders

Project stakeholders include a range of individuals, groups and their representatives who have an interest in the project. Project stakeholders include but are not limited to:

- State government departments and agencies.
- Australian government agencies (e.g., Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC)).
- Local government (Gladstone Regional Council).
- The Gladstone Ports Corporation.
- Local and regional communities (Gladstone, Southend, Calliope, the township of Mount Larcom, Miriam Vale and Boyne Island/Tannum Sands).
- Local industry associations (Gladstone Chamber of Commerce and Industry, Gladstone Economic and Industry Development Board, Gladstone Community Advisory Service, AgForce, Gladstone Engineering Alliance, Gladstone Area Promotion and Development Ltd, Queensland Seafood Industry Association and Gladstone Industry Leadership Group).
- Local business organisations.
- Community and interest groups.
- The Gladstone Foundation.
- Educational institutions (state and private schools, colleges of TAFE and universities).
- Environmental groups.
- Social welfare groups (Lifeline, St Vincent de Paul and The Salvation Army).

During project consultation undertaken to date, these stakeholders have been consulted by Arrow Energy representatives and have been updated throughout the planning and approval process stages.

1.6 Environmentally Relevant Activities

Under the Queensland Environmental Protection Act 1994 (Qld) (EP Act), ‘petroleum activities’ are ‘environmentally relevant activities’ (ERA) for which an environmental authority’ (EA) is required and are specifically classed as either level 1 or level 2 chapter 5A activities depending on environmental risk.

The project (with the exception of the EA to support the activities completed under the petroleum survey licences) requires a level 1 chapter 5A EA for petroleum activities to provide for the proposed LNG plant and feed gas pipeline along with other environmentally relevant activities (ERAs) associated with the project. Table 1.2 details the environmentally relevant activities that may be applicable to the project.

Table 1.2 Environmentally relevant activities that may be applicable to the project

ERAs	Description	Applicable Project Activities
Level 1 chapter 5 activity	Petroleum activities to provide for the proposed LNG plant and feed gas pipeline.	Petroleum activities.
ERA 8 – Chemical storage	Storing 10 m^3 or more of chemicals of class C1 or C2 combustible liquids under AS 1940 or dangerous goods class 3.	Storage of chemicals.
ERA 9 – Hydrocarbon gas refining	Refining natural gas or coal seam methane gas.	Hydrocarbon gas refining at the LNG plant.
ERA 10 – Gas producing	Manufacturing, processing, or refining of 200 tonnes or more of hydrocarbon gas in a year.	Processing production of gas at the LNG plant or other relevant equipment.
ERA 14 – Electricity generation	Generating electricity by using gas at a rated capacity of 10 megawatt (MW) of electricity or more.	Power generation to supply the LNG plant.
ERA 15 – Fuel burning	Using fuel-burning equipment that is capable of burning at least 500 kg of fuel in an hour.	Fuel burning required to operate gas turbines at the LNG plant.
ERA 16 – Extractive and screening (dredging)	Extracting and screening (dredging) of material.	Dredging of project areas outside the Western Basin Dredging and Disposal project. This will include dredging for the materials off-loading facility on Curtis Island, LNG jetty and mainland launch site.
ERA 17 – Abrasive blasting	Cleaning equipment or structures on a commercial basis using a stream of abrasives in either a wet or dry pressure stream.	Abrasive blasting will be necessary during construction and operation of the project.
ERA 18 – Boiler making or engineering	Boiler making, assembling or manufacturing a total of 200 t or more of metal products a year.	Boiler making or engineering will be required during construction of the LNG plant.
ERA 43 – Concrete batching	Producing 200 t or more of concrete or concrete products in a year by mixing cement with sand, rock, aggregate or other similar materials.	Concrete batching will be undertaken on site for facility construction.
ERA 50 – Bulk material handling	Loading or unloading materials at a port in conjunction with operations at a port. It also entails stockpiling bulk materials in conjunction with operations at a port.	Coordination of materials handling from the port on the mainland to the materials off-loading facilities on Curtis Island.
ERA 56 – Regulated waste storage	Operating a facility for receiving and storing regulated waste for more than 24 hours.	Storage of regulated waste prior to treatment or transportation to licensed disposal facility.
ERA 57 – Regulated waste transport	Transporting on a non-commercial basis any quantity of regulated waste in a vehicle.	Transportation of waste to a licenced waste disposal facility.
ERA 58 – Regulated waste treatment	Operating a facility for receiving and treating regulated waste or contaminated soil to render the waste or soil non-hazardous or less hazardous.	Treatment of regulated waste.

Table 1.2 Environmentally relevant activities that may be applicable to the project (cont'd)

ERAs	Description	Applicable Project Activities
ERA 60 – Waste disposal	Operating a facility for disposing of regulated waste.	Disposal of waste generated at LNG plant and ancillary facilities.
ERA 63 – Sewage treatment	Operating one or more sewage treatment works at a site that has a total daily peak design capacity of more than 21 equivalent persons.	Sewage treatment during construction and operation of the LNG plant and ancillary facilities.
ERA 64– Water treatment	Carrying out a number of activities in a way that allows waste, whether treated or untreated, to be released into the environment.	Desalinisation of water at reverse osmosis facility during construction and operation.
ERA 21 Motor vehicle workshop	Operating a workshop on a commercial basis or in the course of carrying on a commercial enterprise involving any one of the following relating to motor vehicles: • maintaining mechanical components, engine cooling radiators or body panels. • spray-painting body panels. • detailing or washing.	Servicing of vehicles on site during construction and operations.
ERA 38 Surface coating	Using, in a year, 1t or more of surface coating materials for: • anodising, electroplating, enamelling or galvanising. • coating or painting or powder coating.	Pipe coating activities conducted on site during scheduled maintenance periods during operations.

Arrow Energy will submit applications for level 1 and or level 2 environmental authority applications in accordance with the Environmental Protection Act following the completion of the EIS process. Level 1 environmental authority applications require a statutory EMP.

This Strategic EMP will assist in developing the two statutory EMPs that will be submitted with the environmental authority applications for the construction and operation of the LNG plant and the feed gas pipeline tunnel (including incidental activities). The purpose of the statutory EMPs is to propose environmental protection commitments to assist the administering authority to develop the conditions of the environmental authority. The statutory EMPs will identify and describe the environmental values that will be impacted by project activities and set out how the environmental management measures identified in the EIS will be implemented. The Coordinator-General's conditions, set as an outcome of the EIS for the Arrow LNG Plant, will be taken into consideration when preparing the level 1 environmental authority.

Arrow Energy must comply with the conditions of its environmental authorities. In the event additional activities not covered by the environmental authority are later proposed, Arrow Energy must seek amendment of its environmental authorities prior to undertaking those works.

1.7 Petroleum Tenures and Authorities

The Petroleum and Gas (Production and Safety) Act 2004 facilitates and regulates petroleum and gas activities carried out in Queensland.

1.7.1 Petroleum Facility Licence

The project requires a petroleum facility licence under the Petroleum and Gas (Production and Safety) Act 2004 (Qld) for the construction and operation of the LNG plant. The licence will allow for the construction and operation of the LNG plant, as well as for 'incidental activities', which include but are not limited to the construction of plant works such as trenches, roads and tunnels, and the construction of mobile or temporary work camps. It is also assumed that the PFL will cover the island based MOFs and jetties and related infrastructure. A petroleum facility licence will not cover the construction and use of offices or residential accommodation on the mainland; additional development permits will be required for structures of this nature.

1.7.2 Petroleum Pipeline Licence

The project requires a petroleum pipeline licence under the Petroleum and Gas (Production and Safety) Act for the construction and operation of the proposed feed gas pipeline and tunnel. The licence also allows for 'incidental activities' related to pipeline construction and operation including road works, mobile and temporary camps and materials storage located within the licence area.

1.7.3 Petroleum Survey Licence

The project requires a petroleum survey licence under the Petroleum and Gas (Production and Safety) Act to authorise site investigations in relation to the petroleum facility and petroleum pipeline.

Arrow Energy has undertaken work under Petroleum Survey Licences (PSL) 67 and 76 over the study area. Investigations for the EIS were conducted under PSL 67 and investigations for the SREIS have been conducted under the authority of both petroleum survey licences to inform the design of the LNG plant, feed gas pipeline and ancillary facilities.

1.8 Project's Financial Assurance

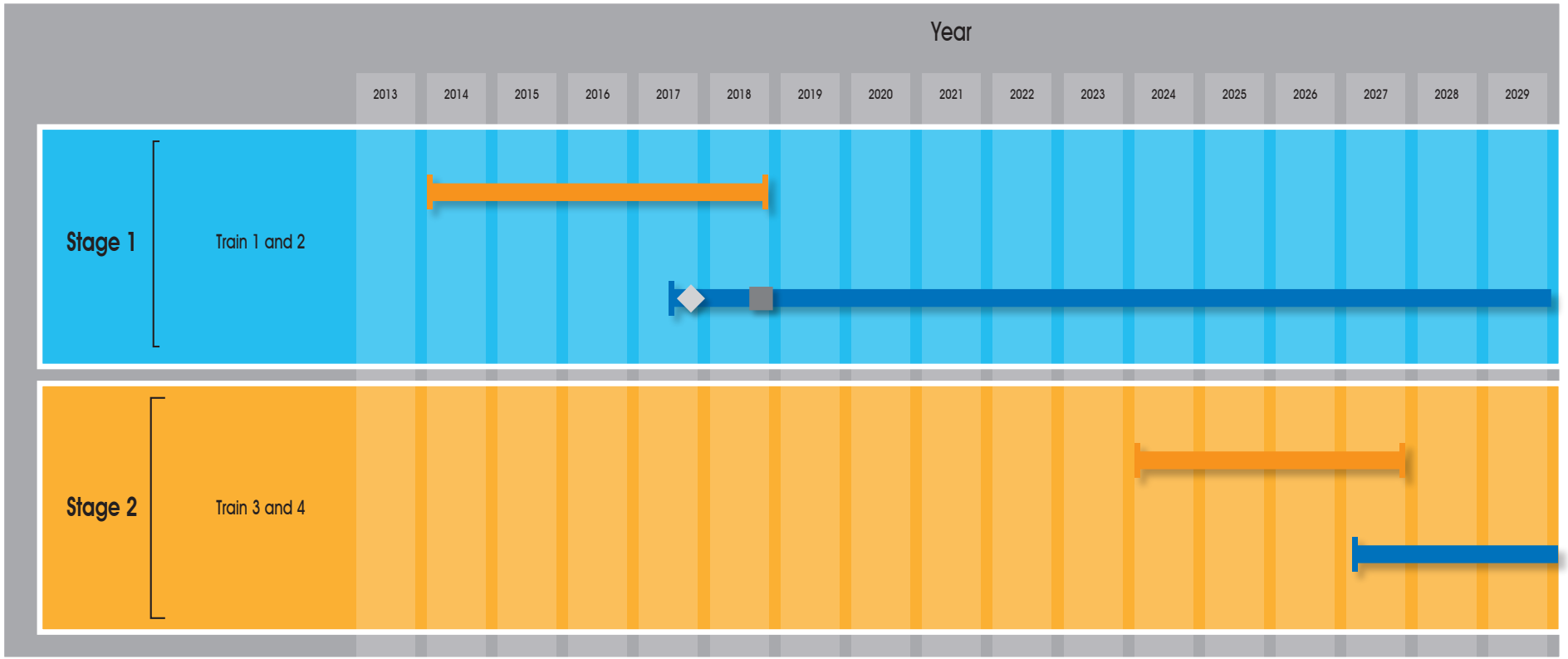
Provision of financial assurance is required for all level 1 petroleum activities under section 310D of the Environmental Protection Act. The level of assurance is to be calculated in accordance with DERM's guideline Financial Assurance for Petroleum Activities, and must include the cost of rehabilitation of any disturbed land that has been the subject of whole or partial surrender due to the grant of a new petroleum authority over the land.

Arrow Energy will calculate the financial assurance for the construction and operation stages as part of an environmental authority application for the project under the Environmental Protection Act. This calculation will be in accordance with DERM guidelines.

1.9 Project Life

The LNG plant will have a design life of approximately 25 years. Regular maintenance and refurbishment is expected to extend the life of the plant beyond that timeframe.

The project will be developed in two stages with the four LNG trains producing up to 18 million tonnes per annum (Mtpa) of LNG. Each LNG train will have a nominal capacity of 4 to 4.5 Mtpa. Stage 1 involves construction and operation of the first two LNG trains and ancillary facilities (i.e., equipment and facilities that support the LNG processing train(s) and the plant utilities). Stage 1 will be constructed so that only limited site preparation is required during stage 2 construction of trains 3 and 4. The first gas from train 1 is planned for late 2017, with train 2 to enter operation 6 to 12 months later (Figure 1.4). Market conditions will determine the timing of the construction of stage 2, with a similar offset period expected between trains 3 and 4 commencing operations.



Source: Coffey Environments and Arrow Energy

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Arrow Energy

Arrow LNG Plant

arrow energy go further

Arrow LNG Plant project staging

Figure No: 1.4

2. DESCRIPTION OF PETROLEUM ACTIVITIES

This section provides a description of the Arrow LNG Plant in terms of its key infrastructure components: LNG plant and ancillary facilities (including marine and logistics facilities), the feed gas pipeline and dredging activities. The project description reflects changes made as a result of detailed front end engineering design (FEED) that was completed after finalisation and exhibition of the EIS. For additional detail on these changes, refer to Chapter 4 of the SREIS.

2.1 LNG Plant and Ancillary Facilities

The following section provides a summary of the key elements of the LNG plant and ancillary facilities.

2.1.1 LNG Plant

The LNG plant will be developed in two stages, with a total capacity of four LNG trains producing up to 18 million tonnes per annum (Mtpa). Each LNG train will have a nominal capacity of 4 to 4.5 Mtpa. Major infrastructure and components required to develop the project will include LNG trains, LNG storage tanks, LNG loading lines, marine infrastructure, feed gas pipeline and tunnel crossing of Port Curtis, construction camp, a 115 m-high flare stack, power generators, administrative buildings and workshops (see Figure 1.2).

Power for the LNG plant and associated site utilities may be supplied from the electricity grid (mains power), on site gas turbine generators, or a combination of both. The two options being considered are all mechanical (power island mode) and mechanical / electrical (partial auxiliary power import mode). A permanent electrical connection may be established to Gladstone North Substation on the mainland via ducts installed by separate horizontal directional drilling (HDD) under Port Curtis to the southern end of Hamilton Point.

The preferred option for water supply is to use the supply of mains water installed by Gladstone Area Water Board through the pipeline under Port Curtis. The reverse osmosis desalination plant will be retained as an option.

The preferred option for wastewater and sewage treatment is to use sewer mains under Port Curtis installed by Gladstone Regional Council. These have sufficient capacity to meet peak construction demands for both the LNG plant and construction camp. The on-site effluent treatment plant will be retained as an option.

2.1.2 Marine Facilities

Marine facilities will include the LNG jetty, materials offloading facility (MOF), personnel jetty and mainland launch site. The SREIS considered:

- The preferred site for a MOF and personnel jetty will be at Boatshed Point. Arrow Energy is investigating a sharing arrangement with Gladstone LNG Project (GLNG) for the Hamilton Point MOF. Arrow Energy is seeking agreement for the use of GLNG's pioneer MOF, which is also located at Hamilton Point, adjacent to the LNG jetty and GLNG's MOF, batching plant and

quarantine facility. The pioneer MOF would be used for 12 to 18 months until the selected MOF is constructed and in operation.

- A permanent mainland launch site at one of two locations; on the Western Basin Reclamation Area (launch site 4N) and a site at the mouth of the Calliope River (launch site 1). Launch site 1 is Arrow Energy's preferred site. During construction, other established launch sites may be considered.

LNG will be transferred from the storage tanks on the LNG plant site to the LNG jetty via above ground LNG loading lines. Loading arms on the LNG jetty will deliver the product to an LNG carrier. The LNG jetty will be located off the northwestern corner of Hamilton Point at the southern end of North China Bay, south of the proposed GLNG jetty.

Delivery of materials to the site on Curtis Island during the construction and operations stages will be facilitated by the MOF, where a combination of roll-on / roll-off (RORO) or lift-on / lift-off (LOLO) vessels and bulk transportation barges will dock to unload preassembled modules, equipment, supplies and construction bulks (e.g., aggregate). The preferred MOF (at Boatshed Point) will be connected to the LNG plant site via a heavy vehicle haul road routed along the western coastline of Boatshed Point, entering the LNG plant site at the southern boundary. A quarantine area will be located south of the LNG plant and will be accessed via the northern end of the haul road.

An integrated personnel jetty will be constructed with the MOF at Boatshed Point to transfer workers from the mainland launch site to Curtis Island by fast passenger and roll on / passenger (RoPax) ferries. Buses will be used to transport workers along the haul road between the personnel jetty to the construction camp and LNG plant site.

On the mainland, the launch site will contain a passenger terminal and a material loading facility. The passenger terminal will include a jetty and transit infrastructure, waiting areas and car parking. The material loading facility will include berths for barges as well as RORO and LOLO vessels, and associated laydown areas, workshops, storage sheds and bulk handling facility. During the construction phase, the area used at launch site 1 would be 52 hectares, allowing for a central laydown point on the mainland.

2.1.3 Laydown and Staging

In addition to the extension of launch site 1 during the construction phase, Arrow Energy has identified two sites for laydown and staging. These include the former Gladstone Power Station ash pond (proposed in the EIS as TWAF 7; this site is no longer considered an option for workforce accommodation) and a site on Red Rover Road, west of Gladstone Power Station. The laydown and staging facility would accommodate car and bus parking, warehouses, laydown areas and, in the case of the Red Rover Road site, potentially a temporary accommodation facility during the peak construction phase. Establishment of the facility would enable personnel transfers to the mainland launch site, and bulk materials launch site, which would reduce the need or amount of parking at Gladstone Marina (pioneer phase) or the bulk materials launch site (construction phase).

2.1.4 Workers Accommodation

Construction camps for up to 3,500 people may be constructed as a part of the project. The main accommodation facility will accommodate up to 2,500 workers and will be located on Curtis Island

at Boatshed Point. In addition, a temporary workers accommodation facility (TWAF), for up to 1,000 workers, may be constructed on the mainland, or a third party accommodation facility may be used to provide additional accommodation should the construction camp on Curtis Island have insufficient capacity during periods of peak construction. Two TWAF locations are being considered on the mainland. These include a pastoral property near Targinnie (TWAF 8) and the Red Rover Road laydown and staging site as shown in Figure 1.2.

2.1.5 Construction Schedule

The plant will be constructed in two stages. Stage 1 will involve construction and operation of the first two LNG trains (trains 1 and 2), associated utilities and ancillary facilities. Site preparation during stage 1 will include development of cut benches for all four LNG trains.

LNG trains 3 and 4 will be constructed in stage 2, bringing the LNG plant to a total capacity of up to 18 Mtpa. First LNG from train 1 is planned for 2017, with train 2 commencing operations approximately 6 to 12 months later. Market conditions will determine the timing of the construction of stage 2, with a similar offset expected between trains 3 and 4 commencing operations.

2.1.6 Construction Method

The LNG plant will generally be constructed using a modular construction method, with preassembled modules being transported to Curtis Island from an offshore fabrication facility. There will also be a proportion of infrastructure stick-built or constructed on site such as LNG storage tanks, buildings, underground cabling, piping and foundations. Where practical, aggregate and all fill material for civil works will be sourced from suitable material excavated and crushed on site as part of the bulk earthworks. Aggregate and structural fill may also be sourced from mainland quarries and transported from the mainland launch site to the LNG plant site by roll-on / roll-off vessels or barges if sufficient quantities cannot be sourced from the site. Concrete production facilities (i.e., batching plants) will be established on the site. Bulk cement requirements will be delivered to the site by RORO or LOLO vessels or barges coming from the mainland launch site or other ports or loading facilities.

2.2 Feed Gas Pipeline and Tunnel

An approximately 9.45 km long, 48” (1,219 mm) internal diameter, high-pressure feed gas pipeline will supply gas to the LNG plant from its connection to the Arrow Surat Pipeline on the mainland, located approximately 2 km from the tunnel launch site. The feed gas pipeline will be constructed in three sections:

- The first length of feed gas pipeline will run from the proposed Arrow Surat Pipeline to the tunnel launch shaft, which will be located on a mudflat south of Fishermans Landing, just south of Boat Creek. This section of pipeline will be constructed using conventional trenching methods within an approximately 40 m wide construction right of way.
- The second section of the feed gas pipeline will traverse Port Curtis in the Arrow Gladstone Harbour Tunnel (also known as The Curtis Island Link) to be bored under the harbour from the launch shaft on the mainland to a reception shaft on Hamilton Point. The tunnel under Port Curtis will have an excavated diameter of up to approximately 6 m, and will be constructed by a tunnel boring machine that will begin work at the mainland launch shaft. Tunnel spoil material may be processed through a de-sanding plant to remove bentonite and water. The

spoil will comprise mainly a finely graded fill material, which will be deposited in a spoil placement area established adjacent to the launch shaft.

- From the tunnel reception shaft on Hamilton Point, the third section of the feed gas pipeline will cross the LNG loading lines to run up the western side of the proposed LNG plant to the gas inlet station, which is located west of trains 1 and 2. This section will be constructed using conventional trenching methods within an approximately 40 m wide construction right of way.

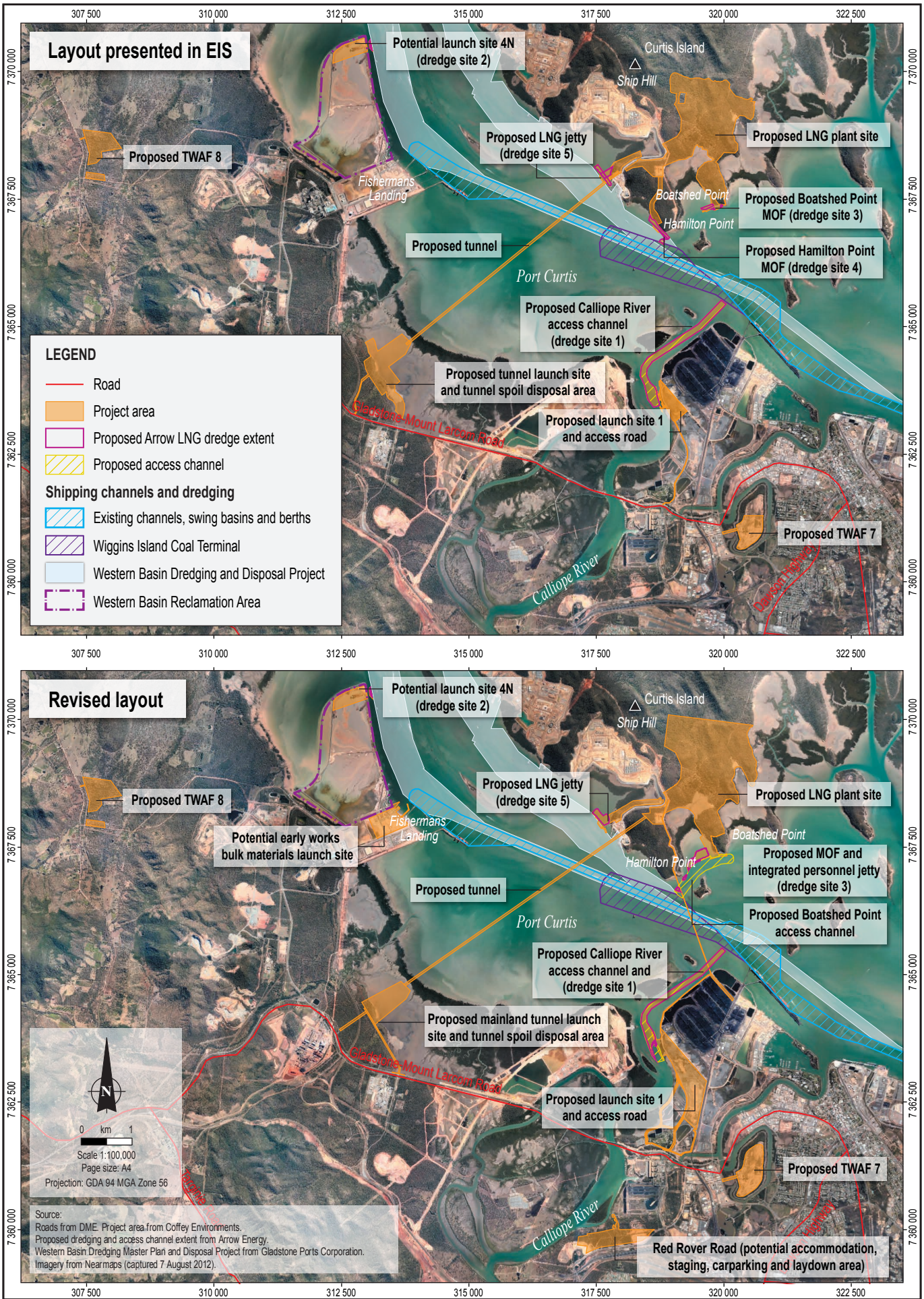
2.3 Dredging

Construction and operation of the Arrow LNG Plant will require dredging to provide and maintain shipping access to marine infrastructure sites on Curtis Island and the mainland. These sites are additional to the much larger dredging program required to improve shipping access within Port Curtis, particularly to facilitate access to the proposed LNG projects. This latter program is being coordinated by the Gladstone Ports Corporation and the environmental impacts of this dredging have been assessed through the Western Basin Dredging and Disposal (WBDD) Project EIS (GHD, 2009a) and EIS Addendum (GHD, 2010).

Five potential dredge sites were identified for the EIS by Arrow Energy. One of these sites is no longer under consideration (Hamilton Point South), but four sites are retained as options. Of the current four sites, only three sites will require dredging to facilitate the project (Figure 2.1). The sites include dredging in areas to provide access to launch sites 1 or 4N, to the LNG jetty, and to the MOF location at Boatshed Point. Maintenance dredging may be required in the Calliope River to provide access to launch site 1 and at the MOF and passenger jetty on Curtis Island.

The preferred option is to place dredge spoil in a combination of existing and approved disposal areas and facilities, following consultation with Gladstone Ports Corporation. Options presently under discussion include the disposal of:

- Boatshed Point MOF and passenger jetty dredge spoil to the East Banks Sea Disposal Site.
- LNG jetty dredge spoil to East Banks Sea Disposal Site or the Western Basin Reclamation Area.
- Launch sites 1 and 4N dredge spoil to Wiggins Island Coal Terminal dredge placement facility (areas B and C) or East Banks Sea Disposal Site.



coffey environments	Date: 10.12.2012 MXT: 7033CC_16_GIS035_v1_2 File Name: 7033_16_F02.01_GIS_VS	Arrow Energy Arrow LNG Plant	arrow energy go further	Dredge site locations	Figure No: 2.1

3. ENVIRONMENTAL MANAGEMENT SYSTEM

3.1 Introduction

Arrow is committed to the sound management of health, safety and the environment throughout all of its business activities. The company maintains a comprehensive and integrated Health, Safety and Environmental Management System (HSEMS) aligned to the principles of AS/NZS ISO 14001, the international standard for environmental management systems, and AS/NZS 4801:2001, the Australian standard for occupational health and safety management systems.

3.2 Policy

A copy of Arrow's environmental policy is included in Appendix 1. The policy governs the development and implementation of HSEMS. Together these documents are the key tools used by Arrow to engage in activities and to supply services in an environmentally sustainable manner. By implementing the HSEMS and site based environmental management plans, Arrow aims to:

- Conduct operations in compliance with all relevant environmental legislation, regulations, licences, permits, standards, approvals and authorities.
- Clearly allocate responsibilities for environmental performance at all levels within Arrow and its business associates, and build environmental competency through provision of structured environmental training to its employees, contractors and other service providers.
- Seek continuous improvement in environmental performance through setting objectives and targets for improved environmental performance, provide sufficient financial and human resources to meet these objectives and targets, apply research and development and cleaner production principles and, where applicable, use environmentally sustainable products and resources.
- Apply industry best practice standards in the management, supply and delivery of coal seam gas.
- Communicate with customers and the community about commitments to this vision, its application and their view of Arrow's performance.
- Report annually on environmental performance.

3.3 Roles and Responsibilities

Arrow is ultimately responsible for the ongoing environmental management of project activities. All Arrow employees and contractors are responsible for the environmental performance of their activities and must demonstrate compliance with Arrow procedures and policies and with any commitments made as part of the HSEMS and this Strategic EMP.

Key Arrow personnel have specific environmental responsibilities when managing environmental management issues. These personnel and their responsibilities are presented in Table 3.1.

Table 3.1 HSEMS Roles and Responsibilities

Role	Responsibility
Chief Executive Officer	• Performance of Arrow. • Corporate environmental policy. • Fostering a partnership that promotes 'ownership' of Arrow's environmental responsibilities.
Chief Operating Officer	• Implementation of corporate and environmental policy. • Systems and resources to ensure compliance with the environmental policy.
Vice President Health, Safety, and Environment	• Performance measurement and reporting, including recommendations for improvement and corrective actions.
General Manager (Assets)	• Implementation of management and monitoring practices and procedures in all operation areas. • Resourcing. • Accountable for compliance.
Environment Managers	• Environmental approvals management. • Ensuring management and monitoring practices and procedures are documented and clearly communicated within the organisation. • Development of operational procedures and practices relevant to the environment. • Coordinating incident response. • Reporting and compliance related issues.
All site and field personnel	• Environmental approvals management. • Development of operational procedures and practices relevant to the environment. • Coordinating incident response. • Reporting and compliance related issues. • Training in and implementing procedures, including those that address environmental management, at the site/operational level. • Overseeing day to day activities. • Carrying out specific activities that ensure compliance with environmental authority conditions, including monitoring and data collection.

3.4 Inductions and Training

Environmental awareness training and inductions appropriate to the level of risk and type of work being performed will be provided to all employees, contractors and visitors. Training plans will be developed to attain, improve and maintain personnel competencies and the overall environmental performance of Arrow. Additionally, plans may be reviewed following a change, incident investigation and hazard studies. A comprehensive training program will be progressively developed to cover all aspects of the project and its impact. Courses will be designed to address the training needs of personnel and the specific stage of the project. Key topics for induction and training are:

- Emergency response procedures.
- Identification and management of hazards and control measures.
- Environmental standard operating procedures.
- Consequences and impacts of departure from hazard and control measures.

- The role of hazard and control measures in achieving company and business unit objectives and targets.
- Environmental compliance.

Training programs will be evaluated regularly to ensure the required learning outcomes are being achieved. Training, competency and awareness of site personnel will be recorded to allow tracking against the needs stipulated by an individual's work area. Training records will be reviewed during internal and external compliance audits. Records will be available upon request.

Contractors and subcontractors will be required to provide competency verification for every new employee working on the project.

3.5 Monitoring and Reporting

Monitoring and reporting provides a direct measure of the project's impacts and consequences, together with an indication of the effectiveness of the HSEMS. Planned monitoring on the project will include the following:

- Monitoring implementation of specific environmental management plans and procedures.
- Regular inspection of construction and operational activities.
- Environmental monitoring of impacts over time (e.g., photo-monitoring and audits).
- Reporting and analysis of regulated discharges, emissions and waste disposal.
- Annual reporting of environmental performance.
- Any other prescribed monitoring and reporting in accordance with the conditions of the relevant environmental authority.

3.6 Incidents and Emergencies

Incident reporting and management within Arrow is reinforced through the requirements set out in environmental management plans and procedures. These procedures and the incident reporting guidelines will be emphasised during the training of personnel involved on the project.

Environmental incidents will be reported through Arrow's management line and investigated to establish immediate and system (root) causes. Corrective actions will be applied to prevent recurrence. Arrow's Compliance and Reporting Manager will ensure that external environmental reporting requirements in the event of any incident are fulfilled.

Arrow has plans and procedures for emergency preparedness and response. These plans and procedures are applied to both environmental and safety events. Specific emergency preparedness and response plans and procedures for the Arrow LNG Plant will be developed as the project moves into construction, operation and decommissioning.

3.7 Inspections, Reviews and Audits

The components of Arrow's HSEMS (including relevant management plans, procedures, and guidelines) will be reviewed and updated as a result of audit outcomes, subsequent corrective actions, changes in activities, procedures or improved technology. Updates will reflect legislative amendments together with relevant project changes or issues that arise during project activities.

A regular programme of audits will be implemented for aspects of design, construction, operation and maintenance activities in conjunction with site environmental improvement plans and review meetings. External audits will be scheduled and conducted where required to evaluate compliance with environmental authority conditions and Arrow's HSEMS.

3.8 Continuous Improvement and Corrective Action

The components of Arrow's HSEMS (including this and other relevant management plans, procedures, and guidelines) will be reviewed and updated as a result of audit outcomes, subsequent corrective actions, changes in activities and procedures or improved technology. Updates will reflect legislative amendments together with relevant project changes or issues that arise during project activities.

3.9 Community Concerns and Complaints

Arrow is committed to managing community concerns in an accountable, transparent, timely and meaningful way. Arrow has in place a complaints management procedure which outlines how staff must handle, report and address complaints. The procedure is consistent with the Australian Standard AS ISO 10002-2006, Customer satisfaction – guidelines for complaints handling in organisations.

Complaints will be recorded in the complaints management system database. All complainants will be treated courteously, and kept informed of the progress of their complaint throughout the complaint management process.

By monitoring complaints and recording their outcomes, Arrow will ensure continued improvement in its operations and activities through meaningful feedback provided about potential improvements identified as a result of complaints.

3.10 Document Control and Records Management

Aligned with the requirements of AS/NZS ISO 14001, Arrow will maintain a register for storage and retrieval of environmental data, records and other relevant information on the project.

4. ENVIRONMENTAL AND SOCIAL VALUES AND MANAGEMENT MEASURES

This chapter provides a summary of the environmental and social values of the project area, project impacts on these values, and environmental protection commitments. The environmental protection commitments are derived from research, environmental best practice and the site specific environmental assessments that support the EIS and SREIS.

4.1 Climate and Climate Change Adaptation

This section describes the adaptation strategies that Arrow Energy will implement to manage potential impacts on the project associated with climate change.

4.1.1 Existing Environmental Values

The Gladstone region has a subtropical climate with wet, hot and humid summers, and dry, mild winters. A review of historical weather patterns indicates that the climate in the Gladstone region is characterised by temperatures typical for a subtropical region, relative humidity that is fairly consistent throughout the year and highly variable rainfall levels and long-term climate variability associated with the effects of the El Niño-Southern Oscillation cycle and the Pacific Decadal Oscillation. The Gladstone region has experienced short term droughts over the years as well as long term droughts, often associated with the oscillation cycle.

While Gladstone lies to the south of Queensland's main area of tropical cyclone occurrence, six cyclones passed within 50 km of the project area between 1906 and 2006.

The Arrow LNG Plant project area experiences dominant southeast trade winds. The portion of the project area located on Curtis Island is not impacted by river floods although the mainland tunnel launch site is located in an area subject to inundation.

4.1.2 Potential Impacts

Climate change will have a number of key impacts on the design, construction and operation of the Arrow LNG Plant. These impacts relate to the potential for:

- Increased bushfire risk associated with the drier conditions caused by declining rainfall, increasing evaporation and higher temperatures.
- Decreased availability of fresh water associated with the declining rainfall and increasing evaporation.
- Decreased efficiency of power generation with higher temperatures being associated with a potential decrease in power output of gas turbines.
- Increased risks to the health of workers and in particular, incidence of heat stress and insect-borne diseases from rising temperatures.
- Damage to infrastructure, inundation and erosion from storm surges and more frequent and severe weather events.

4.1.3 Climate and Climate Change Adaptation

A preventative approach to the design and construction of various project components will, for the most part, ensure that the Arrow LNG Plant is well prepared for the potential effects of climate change.

Management measures proposed for the planning, design and construction phases to address climate change impacts on the project are set out in Table 4.1.

Table 4.1 Climate and climate change adaptation

Element/issue	Planning, design and construction related adaption strategies to manage the impacts of climate change.
Environmental objectives	• To assess risks to the Arrow LNG Plant associated with changing climate patterns. • To identify the preferred and alternative climate change adaptation strategies that will be implemented for the project.
Performance criteria	• Compliance with Australian standards that address climatic factors, in the design and construction of the LNG plant. • Evidence of measures being adopted to reduce climate change induced project risks (e.g., manage bushfire risk, health of workers).
Implementation strategy (planning and design)	• Design the plant in accordance with the most current Australian standards addressing climatic factors including wind, bushfires, and sea level rise for maritime structures. [C10.01] • Consider climate change induced increases in ambient air temperature when specifying the design operating conditions for plant and equipment. [C10.02] • Consider changes to natural tidal inundation and storm surge levels due to climate change when siting permanent facilities. [C10.03] • Seek ways to lower water consumption through water-efficient technologies and practices or by installation of water efficient devices. [C10.04] • Deploy preventative and responsive measures for bushfire management. [C10.05] • Incorporate climate change induced health risks into workplace health, safety and environmental management plans. [10.06] • Engage in government or industry climate change programs. [C10.07] • Estimate and include climate change costs in business cost projection and, at the same time, take advantage of emerging business opportunities that climate change may generate. [C10.08]
Inspection and Monitoring	Monitor the effectiveness of climate change adaptation measures adopted as a part of the project environmental management plans during operations.
Auditing	Undertake internal audits as both scheduled and unscheduled activities for implementation of agreed measures and compliance with performance criteria. Undertake external audits when required to evaluate compliance with environment authority conditions and Arrow's HSEMS.
Reporting	Ensure that reporting reflects government requirements of the project approval and is undertaken in accordance with Arrow's HSEMS requirements set out in Section 3.5 of this Strategic EMP.
Corrective action	Undertake corrective actions in accordance with the outcomes of incident investigations, audits, monitoring results or advice given by the relevant regulatory authority in accordance with Arrow's HSEMS.

4.2 Geology, Landform and Soils

This section describes Arrow Energy's approach to managing potential environmental impacts on existing geology, landform and soils associated with project activities.

4.2.1 Existing Environment and Environmental Values

Port Curtis follows a major fault zone alignment that divides the Coastal Block tectonic unit of the western coast of Curtis Island from the Berserker Block of the mainland. Faulting within the Coastal Block has resulted in development of the downthrust block that forms Port Curtis, now partially infilled by thick (possibly up to 1,000 m) sedimentary sequences, overlying the Wandilla Formation. Faulting has also produced a high degree of rock type variability and depth to rock on Curtis Island, and sediments are typically folded and faulted. Mineral resources in the study area include the Stuart Oil Shale deposit located west of Targinnie. This resource does not outcrop in the project area.

The project area includes a range of landforms from low lying coastal plains to high elevation and relief hills and mountain ranges. No landform sites within the project area are listed on the Australian Heritage Register. The Curtis Coast Regional Coastal Management Plan (EPA, 2003) recognises several sites within or adjacent to the project area as key elements of the coastal landscape including the hogsback ridges on Curtis Island, Mount Larcom and the Mount Larcom Range, coastal plains of Port Curtis and Targinnie State Forest.

Seven broad soil types were identified in the project area, including marine clays, gradational soils (silty clay loam to a clay); texture contrast soils (soils with a clear, abrupt or sharp change in particle size between the surface horizon and subsoil); alluvial sands; and rocky skeletal soils (shallow in depth occurring on steep slopes). Of particular concern to development are sodic, saline, compressible and acid sulfate soils.

Soils in the project area are generally of Class C or Class D agricultural land, predominantly used for grazing beef cattle (where industrial or residential development has not occurred). Ferrous gradational clay soils along the foothills of the Mount Larcom Range are suitable for agricultural production supporting 9.5 ha of Class A agricultural land located within the TWAF 8 site. This land is not farmed at present.

4.2.2 Potential Impacts

The majority of impacts on geology, landform and soils will occur during the construction phase when ground disturbance and vegetation removal is the greatest. Impacts during operation will still be evident as activity continues but are expected to reduce with progressive rehabilitation of sites. Impacts during decommissioning will relate to the degree of rehabilitation adopted and its success.

Impacts from the project on landform, soil and geology values include increased erosion, slope instability, soil compaction, sedimentation, reduced soil quality, dust generation, and impacts on any geological resources (borrow pits and quarries).

Impacts to project sites are described below. Note that land has not yet been reclaimed for launch site 4N, site conditions are not known and therefore have not been discussed.

- **LNG plant site.** Construction of the LNG plant will involve extensive earthworks to transform a naturally undulating landscape to a series of platforms of elevations between approximately 10 and approximately 18 m AHD. Ridges will be cut into, while saddles and gullies will be filled to achieve these level platforms. Most structures will have shallow-engineered rock-fill foundations while those subject to heavy loads or tall buildings (e.g., the flare) are likely to have piled foundations. General impacts include erosion, reduction in soil quality and down-system sedimentation. The most significant impact will be the large-scale topographic alteration of the project area.
- **Feed gas pipeline.** The feed gas pipeline will require a utility tunnel under Port Curtis (with mainland tunnel entry south of Boat Creek and a reception shaft on Hamilton Point), and a length of trenching or under-boring on either side of the tunnel. The utility tunnel for of the feed gas pipeline will produce a significant amount of spoil which will be deposited in a stockpile adjacent to the mainland entry shaft. The largest impacts are anticipated to be associated with trenching, construction water discharge and tunnel spoil stockpiling.
- **TWAF sites.** The landform, geology and soils of TWAF 7 are already significantly modified due to the effects of previous uses as a temporary ash pond and laydown area. Project impacts are anticipated to be minor and landscape recovery short term. The greatest impact to the site of TWAF 8 will be associated with trafficking of access tracks. Construction of TWAF 8 will temporarily remove approximately 9.5 ha of good quality agricultural land from potential agricultural production.
- **Launch sites.** The landform, geology and soil at launch site 1 have already been significantly modified through human activity. The site contains erodible saline soils and fly ash prone to waterlogging and compression. Launch site 4N does not currently exist as it will be established on reclaimed land established with dredge spoil from the WBDD Project.

4.2.3 Geology, Landform and Soils Management

A management hierarchy to avoid, minimise and manage impacts was applied when developing geology, landform and soil management measures. Where avoidance is not possible through project design, measures to minimise and manage impacts will be adopted. Mitigation and management measures for all project related activities associated with each phase of the project are outlined in Table 4.2.

Table 4.2 Geology, landform and soils management

Element/issue	Impacts to the values associated with the geology, landform and soils of the project area.
Environmental objectives	• To avoid adverse impact to unique geological features during construction, operation and decommissioning. • To avoid, minimise and manage impacts to the soil profile during construction, operation and decommissioning. • To maintain soils to support the intended land use. • To minimise alteration of drainage systems (natural and man-made) during construction, operation and decommissioning. • To avoid adverse impact to statutorily recognised landforms during construction and operation. • To effectively manage rehabilitation of environmental values post construction and decommissioning.

Table 4.2 Geology, landform and soils management (cont'd)

Performance criteria	• Soil structure and landform conducive to natural topography, revegetation and intended land use. • Water quality of natural and artificial drainage systems to be maintained. • No damage to significant geological features within the project area. • No contamination of soil profile. • Successful revegetation of disturbed areas.
Implementation strategy (planning and design)	• Prior to construction, carry out detailed geotechnical ground investigations to assess site-specific ground conditions and provide recommendations on slope placement, geometry and drainage. [C11.01] • Prior to construction, carry out geo-environmental investigations to identify the depths at which saline soils occur in terrain unit 1, and coastal areas of terrain units 2 and 3a. The cut and fill program will be designed to segregate saline soils from non-saline soils, where these soils are intended for stockpiling for future rehabilitation of the site. [C11.02] • Prior to construction, prepare topsoil stripping guidelines, which include a schedule and location of areas to be stripped. Quantify the soil type, depth and resources and establish a handling method. Nominate appropriate, site-specific stripping depths and characterise for suitability for use in rehabilitation works. [C11.03] • Design the tunnel spoil placement area to minimise adverse impacts associated with ground compaction, erosion and surface water runoff such that a self sustaining landform is achieved. Incorporate appropriate drainage measures into the design. [C11.04]
Implementation strategy (construction)	• Limit clearing of vegetated areas to the project area. Areas will be stabilised and progressively rehabilitated to reduce prolonged exposure of soils. [C11.05] • Consider use of erosion matting (jute mesh) or sediment socks (sand-filled, UV-resistant fabric tubes) in areas of ground disturbance outside of purpose built drainage channels. [C11.06] • Manage surface runoff to reduce concentration of surface flow, particularly in erodible soils. Provide drainage channels with suitable design features to minimise erosion where surface runoff is disrupted by roads, tracks, fencing and buildings. Place structures within drainage channels to reduce flow velocity where appropriate. [C11.07] Common with Section 4.4.3, Surface Water Hydrology and Water Quality. • Do not create slopes that are steeper than is appropriate for the material encountered. Consider the orientation of cut batters compared with the orientation of bedrock defects. Where batters exceed 10 m in height and 3 m wide, construct benches at 10 m intervals, unless local conditions dictate otherwise. [C11.08] • Avoid works near stream banks during periods of heavy rainfall where practical. If works cannot be timed to avoid heavy rainfall, adopt additional measures, such as the use of berms and silt fences. [C11.09] Common with Section 4.4.3, Surface Water Hydrology and Water Quality, and Section 4.9.3, Freshwater Ecology. • Exclude vehicles from operating in areas not in use for construction or operation and, in general, restrict vehicles to designated access tracks. [C11.10] • Implement sediment and erosion control measures upslope of watercourses, wetlands and coastal areas or in areas with sodic soils to minimise increases in natural sediment discharge. Measures may include sediment traps, silt fencing, riprap, contour banks, detention dams, sediment ponds and vegetation and diversion berms. [C11.11]. Common with Section 4.4.3, Surface Water Hydrology and Water Quality. • Use control measures such as drains, swales, silt fencing and sediment traps around the lower slopes of erodible stockpiles. [C11.12] Common with Section 4.4.3, Surface Water Hydrology and Water Quality.

Table 4.2 Geology, landform and soils management (cont'd)

Implementation strategy (construction) (cont'd)	• Where sodic soils are encountered, implement control measures (such as soil ameliorants) to soils and soil stockpiles to reduce adverse impacts of dispersion, waterlogging and crusting. [C11.13] • For pipeline trenching activities reinstate soil profiles to predisturbance orientation, where practical, using excavated topsoil. [C11.14] • Design saline and sodic subsoil stockpiles to reduce ponding and salt migration to non-saline soils. [C11.15] • Prior to construction commencing, develop a site drainage plan to define how the civil construction will address site drainage, stormwater management, erosion control and stockpile placement. Risks relating to flood events will also be addressed with appropriate mitigation measures to minimise erosion and surface water quality issues. [C11.16] Common with Section 4.4.3, Surface Water Hydrology and Water Quality. • Store topsoil, subsoil and sediment trap soil in separate stockpiles to avoid mixing soil types and introducing salinity to non-saline soils. [C11.17] • Design topsoil stockpiles to allow for nutrient cycling. [C11.18] • Where insufficient topsoil is available at the site, use comparable imported topsoil as a preference, or other proprietary systems (e.g., spray mulch) for rehabilitation. Marine clays, skeletal soils, rock or gravelly soils will not be used in the rehabilitation of topsoil layers [C11.19A] • Control speed limits on site via posted speed limit signs and confine vehicles generally to marked trafficable areas. [C11.20] Common with Section 4.12.3, Air Quality. • Keep trafficked surfaces damp during construction with sprayed water when conditions are dry to suppress dust generation. Use water of a similar quality to that which is available in the locality and do not spray as concentrated flow. [C11.21] Common with Section 4.12.3, Air Quality. • Design and construct a barrier and sediment control pond to trap sediment leaving the LNG plant site before it enters the Port Curtis marine environment or other surface waters. Common with Section 4.4.3, Surface Water Hydrology and Water Quality. [C11.22] • Protect stream channels in soils prone to gully erosion with rock armouring or other appropriate structures and material to reduce erosion potential. [C11.23] Common with Section 4.4.3, Surface Water Hydrology and Water Quality. • Consider the thickness of colluvium, orientation and gradient of cut batters and orientation of bedrock defects when designing cut-and-fill locations to reduce the potential for slope destabilisation. [C11.24] • Batter or shore trench walls in soft, waterlogged soils (particularly in terrain unit 1) to increase stability. [C11.25] • Do not use saline, acidic or sodic soils for backfill padding of trenched pipelines where alternatives are available. [C11.26] • Cap excavated sodic or saline subsoils with non-sodic or non-saline topsoil material, during reinstatement. [C11.27]
Implementation strategy (operations)	• Rehabilitate batters, embankments and borrow pits and revegetate as soon as practical after construction. Reinstate areas no longer required for construction or support services and revegetate as per planting and seeding rehabilitation plans to be developed for the project. [C11.28]
Implementation strategy (decommissioning)	• Re-profile and reinstate topsoil, vegetation and re-establish a stable surface, where practical, during decommissioning and rehabilitation of the LNG plant site. [C11.29] Common with Section 4.4.3, Surface Water Hydrology and Water Quality.

Table 4.2 Geology, landform and soils management (cont'd)

Inspection and Monitoring	Undertake inspections and monitoring in accordance with Arrow's HSEMS. Inspections and monitoring are to reflect project approval requirements directed by government departments, and be undertaken on an as required basis. Conduct inspections at regular intervals during construction to check that mitigation measures are effective in reducing the magnitude of impact and: • Record location and types and rates of visible erosion. • Record location of settlement or subsidence of backfill. • Check for the build up of sediment in sediment traps. • Test soils in areas sensitive to salinity. • Identify areas where ground cover is inadequate. • Observe and record effectiveness and integrity of erosion control measures. • Test runoff water quality at point of discharge. Inspect sensitive areas after intense rainstorm events, where appropriate, and maintain erosion control structures where required. Monitor rehabilitation works quarterly for the first year post construction and annually thereafter until rehabilitation is considered successful in accordance with established performance criteria.
Auditing	Undertake internal audits as both scheduled and unscheduled activities. Conduct monthly audits for certain aspects of construction as required. In addition, undertake spot audits during ad hoc site visits. Undertake external audits when required to evaluate compliance with environment authority conditions and Arrow's HSEMS.
Reporting	Ensure that reporting reflects government requirements of the project approval and is undertaken in accordance with Arrow's HSEMS requirements set out in Section 3.5.
Corrective action	Undertake corrective actions in accordance with the outcomes of incident investigations, audits, monitoring results or advice given by the relevant regulatory authority.

4.3 Land Contamination and Acid Sulfate Soils

This section describes Arrow Energy's approach to managing potential environmental impacts associated with land contamination and acid sulfate soils (ASS) due to project activities.

4.3.1 Existing Environment

There are no lots in the project area listed on the Environmental Management Register or the contaminated land register as at October 2011. A notifiable activity of a 'cattle dip' has been identified on the LNG plant site (Lot 2 on Plan SP207281) on Curtis Island. Under the Environmental Protection Act, the identification of a notifiable activity requires the listing of that property on the Environmental Management Register.

Other known sources of contaminants of concern within the project area include corroded storage drums and battery stockpiles. There is also the potential for lead, asbestos products, minor volumes of fuels, oils, paints, solvents and other regulated wastes, potential former waste disposal sites, and landfill and septic systems that may occur within the LNG plant site.

At the mainland tunnel entrance, potential sources include abandoned car bodies, waste and contaminated sediment from adjacent industrial land uses. Ash is present in settling ponds at

TWAF 7 and launch site 1, and airborne coal dust from the RG Tanna Export Coal Terminal at launch site 1.

Areas within the project area potentially containing ASS include the LNG plant site, LNG loading lines, Boatshed Point haul road and MOF, LNG jetty, mainland tunnel entrance, Hamilton Point reception shaft, TWAF 7, launch site 1, and the dredge sites.

4.3.2 Potential Impacts

The construction and operation of the project has the potential to disturb existing contaminated land and cause land contamination. Activities that present a risk to personnel and the environment include:

- Disturbance to known contaminated areas spreading contamination into a greater area of impact potentially exposing onsite workers and environmental receptors (e.g., surface water).
- Earthworks encountering unidentified contaminated soils, leading to a spread of contamination or removal from site in an uncontrolled manner.
- Poor storage or disposal of general and putrescible wastes generated at the LNG plant, construction camp, launch and TWAF sites during construction and operation leading to uncontrolled releases.
- Poor storage and handling of chemicals and fuels; leading to uncontrolled releases.
- Fires involving chemicals and fuels, as well as other engineered materials and liquids.
- Groundwater dewatering, with the discharge of the extracted water affecting soil and surface water chemistry.
- Uncontrolled release of water used in hydrostatic testing of the pipeline which may have acquired contaminants.

Construction of the project has the potential to disturb soils below 5 m AHD potentially containing ASS. Construction activities that have the potential to disturb ASS are:

- Excavation works at the LNG plant site, feed gas pipeline site on Curtis Island, Boatshed Point or Hamilton Point, LNG jetty, MOF, personnel jetty, launch site 1, mainland tunnel entrance and TWAF 7.
- Filling activities at the TWAF 7, MOF and launch site 1.
- Load impacts from the presence of embankments and structures at TWAF 7.
- Soil disturbance from land clearance and traffic movements at the LNG plant site, haul roads on Curtis Island, LNG jetty, reception shaft on Curtis Island, MOF, personnel jetty, feed gas pipeline tunnel entrance and TWAF 7.
- Dewatering through trenching or tunnelling material associated with the LNG loading lines and feed gas pipeline on Curtis Island, feed gas pipeline mainland tunnel entrance, feed gas pipeline reception shaft.
- Dredging associated with facilitating access to launch sites 1 and 4N, the Boatshed Point MOF and the LNG jetty.

Construction activities involving the use of acidic, non-acid sulfate soils as fill also have the potential to result in the release of acidic leachates. If soils of this nature exist at the LNG plant site they are likely to be cut from above 5 m AHD and used as structural fill and backfill associated with the LNG plant, haul road, on land infrastructure at the LNG jetty, MOF and personnel jetty. Extensive geotechnical surveys have been completed on the project site. Arrow Energy accordingly has a detailed understanding of the acid sulphate soils profile of the site. This understanding will inform development of detailed earthworks and dredging plans that incorporate measures for management of acid sulphate soils.

4.3.3 Land Contamination and Acid Sulfate Soil Management

Arrow Energy will adopt appropriate mitigation and management measures focused on reducing the residual risks of disturbing contaminated land and ASS. Table 4.3 outlines the mitigation and management measures relevant to land contamination and ASS.

Table 4.3 Land contamination and acid sulfate soils management

Element/issue	Potential for all activities to disturb existing contaminated land and ASS and cause land contamination.
Environmental and social objectives	• To identify and manage existing contaminated land within the project area of disturbance. • To reduce risk of land contamination by project activities during construction and operation. • To manage and mitigate disturbance to ASS during project construction and operation.
Performance criteria	• Any contamination or spill incidents are effectively contained, documented and closed out. • No additional contamination occurs to ground or surface waters. • Compliance with applicable government policy and guidelines for the assessment and management of potentially contaminated land and ASS.
Implementation strategy (planning and design)	Prior to construction, the extent of contamination will be further defined where required, and mitigation measures will be refined as appropriate. [C12.01]
Implementation strategy (construction)	**Former cattle dip** • Undertake additional assessment of the area of potential contamination and develop management or remediation via a DERM-accepted method. Validate the impacted area as per the draft guidelines for the assessment and management of contaminated land in Queensland 1998 (DoE, 1998) and national environment protection (assessment of site contamination) measure (NEPC, 1999). [C12.02] • Remove livestock dip and spray race structure. [C12.03] • Manage or remediate impacted soil and groundwater in accordance with current Queensland guidelines. [C12.04] **Ash in settling ponds** • Undertake Stage 2 assessment of ash to determine contamination status. [C12.05] • Where practical, avoid disturbance of buried ash during construction. [C12.06] • Establish effective management methods for disturbed ash during construction activities including erosion and sediment controls and dust suppression. Use appropriate personal protective equipment. [C12.07] • Place suitable capping material and develop a site management plan if required. [C12.08]

Table 4.3 Land contamination and acid sulfate soils management (cont'd)

Implementation strategy (construction) (cont'd)	**Waste battery stockpiles** • Remove batteries from site for recycling. [C12.09] • Undertake shallow surface soil validation sampling. [C12.10] **Chemicals and fuel use or storage** • Construct facilities in accordance with relevant Australian standards. [C12.11] • Appropriately train staff in the use of hazardous materials. [C12.12] • Immediately clean up any spills and conduct investigations into any significant releases. [C12.13] **Fires and emergency releases of hazardous materials** • Provide emergency response training to staff handling dangerous goods. [C12.14] • Construct facilities and spill containment in accordance with current Australian standards. [C12.15] • Regularly inspect infrastructure using or storing hazardous materials, or test for integrity. [C12.16] **ASS** • Develop an ASS management plan prior to construction work. In the plan, specify how onsite ASS disturbances should be managed in accordance with SPP2/02 and the methods set out in Queensland acid sulfate soil technical manual soil management guidelines (Dear et al., 2002). [C12.17] Common with Section 4.5.3, Groundwater.
Implementation strategy (operations)	• Provide emergency response training to staff handling dangerous goods. [C12.14] • Immediately clean up any spills and conduct investigations into any significant releases. [C12.13] 'Chemicals and fuel use or storage' (as for construction), 'Fires and emergency releases of hazardous materials' strategies (as for construction).
Implementation strategy (decommissioning)	Remediate areas of contamination that have resulted from the project to a level that protects human health and the environment. [C12.18]
Inspection and monitoring	Inspection and monitoring programs will be designed to meet the ongoing requirements of any managed contaminated sites where engineering or procedural controls are implemented. Inspection and monitoring requirements will be detailed in management plans and may include: • Inspection of engineering controls such as surface seals/capping layers. • Monitoring of surface and groundwater. • Monitoring of sediment within drainage lines. The ASS monitoring, reporting and auditing regime will be detailed in the ASS management plan in accordance with SPP 2/02.
Auditing	Undertake internal audits as both scheduled and unscheduled activities for implementation of agreed measures and compliance with performance criteria. Conduct regular internal audits throughout the life of the project and spot audits during ad hoc site visits. Undertake external audits when required to evaluate compliance with environmental authority conditions and Arrow's HSEMS.
Reporting	Ensure reporting reflects government requirements of the project approval and is undertake in accordance with Arrow's HSEMS requirements set out in Section 3.5 of this Strategic EMP.

Table 4.3 Land contamination and acid sulfate soils management (cont'd)

Corrective action	Undertake corrective actions in accordance with the outcomes of incident investigations, audits, monitoring results or advice given by the relevant regulatory authority in accordance with Arrow's HSEMS.

4.4 Surface Water Hydrology and Water Quality

This section describes Arrow Energy's approach to managing potential environmental impacts on surface water hydrology and water quality associated with project activities.

4.4.1 Existing Environment and Environmental Values

Curtis Island and the Gladstone region have a sub-tropical climate with the bulk of rainfall occurring in the summer. This seasonality influences the characteristics of the surface water features of the area.

Many of the waterways flowing into Port Curtis are heavily tidally influenced. Both the Calliope River and Auckland Creek are tidal and have been disturbed to varying degrees by past land use and bank alteration.

There is a predominantly dry drainage system in place on Curtis Island that will be diverted as a result of the project. The drainage system has been determined to comprise predominantly overland flow (only during and immediately after heavy rain) and has only terrestrial environmental values. Creeks in the upper Auckland Creek catchment on the mainland are considered to be ephemeral streams, Flows only occur during large rainfall events significant enough to generate substantial overland flow.

The only recognised fresh watercourses potentially impacted by the project are Boat Creek, north of the mainland tunnel entry shaft and the upper reaches of Targinie Creek near TWAF 8. Limited water quality information is available for these watercourses, which only flow after heavy rain:

- Boat Creek water quality is characterised by lower pH, higher conductivity and higher concentrations of bioavailable aluminium, copper, cobalt and manganese in comparison to other Port Curtis estuaries. Groundwater intrusion or surface water runoff from the upper reaches is likely to be influencing water quality within the area.
- Sampling information available for the lower estuarine reach of Targinie Creek, well downstream of the proposed TWAF 8, showed concentrations of ammonia, total nitrogen and total phosphorous exceeding the Queensland Water Quality Guidelines for the Central Coast region mid-estuarine systems. Metal concentrations and hydrocarbons were mostly below detection limits.

Flood modelling carried out for the project showed that a significant portion of the central southern end of the LNG plant site would be inundated by a 100 year average recurrence interval (ARI) event (presenting a low to moderate hazard). The site surface water drainage system will divert surface water runoff from the existing catchment area and drainage system, and away from plant infrastructure to a sediment basin, where it will settle prior to being discharged. Rainfall and stormwater runoff from a 1:100 year ARI event will exceed the capacity of the low-flow pipes and back up in the detention basin allowing controlled discharge. This system will be designed to

comply with Best Practice Erosion and Sediment Control (IECA 2008), which will ensure adequate detention time before discharge. TWAF 7 will not be affected by the 100 year ARI event or probable maximum flooding scenarios. The mainland tunnel entry shaft and tunnel spoil disposal area are located within a zone of flood inundation from Boat Creek for the 10 year ARI event. The Red Rover Road site has not been assessed for flood risk, but should this option be taken further, full flood modelling and risk assessment will be undertaken prior to construction taking place.

The nationally important Port Curtis wetlands lie within the Calliope River basin at the tunnel entrance and spoil disposal area, as well as at launch site 1. No project activities are located within The Narrows wetlands. Wetland types that may be impacted by project activities include mangroves and related tree communities on the Curtis Island coast, salt flats and salt marshes in the footprint of the mainland tunnel launch site, and coastal or sub-coastal floodplain tree swamps in the footprint of the LNG plant on Curtis Island.

4.4.2 Potential Impacts

The issues and potential impacts on the hydrology, geomorphology, and water quality from project construction, operation, and decommissioning are described below.

- **Erosion and sedimentation.** Erosion and increases in sediment loads in watercourses will occur during rainfall at all project sites as areas are cleared of vegetation and site preparation earthworks are carried out. Operating vehicles and machinery near stream banks and within the riparian zone may cause erosion and deposition of sediment within waterways. Flooding during high rainfall events will increase erosion and sedimentation rates in areas of exposed earth. Stormwater may become contaminated with hydrocarbon or chemical residues in storage facilities such as bunds. Spills of chemicals or fuels are also potential sources of contamination if they enter watercourses at project sites.
- **Loss of wetlands.** Wetland areas will be lost and areas of riparian vegetation will be damaged or removed during construction. Wetlands will be infilled during the construction of the materials off-loading facility, and covered over at the mainland tunnel launch site.
- **Curtis Island stream diversions.** Parts of a predominantly dry drainage network will be infilled during the construction of the LNG plant, with subsequent realignment of drainage routes necessary to control overland flow from three of the sub catchments within the area. Drainage will be diverted to an existing ephemeral watercourse to the west of the project site.
- **Calliope River mouth dredging.** Dredging at the mouth of the Calliope River will potentially cause changes to the tidal hydraulics, flood-related sediment transport causing local bed erosion, and geotechnical bank slope stability related to either undermining of bank toe areas or surcharging of the bank itself with works or water table changes.

4.4.3 Surface Water Management

Arrow Energy will adopt appropriate mitigation and management measures to address potential impacts on surface water from the project.

Management measures for all project activities from design and planning through to decommissioning are found in Table 4.4.

Table 4.4 Surface water hydrology and water quality management

Element/issue	Potential for project activities to impact on the values associated with surface water hydrology and water quality.
Environmental objectives	• To avoid or reduce potential adverse effects on hydrology, geomorphology and surface water quality during all project stages. • To identify mitigation strategies to reduce adverse effects on hydrology, geomorphology and surface water quality.
Performance criteria	• Stormwater quality meets the Environmental Protection (Water) Policy objectives for the Port Curtis area. • Erosion and sediment control structures are designed and managed effectively during construction and operations. • Changes to the hydrology and geomorphology of the project area are avoided or minimised. • Stream diversions are designed and operated to provide for the transport of sediment during the life of the project.
Implementation strategy (planning and design)	• Locate sensitive project infrastructure to avoid the 1:100 yr ARI where practical. [C13.01] • Design stream diversions and adjacent flood corridors to manage a minimum of a 1:100 year ARI event. [C13.02] • Design the stream diversion at the LNG plant site; to prevent erosion or deposition at greater than natural rates; as a corridor, which may contain a formalised channel and constructed flood plain zone; and to allow for the transport of sediment. [C13.03] • Design TWAF 8 to minimise disturbance to the 'of concern' RE 11.3.4 ('*Eucalyptus tereticornis* and/or Eucalyptus spp. tall woodland on alluvial plains') to maintain connectivity of habitat along the Targinie Creek riparian zone. [C13.04] Common with Section 4.8.3, Terrestrial Ecology, and Section 4.9.3, Freshwater Ecology. • Where practical, align the perimeter fence at TWAF 8 to adopt the alignment of the existing fence where it crosses Targinie Creek. [C13.05] Common with Section 4.8.3, Terrestrial Ecology, and Section 4.9.3, Freshwater Ecology. • Design any intra-site access road crossing of Targinie Creek at TWAF 8 to include box culverts (or similar) to enable fauna movement under the road and along the wildlife corridor. [C13.06] Common with Section 4.8.3, Terrestrial Ecology, and Section 4.8.3, Freshwater Ecology. • Keep the footprint of the mainland tunnel entry shaft and tunnel spoil disposal area to a minimum of 500 m clear of Boat Creek. [C13.07] Common with Section 4.9.3, Freshwater Ecology. • Treat stormwater generated from TWAF 7, TWAF 8, launch site 1, the tunnel shaft entry site and tunnel spoil disposal area in temporary sediment basins located at each site. [C13.08] • Divert sediment-laden water from disturbed areas at the LNG plant site to temporary sedimentation pond(s). [C13.09] • Manage all surface water generated from the LNG plant site by a stormwater treatment system to ensure discharged water complies with regulatory requirements. [C13.10] Common with Section 4.22.3, Waste Management. • Use control measures such as drains, swales, silt fencing and sediment traps around the lower slopes of erodible stockpiles. [C11.12] Common with Section 4.2.3, Geology, Landform and Soils.

Table 4.4 Surface water hydrology and water quality management (cont'd)

Implementation strategy (planning and design) (cont'd)	• Implement sediment and erosion control measures upslope of watercourses, wetlands and coastal areas or in areas with sodic soils to minimise increases in natural sediment discharge. Measures may include sediment traps, silt fencing, riprap, contour banks, detention dams, sediment ponds and vegetation and diversion berms. [C11.11] Common with Section 4.2.3, Geology, Landform and Soils. • Prior to construction commencing, develop a site drainage plan to define how the civil construction will address site drainage, stormwater management, erosion control and stockpile placement. Risks relating to flood events will also be addressed with appropriate mitigation measures to minimise erosion and surface water quality issues. [C11.16] Common with Section 4.2.3, Geology, Landform and Soils.
Implementation strategy (construction)	• Protect stream channels in soils prone to gully erosion with rock armouring or other appropriate structures and material to reduce the erosion potential. [C11.23] Common with Section 4.2.3, Geology, Landform and Soils. • Manage surface runoff to reduce concentration of surface flow, particularly in erodible soils. Provide drainage channels with suitable design features to minimise erosion where surface runoff is disrupted by roads, tracks, fencing and buildings. Place structures within drainage channels to reduce flow velocity where appropriate. [C11.07] Common with Section 4.2.3, Geology, Landform and Soils. • Design and construct a barrier and sediment control pond to trap sediment leaving the LNG plant site before it enters the Port Curtis marine environment or other surface waters. [C11.22] Common with Section 4.2.3, Geology, Landform and Soils. • Avoid works near stream banks during periods of heavy rainfall where practical. If works cannot be timed to avoid heavy rainfall, adopt additional measures, such as the use of berms and silt fences. [C11.09] Common with Section 4.2.3, Geology, Landform and Soils, and Section 4.9.3, Freshwater Ecology. • Provide secondary containment for any fuel, oil or chemicals in above ground storage facilities in accordance with applicable Australian standards. [C13.11] • Develop appropriate spill prevention and response plans to cover project activities and the types and quantities of fuel, oil and chemicals held at each site. [C13.12] Common with Section 4.5.3, Groundwater and Section 4.22.3, Waste Management. • Train all relevant personnel in spill response and recovery procedures. [C13.13] Common with Section 4.7.3, Marine Water Quality and Sediment, and Section 4.22.3, Waste Management. • Maintain live capacities of storage bunds to maximise capacity in the event of a storm or spill. [C13.14] • Do not abstract freshwater from watercourses, or dispose of effluent directly into freshwater watercourses, except clean stormwater. [C13.15] Common with Section 4.9.3, Freshwater Ecology. • Where waterway crossings are necessary, cross ephemeral streams in preference to permanent streams, where practical. Where pipeline waterway crossings are necessary, approach stream crossings perpendicular to the stream where practical to reduce bank erosion risk and minimise the footprint within the bed and riparian zone. [C13.16] Common with Section 4.9.3, Freshwater Ecology. • Where practical, ensure that grasses and other ground cover remain in place to assist with trapping mobilised sediments. [C13.17] • Avoid the use of herbicides within riparian zones or directly over watercourses. Where this is not possible, use products specifically approved for this purpose. [C13.18]

Table 4.4 Surface water hydrology and water quality management (cont'd)

Implementation strategy (construction) (cont'd)	• Develop site-specific vegetation management plans to reinstate native plant species to areas to be rehabilitated, including riparian margins. Exotic sterile grasses may be used in areas where temporary cover is required to aid in soil stabilisation. [C13.19] • Undertake earthworks and rehabilitation activities to facilitate drainage and reduce the potential for standing water to accumulate. [C13.20] Common with Section 4.9.3, Freshwater Ecology. • Avoid discharging tail water from the tunnel spoil disposal area into Boat Creek. [C13.21] Common with Section 4.9.3, Freshwater Ecology. • Where works are required in watercourses, they will be confined to reduced width construction right of ways that preserve, to the extent practical, the integrity of the riparian vegetation and any associated wildlife corridors. [C13.22] Common with Section 4.9.3, Freshwater Ecology.
Implementation strategy (operations)	• Routinely inspect and maintain the stormwater treatment system. [C13.23] • Treat all surface water and stormwater generated within the LNG plant site in a stormwater system to ensure discharged water meets regulatory requirements. [C13.24] • Collect contaminated stormwater for treatment before discharge. [C13.25] • Only treat surface water generated within the LNG plant site in the stormwater treatment system. Divert runoff generated outside the LNG plant site away from the LNG plant site stormwater system via the proposed stream diversion. [C13.26] • Place structures within drainage channels to reduce flow velocity where appropriate. [C13.27] • Remove litter and other debris from within the treatment system, especially around the inlet and outlet structures. [C13.28] • Do not abstract freshwater from watercourses, or dispose of effluent directly into freshwater watercourses, except clean stormwater. [C13.15] Common with Section 4.9.3, Freshwater Ecology. • Keep areas within and around the stormwater treatment system free of weeds, and other undesired overgrowth. [C13.29]
Implementation strategy (decommissioning)	• Consider post-decommissioning channel form for the stream diversion design and provide for a self-sustaining waterway, without the need for maintenance beyond the life of the project. [C13.30] • Re-profile and reinstate topsoil, vegetation and re-establish a stable surface, where practical, during decommissioning and rehabilitation of the LNG plant site. [C11.29] Common with Section 4.2.3, Geology, Landform and Soils.
Inspection and Monitoring	• Check the sediment basins for damage and accumulation of rubbish trash or other debris on a regular basis. Repair any damage as soon as practical. Dispose of sediment in an appropriate disposal area, or mix with dry soil on the site if appropriate. • Inspect the integrity of fill material (i.e., for slumping) used in construction of drainage systems and repair as necessary. • Undertake monitoring of the stream diversion to obtain baseline data prior to the commencement of construction and undertake monitoring of the stream diversion during construction and operation to ensure the diversion is performing according to design specifications. • Inspect sensitive areas, where appropriate, after intense rainfall events and maintain erosion control structures where required.

Table 4.4 Surface water hydrology and water quality management (cont'd)

Inspection and Monitoring (cont'd)	• Ensure that inspections and monitoring reflects project approval requirements directed by government departments. Develop a detailed site environmental monitoring program and document in construction and operations environmental plans. • Inspect sediment control measures (drains, sediment and stormwater detention basins) on a quarterly basis. • Monitor water to be discharged on a quarterly basis during the operational stages. • Perform operations monitoring of the stream diversion to maintain the channel condition and reduce risk to project infrastructure.
Auditing	Undertake internal audits as both scheduled and unscheduled activities for implementation of agreed measures and compliance with performance criteria. Conduct regular internal audits throughout the life of the project and spot audits during ad hoc site visits. Undertake external audits when required to evaluate compliance with environmental authority conditions and Arrow's HSEMS.
Reporting	Ensure reporting reflects government requirements of the project approval and is undertaken in accordance with Arrow's HSEMS requirements set out in Section 3.5 of this Strategic EMP.
Corrective action	Undertake corrective actions in accordance with the outcomes of incident investigations, audits, monitoring results or advice given by the relevant regulatory authority in accordance with Arrow's HSEMS.

4.5 Groundwater

This section describes Arrow Energy's approach to managing potential groundwater impacts associated with project activities.

4.5.1 Existing Environment and Environmental Values

Groundwater aquifers can range up to tens of metres thick and are influenced by the topography and their geological setting. Three types of groundwater aquifers may occur:

- **Shallow aquifers.** Composed of alluvial sedimentary deposits, consisting of sand, silt and clay particles generally found 8 m below ground level (mbgl). This aquifer type is likely to occur under lower lying areas of the LNG plant site, shoreline areas of the LNG plant marine infrastructure, TWAF 7, TWAF 8, shoreline areas of launch site 1, and the mainland tunnel entrance and tunnel spoil disposal area.
- **Unconfined bedrock aquifers.** May occur within weathered or fractured bedrock in higher topography away from surface water bodies. Unconfined bedrock aquifers may occur at higher areas of the LNG plant site, TWAF 7 and TWAF 8.
- **Semi-confined aquifers.** May occur within weathered and fractured rock layers, as well as in stratified alluvium and transition zones between weathered and fresh bedrock exhibiting low permeability. Semi-confined aquifers may occur within the vicinity of the LNG plant site.

Diffuse recharge (recharge resulting from the areal infiltration of rainfall) is likely to be the dominant recharge process for shallow aquifer systems, due to the relatively high rainfall within the project area. Deeper aquifers may be recharged through leakage from overlying shallow

aquifers. Groundwater flow is expected to be from upland areas towards the coast. Local hydrological boundaries such as streams and estuaries are also likely to receive groundwater discharge and locally influence groundwater flow direction.

Groundwater is generally of poor quality ranging from marginally fresh to brackish and saline water. Groundwater in the shallow alluvial/estuarine deposits on the mainland can be classified as brackish to saline, generally unsuitable for drinking, stock watering and irrigation. The groundwater resources within the 2 km of the project area do not appear to be used for water supply (DERM, 2011). This is possibly a reflection of generally poor water quality, and low yields (hence limited sustainability of supply).

Elevated levels of dissolved chromium, cobalt, copper and zinc were observed for some shallow and deep groundwater systems. Concentrations of these metals exceed ANZECC/ARMCANZ (2000) guidelines for freshwater and marine ecosystems. The groundwater from both shallow (< 8 m) and some deep (> 20 m) bores, is recognised as unsuitable for both discharge into fresh or marine water environments and for domestic use due to elevated dissolved metals.

Groundwater dependent ecosystems that may rely on groundwater in the project area include deep-rooted phreatophytes in wetland areas.

4.5.2 Potential Impacts

There is no proposed extraction of groundwater for use in the project construction, operations or decommissioning phases. The following issues and potential impacts to groundwater have been identified during construction, operations and decommissioning of the project:

- **Ground disturbance and dewatering leading to reduced aquifer recharge**. Clearing of vegetation, resurfacing with impermeable materials and ground compaction during construction of all project areas may reduce infiltration rates and recharge to shallow unconfined groundwater systems on Curtis Island and the mainland. Clearing of land can also reduce transpiration losses, increasing net recharge; although this is likely to be offset by a reduction in infiltration caused by development cover from buildings, concrete, and hardstanding.
- **Ground compaction, tunnelling and dewatering leading to altered aquifer level, flow and gradient**. Construction of the LNG plant, launch site 1, accommodation, laydown and staging areas may compact underlying unconfined shallow aquifers and alter hydrogeological characteristics (i.e., porosity, permeability, structure) affecting groundwater flow, levels and gradients. Temporary and localised reduction of groundwater levels by dewatering may be experienced during the installation of the feed gas pipeline.
- **Saline intrusion from high-salinity aquifers to lower-salinity aquifers**. Intrusion of saline water to deeper aquifers with lower salinity could occur during activities that intersect these groundwater systems, impacting groundwater values at those sites. Construction of the tunnel launch shaft and tunnel reception shaft may intersect shallow and deep groundwater systems. Proposed construction methods may employ a bentonite or grout curtain to seal the geological strata as the shaft is excavated, minimising the potential for groundwater ingress and leakage to other aquifers.
- **Contamination by leaks, spills and discharge of hazardous or detrimental materials**. Shallow groundwater quality could be degraded through unintentional spills and leaks of hazardous materials. These leaks may originate through poor storage and handling of

petroleum based fuels and lubricants, chemicals used on the site and waste water generated by project activities and through pipeline and tunnel construction. Contaminants entering the groundwater system can migrate to deeper groundwater systems vertically and horizontally though the aquifer. Contaminated shallow groundwater could migrate to deeper groundwater systems and impact groundwater dependent ecosystems.

- **Degradation of groundwater quality through disturbance to acid sulfate soils**. The construction of marine infrastructure and haul roads on Curtis Island will involve excavation in low-lying areas where marine/estuarine sediments may generate acid from oxidation of sulphide minerals in the potential acid sulfate soils. This may cause the acidification and degradation of shallow groundwater quality. The resultant low pH conditions could lead to the mobilisation of metals in groundwater and subsequent discharge to the sea. At the feed gas pipeline mainland tunnel entrance, excavation activities have the potential to cause deterioration in groundwater quality due to the exposure of acid sulfate soils where they occur. The construction of launch site 1 and a laydown and staging area at the TWAF 7 site near low-lying areas along Auckland Creek may generate acid groundwater conditions due to exposure of acid sulfate soils.

4.5.3 Groundwater Management

Arrow Energy will adopt appropriate mitigation and management measures to address potential impacts on groundwater from the project.

Management measures for all project activities from design and planning through to decommissioning are found in Table 4.5.

Table 4.5 Groundwater management

Element/issue	Potential for project activities to impact on groundwater values.
Environmental objectives	To avoid or reduce potential adverse effects to groundwater values from construction and operation of the project.
Performance criteria	• Fuels, lubricants, chemicals, hydrocarbons, effluents and waste are stored, handled, treated and disposed so as not to contaminate groundwater. • Construction and operational activities do not have an observable impact to baseline groundwater quality.
Implementation strategy (planning and design)	• Design the facility drainage system such that accidental releases of hazardous substances are collected to reduce the chance of contamination seeping into the groundwater system. [C14.01] • Prepare a materials handling and waste management plan to manage any potential contaminants, soils or materials that might result in impacts to shallow groundwater through either short-term or long-term leaching. [C14.02]
Implementation strategy (construction and operations)	• Minimise the extent and duration of construction dewatering required. [C14.03] • Develop an ASS management plan prior to construction work. In the plan, specify how onsite ASS disturbances should be managed in accordance with SPP2/02 and the methods set out in Queensland acid sulfate soil technical manual soil management guidelines (Dear et al., 2002). [C12.17] Common with Section 4.3.3, Contaminated Land and Acid Sulfate Soils.

Table 4.5 Groundwater management (cont'd)

Implementation strategy (construction and operations) (cont'd)	• Store fuels, chemicals and hazardous wastes in appropriately sized, bunded storage facilities (in leak proof sealed containers). [C14.04] Common with Section 4.22.3, Waste Management. • Where fuel or oil is contained in above ground storage facilities, ensure they are constructed with suitable secondary containment in accordance with Australian standards. [C14.05] • Maintain accurate records of fuels and oils stored in underground storage tanks to enable leak detection through quantity auditing. [C14.06] • Develop appropriate spill prevention and response plans to cover project activities and the types and quantities of fuel, oil and chemicals held at each site. [C13.12] Common with Section 4.4.3, Surface Water Hydrology and Water Quality, and Section 4.22.3, Waste Management. • Minimise site storage of brine products. [C14.07] • Collect sewage and greywater generated from the pioneer camp in portable disposal units or other mobile collection facilities. Use a licensed waste contractor to service the sewage facilities and dispose of effluent at a licensed waste management facility. Dispose of sewage from the mainland TWAF through a connection to the local sewerage network or ensure that it is collected in portable disposal units or other mobile collection facilities. [C14.08] Common with Section 4.22.3, Waste Management. • Implement engineering controls to minimise the extent of aquifer drawdown and saline-water encroachment such as sheet piling of excavations or groundwater reinjection. [C14.09]
Implementation strategy (decommissioning)	• Prepare a materials handling and waste management plan to manage any potential contaminants, soils or materials that might result in impacts to shallow groundwater through either short-term or long-term leaching. [C14.02] • Follow standard guidelines for decommissioning of all monitoring bores including the manual of water well construction practices (US EPA, 1977) and minimum construction requirements for water bores in Australia (DNRME, 2003). [C14.10]
Inspection	• Undertake routine inspections (during construction and operations) of the handling, storage and disposal of chemicals, fuels and hydrocarbons for compliance with applicable Australian standards.
Monitoring	**Pre-construction** Establish a groundwater monitoring program prior to construction. The program is expected to include a network of existing and new monitoring bores to provide a base level of groundwater quality data as well as the level of groundwater present at each bore location. In the monitoring, target shallow unconfined and deeper confined aquifers in the vicinity of the LNG plant, TWAF and launch site 1. Parameters to be monitored shall be described in the groundwater monitoring plan. Relocate pre-construction monitoring bores that are likely to be damaged by project construction activities so monitoring can continue during operations. **Construction** Prepare a construction groundwater management plan prior to construction commencing and include monitoring requirements. **Operation** During operation, undertake groundwater level monitoring on a quarterly basis. Parameters to be monitored shall be described in the groundwater monitoring plan. Review the groundwater monitoring programme after 3 years and agree any changes and ongoing requirements with the relevant authority.

Table 4.5 Groundwater management (cont'd)

Auditing	Undertake internal audits as both scheduled and unscheduled activities for implementation of agreed measures and compliance with performance criteria. Conduct regular internal audits throughout the life of the project and spot audits during ad hoc site visits. Undertake external audits when required to evaluate compliance with environment authority conditions and Arrow's HSEMS.
Reporting	Ensure reporting reflects government requirements of the project approval and is undertaken in accordance with Arrow's HSEMS requirements set out in Section 3.5 of this Strategic EMP.
Corrective action	Undertake corrective actions in accordance with the outcomes of incident investigations, audits, monitoring results or advice given by the relevant regulatory authority in accordance with Arrow's HSEMS.

4.6 Coastal Processes

This section describes Arrow Energy's approach to managing potential environmental impacts on coastal processes associated with project activities.

4.6.1 Existing Environment and Environmental Values

Port Curtis is a shallow coastal basin, situated directly offshore from Gladstone within the greater Port of Gladstone. Port Curtis is separated from the Coral Sea by Facing and Curtis islands, which protect the port from ocean generated waves and swells. The resulting sheltered environment is only exposed to wind-driven waves generated within Port Curtis itself. The Calliope River flows into Port Curtis and is one of the few remaining waterways in Queensland where major water-retaining infrastructure does not interrupt environmental flows to the coast. Various smaller tributaries also discharge into Port Curtis and The Narrows.

Tides in Port Curtis are semi-diurnal, with two high and low tides per day. Within the Calliope River, the tidal cycle influences water levels up to 25 km upstream of the river mouth. Water currents within Port Curtis are controlled by the tidal cycle, and good tidal flushing and large current velocities exist as a result of the large tidal storage areas present and the amplification effect on water levels.

During cyclones, water levels at the coast may be substantially higher than normal due to storm surge effects. Storm surges are increases in water level caused by onshore cyclonic winds pushing on the ocean surface and reduced atmospheric pressure.

Mobilisation and transport of seafloor sediments occurs due to the combined action of waves and water currents, or by water currents alone. Low wave heights in Port Curtis mean wave action does not play a significant role in sediment transport processes, although small waves can be important in mobilising fine sediments in the shallower parts of Port Curtis. Except during major flood events, sediment transport processes within the Calliope River are governed by tides.

4.6.2 Potential Impacts

The following issues and potential impacts to coastal processes have been identified during construction, operations and decommissioning of the project:

- **Impacts to tides and water currents**. Computer modelling undertaken to assess the impacts in both Port Curtis and the Calliope River from project dredging and the installation of marine infrastructure showed that within Port Curtis there is no effect on highest and lowest tidal events. There are some changes (up to 0.6 m/s) to water current speeds in the vicinity of the LNG jetty swing basin, Boatshed Point and launch site 1, but these will have a negligible influence on coastal processes in the study area as they occur over a small area within a large well-mixed dynamic environment. Water levels in the Calliope River will not be affected at high tide. At low tide, water levels during spring tides will be lower at some locations by up to 0.5 m. Further modelling was carried out for the SREIS to assess the impacts on low tide levels in the Calliope River following the dredging of the bar at the river mouth. Intertidal banks between the river mouth and a point near the Gladstone Power Station may be exposed by up to an additional 0.5 m on the lowest low tide. This lowering of water levels may restrict upstream access to some vessels on the lowest low tides for a few hours each month. Lower reaches of the river which currently experience restricted access, will now be accessible under all tidal regimes. Water current speeds will increase at the mouth of the newly dredged Calliope River channel during ebb spring tides, and decrease to the west of the channel. Under flood spring tidal conditions, water current speeds are predicted to increase to the west of the dredged channel and decrease within the dredged channel along its eastern bank.
- **Impacts to waves**. Computer modelling was undertaken to assess impacts due to project activities in Port Curtis to the day-to-day wave climate and to extreme waves. Project infrastructure will not affect wave heights during extreme events and the day-to-day wave climate within Port Curtis will not be affected at the majority of locations assessed. Between the LNG jetty and Hamilton Point, significant wave heights from the southeast will be reduced by 1.5%. Offshore from Hamilton Point, significant wave heights from the east-southeast will increase slightly (by 1.5%).
- **Impacts to extreme water levels**. Project activities will not affect extreme water levels resulting from cyclonic conditions such as storm tides, either under current or future climatic conditions.
- **Impacts to sediment transport and deposition and shoreline processes**. Dredging activities and the installation of marine infrastructure could change the existing tidal regime and water current patterns in Port Curtis which in turn may affect sediment transport and shoreline processes. Fine sediment will be deposited at varying rates at the Boatshed Point MOF and integrated passenger jetty, and at launch site 1. This material will need to be removed during maintenance dredging. Overall net sand transport within the Calliope River will not be affected by project activities.

4.6.3 Coastal Processes Management

Arrow Energy will adopt appropriate mitigation and management measures to address potential impacts on coastal processes from the project.

Management measures for all project activities from design and planning through to decommissioning are found in Table 4.6.

Table 4.6 Coastal processes management

Element/issue	Potential for project activities to impact on coastal process values.
Environmental and social objectives	• To avoid or reduce potential adverse effects on coastal processes resulting from the project. • To identify mitigation strategies to reduce adverse effects on coastal processes to an acceptable level.
Performance criteria	• No exceedance of parameters for turbidity and total suspended solids as established in the dredge management plan for all stages of the project. • Coastal processes occur unhindered post decommissioning.
Implementation strategy (design and construction)	• Stabilise the shoreline, where required, at the high tide level where marine infrastructure is installed. [C15.01] • Develop a dredge management plan that considers the appropriate water and sediment monitoring data (e.g., current WBCC Project data) and will include: [C15.02] – Requirements for monitoring of water quality. [C15.03] – Actions to be taken to minimise impacts of dredging on sensitive areas should water quality monitoring data show performance criteria are exceeded. Finalise specific actions in the dredge management plan. [C15.04] Common with section 4.7.3, Marine Water Quality and Sediment and Section 4.10.3, Marine and Estuarine Ecology.
Implementation strategy (operations)	• Implement management measures from the dredge management plan to address impacts from maintenance dredging. [C15.05]
Implementation strategy (decommissioning)	• Subject to landlord requirements, decommission the LNG jetty and loading facilities in a similar manner to the LNG plant. [C15.06A] • Leave the MOF and shore protection works at the LNG jetty (local benthic habitat and associated flora and fauna will have adapted to its presence over the operational life of the project). [C15.07] • Only demolish the mainland launch site if another use is not identified. [C15.08]
Inspection and monitoring	• Specify in the dredge management plan, water quality and marine ecology monitoring requirements including those to assess the impact of dredging in the Calliope River. • Undertake other inspections and monitoring in accordance with Arrow's HSEMS and to reflect project approval requirements directed by government departments. • Undertake inspections at regular intervals during operations to check that mitigation measures are effective in reducing the magnitude of impacts.
Auditing	Undertake internal audits as both scheduled and unscheduled activities for implementation of agreed measures and compliance with performance criteria. Conduct regular internal audits throughout the life of the project and spot audits during ad hoc site visits. Undertake external audits when required to evaluate compliance with environment authority conditions and Arrow's HSEMS.
Reporting	Ensure reporting reflects government requirements of the project approval, the requirements set out in the dredge management plan, and is undertaken in accordance with Arrow's HSEMS requirements set out in Section 3.5 of this Strategic EMP.
Corrective action	Corrective actions will be undertaken in accordance with the outcomes of incident investigations, audits, monitoring results or advice given by the relevant regulatory authority in accordance with Arrow's HSEMS.

4.7 Marine Water Quality and Sediment

The section describes Arrow Energy's approach to managing impacts to existing marine water and sediment quality from project activities.

4.7.1 Existing Environment and Environmental Values

Port Curtis is located directly offshore from Gladstone within the greater Port of Gladstone. The region includes areas of high conservation values: Curtis Island and the majority of Port Curtis are within the Great Barrier Reef World Heritage Area, and are adjacent to the Great Barrier Reef Marine Park. Port Curtis is also listed as a nationally important wetland in Queensland (Figure 4.1).

The Calliope River drains into Port Curtis, as do the Boyne River, Boat Creek and Auckland and South Trees inlets. To the south are the connected waterways of Colosseum Inlet, Seven Mile Creek and Rodds Bay. Northwards, Grahams Creek and a number of smaller tributaries discharge to The Narrows (Water Resource (Calliope River Basin) Plan 2006).

Water

Within Port Curtis, levels of total phosphorus, chlorophyll a, dissolved oxygen and turbidity exceed water quality guideline criteria in some places. There are also some exceedences of water quality guideline criteria for pH, however these levels are within the EHP reported long term averages. Concentrations of metals are also higher for Port Curtis than for oceanic seawater, with exceedences of copper, zinc and cobalt. Concentrations of aluminium and iron in Port Curtis can be significantly higher than those for oceanic seawater, and concentrations of other major elements (e.g., manganese, fluoride, boron) appear to be consistent with concentrations present in oceanic seawater.

Within the Calliope River, levels of total nitrogen, TOC, filtered reactive phosphorus and turbidity exceed water quality guideline criteria in some places. There are also some exceedences of water quality guideline criteria for chlorophyll-a; however these levels are within the EHP reported long term averages. Concentrations of metals in the Calliope River are generally low.

Overall, concentrations of metals and turbidity in Port Curtis have increased over time. It is likely this can be attributed to resuspension of metal bound sediments in the water column, due to increased shipping traffic and dredging activities. Concentrations of aluminium reported are not considered an issue as the pH is generally not conducive to the unbinding of metals.

Sediment

From the sediment sampling for the EIS and SREIS, arsenic was found to be elevated in three samples. The NAGD guidelines recognise that sediments in Australia commonly have high levels of naturally occurring arsenic compounds. Chromium and nickel concentrations in Port Curtis are naturally elevated (but did not exceed guidelines), but concentrations of other metals, polychlorinated biphenyl, polycyclic aromatic hydrocarbon, pesticides and tributyltin were not found to be elevated. No apparent trend exists in the location or depth of the occurrence of metals in sediments, and it is likely that the presence of metals may be naturally occurring i.e., metals were found to occur at depths which have not been influenced by anthropogenic activities.

coffey environments	Date: 13.12.2011 MXT: 7033CA_07_GIS036_v1_6 File Name: 7033_EMP_F04.01_GIS_GL	Arrow Energy Arrow LNG Plant	arrow energy go further	Regional context	Figure No: 4.1

Within Calliope River sediments, polycyclic aromatic hydrocarbon, organochloride and organophosphate pesticides have not been found and organic carbon content is generally very low. Metal concentrations are not elevated, with the exception of one case of Arsenic, which is likely to be naturally occurring.

4.7.2 Potential Impacts

Potential impacts on marine water quality and sediment from project construction, operation, and decommissioning are described below:

- Construction. Numerous construction activities could impact on water quality in Port Curtis.
  - Dredging to support the construction of marine facilities at the mainland launch site, Curtis Island LNG jetty and Curtis Island MOF and personnel jetty will cause plumes of suspended sediment to form in the water column and subsequent deposition of material on the seafloor. Modelling shows that the rate of plume deposition to the seafloor is greatest at the dredge location (i.e., 1 mm/d) and reduces with distance. Much of this material will be re-dredged and taken onboard the dredging vessel as areas are dredged to required water depths.
  - The large number of vessel movements during construction means small amounts of some substances (e.g., diesel fuel, oils) may be spilled on deck and subsequently washed overboard with local contamination of receiving waters.
  - Pile driving during the construction of the mainland launch site, MOF and LNG jetty may disturb seafloor sediments and cause plumes of suspended sediment to form in the water column.
  - Dewatering of tunnel spoil (which may include acid sulfate soils) during construction of the feed gas pipeline Port Curtis tunnel crossing will require excess water to be discharged to Port Curtis at the tunnel launch site.
  - Discharge to Port Curtis of hydrostatic test water used to test the feed gas pipeline and LNG tanks may impact marine water quality and sediments, particularly if biocides or oxygen scavengers are added to the water during testing. The volumes of hydrostatic test water to be discharged to Port Curtis via the Boatshed Point outfall pipeline have been revised. For three LNG tanks with 180,000 m^3 capacity, the worst-case total test volume to be used has been estimated at 360,000 m^3. Actual volumes will be less than 360,000 m^3 and the final volume, discharge rate and discharge location will be developed during detailed design.
  - If the sewer mains installed by GRC are not used as an option for the disposal of effluent, the discharge of treated sewage generated at the construction camp during stage 1 construction into Port Curtis offshore of Boatshed Point may impact water quality by releasing nutrients and pathogenic organisms to the environment.
  - Propeller wash from vessels navigating shallow waters may disturb seafloor sediments and cause plumes of suspended sediment to form.
- Operations. Numerous operational activities could impact on water quality in Port Curtis.
  - Maintenance dredging is likely to be required in the Calliope River to maintain access to launch site 1 with similar impacts to construction dredging although of a smaller scale.

– If the GAWB water supply is not used, or is inadequate to meet demand and the reverse osmosis desalination plant option is taken forwards, brine discharged into Port Curtis off Boatshed Point will locally increase salinity at and around the point of discharge. If the GRC installed sewer mains are not used, this discharge may also include process water and under circumstances exceeding design (e.g., extreme rainfall events), treated effluent from the LNG plant sewage treatment plant. Modelling shows that water quality criteria will be achieved within 10 m from the point of discharge. The preferred option is to use the installed sewer mains which will be sufficient to meet peak construction demands for both the LNG plant and construction camp, and not impact on marine water quality in Port Curtis.

– Vessel movements during operations may result in the spillage of small amounts of hazardous substances into Port Curtis, causing local contamination of receiving waters.

4.7.3 Marine Water Quality and Sediment Management

Arrow Energy will adopt appropriate mitigation and management measures to address potential impacts on marine water quality and sediment from the project.

Management measures for all project-related activities from design and planning through to decommissioning are found in Table 4.7.

Table 4.7 Marine water quality and sediment management

Element/issue	Potential for project activities to impact on marine water and sediment quality.
Environmental and social objective(s)	• To avoid and reduce potential adverse effects on marine water and sediment quality resulting from the project during design, construction and operation. • To achieve project water quality and sediment quality objectives during construction and operations. Note that Arrow is committed to establishing project water quality criteria that are based on the existing baseline water quality of relevant locations within Port Curtis. • To identify mitigation strategies to reduce any adverse effects on water quality and sediment quality environmental values to an acceptable level.
Performance criteria	• Compliance with relevant water quality criteria.
Implementation strategy (planning and design)	• If an RO plant is adopted, the design of the brine discharge outfall from the LNG Plant will include a three-port diffuser at the end of the pipeline located close to the water surface (or the ports angled towards the surface) to maximise dilution of the negatively buoyant discharge stream. [C16.01A] • Obtain sediment samples from geotechnical drill cores to further characterise marine sediments disturbed during construction. Use the results to inform the development of the dredge management plan. [C16.02] • Develop a dredge management plan that considers the appropriate water and sediment monitoring data (e.g., current WBDD Project data) and will include: [15.02] – Requirements for monitoring of water quality. [15.03] – Actions to be taken to minimise impacts of dredging on sensitive areas should water quality monitoring data show performance criteria are exceeded. Finalise specific actions in the dredge management plan. [15.04] Common with Section 4.6.3, Coastal Processes, and Section 4.10.3, Marine Ecology.

Table 4.7 Marine water quality and sediment management (cont'd)

Implementation strategy (construction and operations)	• Prior to discharge to Port Curtis, test and treat excess water at the mainland tunnel launch site in an onsite water treatment plant to meet water quality criteria. [C16.03] • Test and treat all discharges to Port Curtis to meet water quality criteria, as required, prior to discharge. [C16.04] • Develop spill response plans to cover marine activities, including all vessel operations. [C16.05] • Refuel vessels in designated areas where spill response kits are located. [C16.06] • Train all relevant personnel in spill response and recovery procedures. [C13.13A] Common with Section 4.4.3, Surface Water Hydrology and Water Quality, and Section 4.22.3, Waste Management. • Limit activities on vessels that may cause spillages to the deck to areas where deck water can be routed to and passed through oil/water separators (to meet water quality criteria) before discharge overboard. [C16.07] • Store solvents and other oil-based or flammable materials in accordance with applicable Queensland regulations. [C16.08] • Maintain a minimum practical inventory of hazardous materials on board vessels. [C16.09] • Store on board wastes produced by vessels that cannot be discharged under the MARPOL Convention and then transfer to an approved onshore facility for treatment, reuse, recycling or disposal. [C16.10] • Where practical, schedule the timing of maintenance dredging to coincide with the most favourable climatic conditions for minimising impacts to water quality and sediment (i.e., during neap tides when water currents are weakest or periods of calm winds and waves). [C16.11] • Source hydrostatic test water from Port Curtis, the town water supply or from fresh water generated in the reverse osmosis plant. Test and treat water to meet water quality criteria as necessary prior to discharge to Port Curtis. [C16.12] • Develop water quality criteria in consultation with the regulator that reflect existing water quality conditions in the receiving environment, and implement these criteria through the conditioning process associated with statutory approvals such as the dredge management plan and specific environmental authorities. [C16.14]
Implementation strategy (decommissioning)	• Develop a detailed decommissioning plan for the site to include procedures and methods for managing effluent during decommissioning. [C16.13]
Inspection and monitoring	• Include inspection and monitoring activities in the dredge management plan. • Specify in the dredge management plan, water quality and marine ecology monitoring requirements including those to assess the impact of dredging in the Calliope River. • Perform periodic marine water quality monitoring to establish water quality both inside and outside the mixing zone in Port Curtis, and for compliance with the water quality criteria at the mixing zone boundary. • Participate in the ongoing Port Curtis Integrated Monitoring Program (PCIMP) water quality monitoring studies.
Auditing	Undertake internal audits as both scheduled and unscheduled activities for implementation of agreed measures and compliance with performance criteria. Conduct regular internal audits throughout the life of the project and spot audits during ad hoc site visits. Undertake external audits when required to evaluate compliance with environment authority conditions and Arrow's HSEMS.

Table 4.7 Marine water quality and sediment management (cont'd)

Reporting	Ensure reporting reflects government requirements of the project approval and is undertaken in accordance with Arrow's HSEMS requirements set out in Section 3.5 of this Strategic EMP.
Corrective action	Undertake corrective actions in accordance with the outcomes of incident investigations, audits, monitoring results or advice given by the relevant regulatory authority in accordance with Arrow's HSEMS.

4.8 Terrestrial Ecology

This section describes Arrow Energy's approach to managing potential environmental impacts on terrestrial ecology associated with project activities.

4.8.1 Existing Environmental Values

The project area is located within the Southeast Queensland bioregion, which possesses a high diversity of habitats and associated flora and fauna species with high rates of endemism and substantial numbers of conservation listed species (GHD, 2009b).

Widespread disturbance of flora and fauna values in the Gladstone region has led to notable weed invasion which has impacted on native flora and fauna diversity.

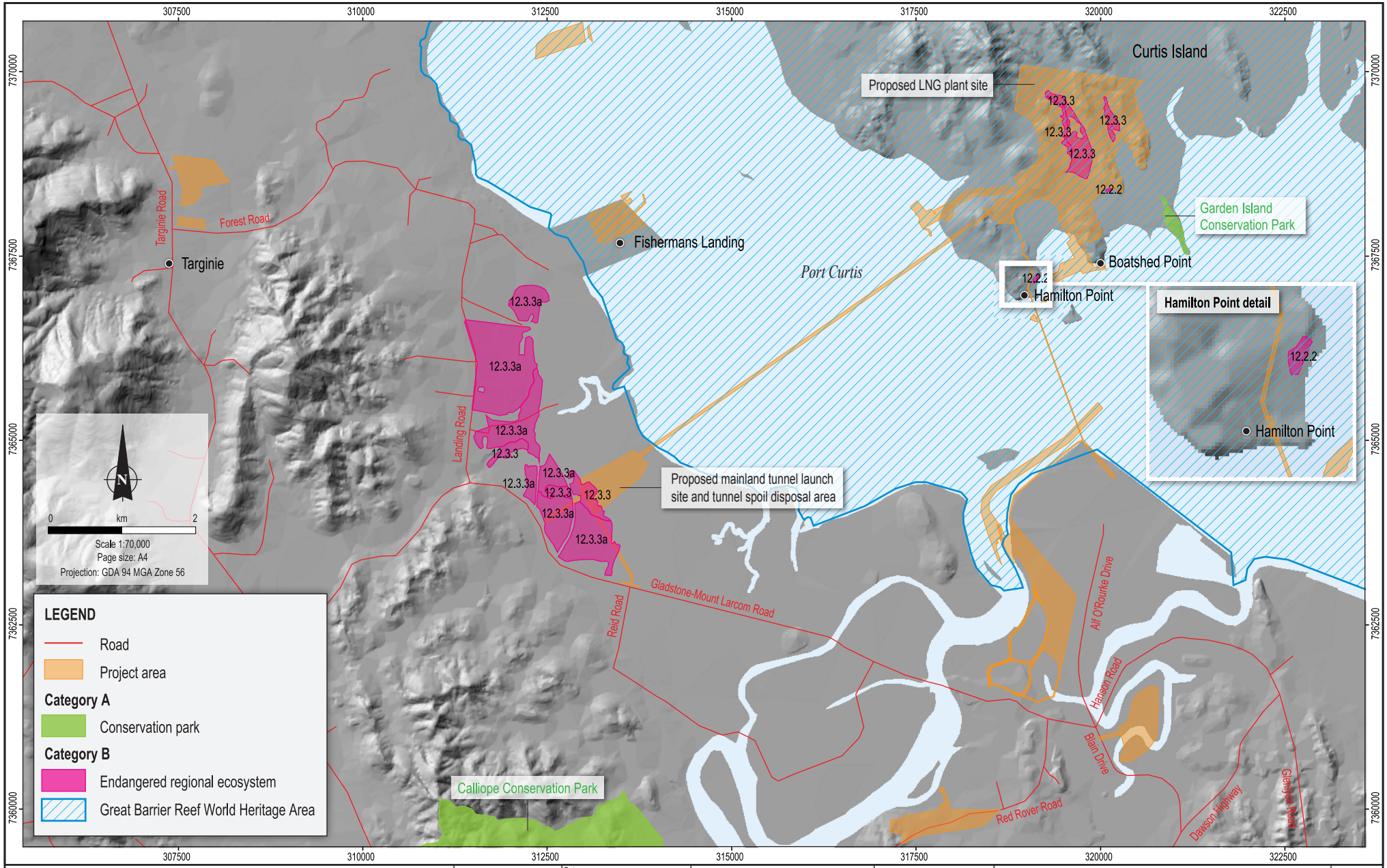
The Environmental Protection Regulation 2008 (Qld) classifies environmentally sensitive areas (ESAs) based on a ranking of environmental sensitivity (Figure 4.2). Category A and Category B ESAs present within the project area of the Arrow LNG Plant are as presented in Table 4.8 below. The only ESAs present within the project area, relate to the Great Barrier Reef World Heritage Area, and areas of 'endangered' RE.

Table 4.8 Environmentally sensitive areas present in the Arrow LNG Plant project area

Environmentally Sensitive Area (ESA)	Area to be Cleared (ha)
The Great Barrier Reef World Heritage Area (Category B).	430.7 (including marine infrastructure)
Endangered regional ecosystem RE 12.3.3 (Category B).	37.73
Endangered (biodiversity status) regional ecosystem RE 12.2.2 (Category B).	0

The key ecological values of the terrestrial ecology study area established for the EIS and SREIS include the following:

Threatened Flora Communities. One ecological community listed as 'threatened' under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act) was located within the study area, the Littoral Rainforest and Coastal Vine Thickets of Eastern Australia ('critically endangered'). The presence of this community was confirmed on the eastern side of Hamilton Point in field surveys. A broad beach ridge was also identified to the northeast of Boatshed Point. There are two small patches of vine thicket at the eastern end of the beach ridge, and being associated with a dune system, these are consistent with the EPBC Act listed threatened ecological community.



Source:
Place names and roads from DME.
Project area and hillshade from Coffey Environments.
Endangered regional ecosystems from Ecosure and 3D Environmental.
Conservation parks from DERM. World Heritage Area from DEWHA.

coffey environments

Date: 12.12.2012
MXD: 7033CC_16_GIS050_v1_1
File Name: 7033_EMP_F04.02_GIS_GL

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Arrow LNG Plant

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Environmentally sensitive areas in proximity to the Arrow LNG Plant project area

Figure No: 4.2

Vegetation communities listed as 'endangered' under the Vegetation Management Act 1999 (Qld) confirmed as being present within the study area include RE 12.2.2 (microphyll-notophyll vine forest on beach ridges) and RE12.3.3 (Eucalyptus tereticornis woodland to open forest on alluvial plains).

Conservation listed flora species. Database searches for the EIS and SREIS indicated potential for 37 species with a conservation status under the EPBC Act or Nature Conservation (Wildlife) Regulation 2006 (Qld) to occur within the study area. None of the species identified in database searches were found during the field surveys for either the EIS or SREIS, and review of the databases indicated that none were likely to be found in the project area based on habitat requirements or known range.

An extract of the latest Queensland herbarium floristic records from a 100 km buffer around the study area indicate that C. shirleyana is no longer recognised in the project area or surrounds. The specimen submitted from Boatshed Point during the EIS has also formally been recognised as an undescribed species (Cupaniopsis sp.). A previous extract from a similar area in late 2011 identified several specimens of C. shirleyana, although these have all been reclassified as the same undescribed species in the latest extract. Hence, C. shirleyana has no further relevance to the project and the specimens on Boatshed Point are to be treated as an undescribed species of Cupaniopsis.

The following plant species found in the study area are at the limit of their distributional range and of local significance:

- Capparis ornans, Crotalaria brevis, Durabaculum undulatum, Ehretia grahamii, Melaleuca fluviatilis and Rhamnella viensis - all at the southern limit of their distribution.
- *Graptophyllum spinigerum* and *Rhysotoechia bifoliata* - at the northern limit of their distribution.
- *Macrozamia miquellii* - endemic to the Port Curtis pastoral district.

Fauna species. Field surveys conducted for the EIS and SREIS recorded 191 terrestrial fauna species, with database searches identifying 54 species of conservation status under the EPBC Act or Nature Conservation (Wildlife) Regulation as potentially being present within the study area.

Further refinement of the search results based on known range, likelihood of occurrence and habitat preferences identified that a large number of these species were unlikely to be present with the Arrow LNG Plant project area.

Twelve species from the database searches were assessed as potentially occurring within the project area either due to the presence of large areas of suitable habitat, or being recorded as part of surveys for the Arrow LNG Plant or other studies:

- Brigalow scaly-foot *Paradelma orientalis*
- Black-necked stork *Ephippiorhynchus asiaticus*
- Grey goshawk *Accipiter novaehollandiae*
- Square-tailed kite *Lophoictinia isura*
- Squatter pigeon *Geophaps scripta scripta*
- Glossy black cockatoo *Calyptorhynchus lathami*
- Powerful owl *Ninox strenua*

- Little pied bat *Chalinolobus pictatus*
- Grey-headed flying-fox *Pteropus poliocephalus*
- Koala *Phascolarctos cinerus*
- Northern quoll *Dasyurus hallucatus*
- Water mouse *Xeromys myoides*

Detailed dossiers were produced for these species with black-necked stork and water mouse known to occur in the project area, and grey goshawk, square-tailed kite, squatter pigeon and powerful owl expected to occur.

Fifty two species classed as migratory under the EPBC Act were identified in the database searches as potentially occurring within the study area. The majority of these species are wetland birds (terns, egrets and waders) found in various intertidal areas around Port Curtis. Field surveys recorded seven migratory and five non-migratory species of shorebird during August and September 2012. These species included the beach stone-curlew and the eastern curlew, both listed as 'vulnerable' under Nature Conservation (Wildlife) Regulation. All counts were well below thresholds of national and international significance with the exception of eastern curlew, which met national significance criteria at Clinton ash ponds in September 2012. The surveys are due to conclude in March 2013.

Essential habitat for a number of species occurs within the project area. At the Red Rover Road site, habitat made up of RE 12.3.3 is mapped by DERM (now EHP) as being essential habitat for koala. There do not appear to be any local records of this species, and this species is highly unlikely to occur at this site. No RE 12.3.3 was located at the Red Rover Road site during the flora survey when REs were ground truthed. The site was dominated by RE 12.11.6.

At the mainland tunnel launch site, essential habitat for koala (RE 12.3.3) and little pied bat (RE 11.3.29, 12.3.3) is mapped. While no records for either species occur within the project area, records of little pied bats occur within 1 km to the north. However it is considered unlikely that either species is present.

At TWAF 7, areas of vegetation adjacent to, and within the site are mapped as essential habitat for Lewin's rail (*Rallus pectoralis*). The area is not the preferred freshwater and associated grassland habitat of the species and it is likely that a transient individual was recorded while in the area.

TWAF 8 does not contain any essential habitat. Koala essential habitat is located approximately 500 m to the east and coastal sheathtail bat *(Taphozous australis)* approximately 200 m to the east. Coastal sheathtail bat is unlikely to frequent the area.

Pest species. Field surveys recorded 56 introduced plant species within the study area. Three species are recognised as Weeds of National Significance:

- Rubber vine (*Cryptostegia grandiflora*).
- Common lantana (*Lantana camara var. camara*).
- Salvinia (*Salvinia molesta*).

The common prickly pear (*Opuntia stricta*) was also found on Curtis Island, at Boatshed Point and the LNG plant site, and many others were observed in the wider region.

Ecological surveys identified two pest fauna species, cane toad (*Rhinella marina*) and the wild dog (*Canis familiaris*) declared under the *Land Protection (Pest and Stock Route Management) Act 2002* (Qld) or as a key threatening process under the EPBC Act. Feral pig (*Sus scrofa*) is also known to be a major pest species on Curtis Island.

4.8.2 Potential Impacts

Key impacts on terrestrial ecology relate to activities associated with construction and operation and include:

- Vegetation will be cleared from the project area on Curtis Island as well as from project sites on the mainland leading to habitat loss and fragmentation, with a loss of connectivity between habitats. Risks of pest introduction and spread will also increase in these areas.
- The LNG plant and ancillary facilities have been repositioned during design to largely avoid removal of vegetation from a small area of vine thicket at Boatshed Point (on Curtis Island) that contains a new species of tuckeroo (Cupaniopsis sp. indet).
- Approximately 40 ha of the endangered vegetation community, RE 12.3.3 (Eucalyptus tereticornis (forest red gum) woodland to open forest on alluvial plains), occurs at the Arrow Energy LNG plant site on Curtis Island and at the mainland tunnel launch site and will be cleared for construction.

  The patches of critically endangered littoral vine thicket, RE 12.2.2 (microphyll/notophyll vine forest on beach ridges) northeast of Boatshed Point, and the community on Hamilton Point will not be cleared as they are avoided and/or the site layout will be revised in detailed design to ensure they are avoided.

  At a bioregion level, clearance is minor, typically less than 0.1% of the extent of the regional ecosystem within the bioregion. The exceptions to this are RE 12.1.2 (saltpan vegetation including grassland, herbland and sedgeland on marine clay plains) and RE 12.11.7 (Eucalyptus crebra woodland on metamorphics and interbedded volcanics) which are both less than 0.2% of the extent of the regional ecosystem within the bioregion; and RE 12.11.14 (Eucalyptus crebra, Eucaplyptus tereticornis woodland on metamorphics ± interbedded volcanics) which totals 0.35% of the extent of this regional ecosystem within the bioregion.
- Migratory birds frequenting the project area may be disturbed by lighting, noise and vehicle and personnel movement, especially during construction in areas adjacent to the mainland tunnel entry shaft and tunnel disposal area. The majority of these species are migratory shorebirds which use the mudflats for feeding, and nearby mangroves for roosting. Measures will be implemented during construction to manage disturbance to birds from noise and light. The nearest shorebird roost is over 1 km to the southeast of the mainland tunnel entry shaft, while the mudflats themselves lie adjacent to a major shorebird feeding site. This site will be shielded to some extent from construction works by intervening mangroves.
- Although project activities generally avoid mangrove areas, construction will require approximately 5.5 ha of mangrove on Curtis Island to be removed. Loss of this area is likely to result in loss of habitat for the water mouse; and it may create a movement barrier and increase isolation of local populations. Evidence of a water mouse population was identified on Curtis Island to the east and west of Boatshed Point. Habitat at mainland sites was assessed as sub-optimal.

An estimate of the regulated vegetation to be cleared in the project area, including area (ha) is set out in Table 4.9.

Table 4.9 Regulated vegetation to be cleared within the Arrow LNG Plant project area

Regional Ecosystem	Area Cleared Within Project Area (ha)						Total Arrow LNG Plant Clearance (base case) (ha)	Total Arrow LNG Plant Clearance (alternative case) (ha)	Area of Regional Ecosystem to be Cleared as a Proportion of that Available Within the Bioregion (%) (based on base or alternative case, whichever greatest)
	MTLS	TWAF 8	RRR	LS1	CI	TWAF 7			
RE 11.3.4 *Eucalyptus tereticornis* and/or *Eucalyptus* sp. tall woodland on alluvial plains (OC).	-	23.91	-	-	-	-	-	23.91	0.01
RE 12.1.2 Saltpan vegetation including grassland, herbland and sedgeland on marine clay plains (LC).	32.5	-	-	4.5	17.49	0.52	55.01	49.99	0.19
RE 12.1.3 Mangrove shrubland to low closed forest on marine clay plains and estuaries (LC).	-	-	0.61	2.01	2.48	0.21	4.7	3.09	0.01
RE 12.11.14 *Eucalyptus crebra*, *Eucalyptus tereticornis* woodland on metamorphics ± interbedded volcanics (OC).	-	-	-	-	74.74	-	74.74	74.74	0.25
RE 12.11.4 Semi-evergreen vine thicket on metamorphics ± interbedded volcanics (OC).	-	-	-	-	0.66	-	0.66	0.66	0.02
RE 12.11.6 *Corymbia citriodora*, *Eucalyptus crebra* open forest on metamorphics ± interbedded volcanics (LC).	-	-	22.71	-	68.14	-	68.14	90.85	0.04
RE 12.11.7 *Eucalyptus crebra* woodland on metamorphics +/- interbedded volcanics (LC).	-	-	-	-	59.45	-	59.45	59.45	0.19

Table 4.9 Regulated vegetation to be cleared within the Arrow LNG Plant project area (cont'd)

Regional Ecosystem	Area Cleared Within Project Area (ha)						Total Arrow LNG Plant Clearance (base case) (ha)	Total Arrow LNG Plant Clearance (alternative case) (ha)	Area of Regional Ecosystem to be Cleared as a Proportion of that Available Within the Bioregion (%) (based on base or alternative case, whichever greatest)
	MTLS	TWAF 8	RRR	LS1	CI	TWAF 7			
RE 12.2.11 Corymbia spp., Eucalyptus spp., Acacia spp. open forest to low closed forest on beach ridges in northern half of bioregion (LC).	-	-	-	-	0.47	-	0.47	0.47	<0.01
RE 12.3.3 *Eucalyptus tereticornis* woodland to open forest on alluvial plains (E).	7.87	-	-	-	29.86	-	37.73	37.73	0.09
RE 12.3.6 *Melaleuca quinquenervia*, *Eucalyptus tereticornis*, *Lophostemon suaveolens* woodland on coastal alluvial plains (LC).	-	-	-	-	2.62	-	2.62	2.62	0.02
RE 12.3.7 *Eucalyptus tereticornis*, *Melaleuca viminalis*, *Casuarina cunninghamiana* fringing forest (LC).	-	-	0.59	-	-	-	-	0.59	<0.01

MTLS = mainland tunnel launch site, RRR = Red Rover Road site, LS1 = launch site 1, CI = Curtis Island. Clearance as a proportion of the bioregion following Accad (2008).

Regional Ecosystem (Status under VMA) – E = Endangered, OC = Of Concern, LC = Least Concern.

4.8.3 Terrestrial Ecology Management

Arrow Energy will adopt appropriate mitigation and management measures to address potential impacts on terrestrial ecology from the project.

Management measures for all project related activities from design and planning through to decommissioning are found in Table 4.10.

Table 4.10 Terrestrial ecology management

Element/issue	Potential for all activities to impact on terrestrial ecology values.
Environmental objectives	• To avoid or reduce the adverse effects on terrestrial ecology values during project construction, operation and decommissioning. • To protect terrestrial ecology and associated biodiversity of state and national significance. • To prevent the introduction and spread of new or existing weeds or plant and animal pathogens. • To avoid or reduce the direct loss of terrestrial habitat and achieve a net gain biodiversity offset.
Performance criteria	• No removal of vegetation within protected areas / no-go areas. • No reported instances of unauthorised clearing or disturbance of listed flora species or threatened communities. • Implementation of an approved offset plan and compliance with reporting conditions of the plan. • Compliance with the Queensland Government Environmental Offsets Policy. • Evidence of implementation of translocation and relocation programs.
Implementation strategy (planning and design)	• Prepare construction and operations environmental management plans. These documents are to include detailed information about significant flora and fauna species and their management and ongoing conservation. Include site-specific mitigation and details of monitoring and inspection to be undertaken, in the environmental management plans consistent with advice provided by government. [C17.01] • Develop an Environmental Offsets Operational Management Plan that addresses terrestrial and marine offset requirements in consultation with relevant government stakeholders prior to commencement of construction. The plan will provide details on offset options and opportunities, and details on how the offset meets relevant policies and how it will be managed over the life of the offset. [C17.02A] Common with Section 4.10.3, Marine Ecology. • An area of semi-evergreen vine thicket community (containing the *Cupaniopsis* vegetation community) will be retained by the project on Boatshed Point. This area will be demarcated prior to the commencement of construction and workers and machinery will be prohibited from accessing the area. The boundary of the semi-evergreen vine thicket community to be retained will be fenced off with a 20-m buffer between the semi-evergreen vine thicket community *(*including the *Cupaniopsis* vegetation community) and the fence and area of disturbance. The retained vine thicket area is designed to protect a viable semi-evergreen vine thicket vegetation community and a viable population of *Cupaniopsis* sp. indet. on Boatshed Point. Do not develop within the fenced area of the retained semi-evergreen vine thicket community. Establish roles and responsibilities for the management of the retained semi-evergreen vine thicket community. [C17.03A] • A wildlife corridor of 20 m will be established on the eastern side of Boatshed Point to maintain connectivity between the semi-evergreen vine thicket community and the environmental management precinct. [C17.04]

Table 4.10 Terrestrial ecology management (cont'd)

Implementation strategy (planning and design) (cont'd)	• Design TWAF 8 to minimise disturbance to the of concern RE 11.3.4 ('*Eucalyptus tereticornis* and/or Eucalyptus spp. tall woodland on alluvial plains') to maintain connectivity of habitat along the Targinie Creek riparian zone. [C13.04] Common with Section 4.4.3, Surface Water Hydrology and Water Quality, and Section 4.9.3, Freshwater Ecology. • Where practical, align the perimeter fence at TWAF 8 to adopt the alignment of the existing fence where it crosses Targinie Creek. [C13.05] Common with Section 4.4.3, Surface Water Hydrology and Water Quality, and Section 4.9.3, Freshwater Ecology. • Design any intra-site access road crossing of Targinie Creek at TWAF 8 to include box culverts (or similar) to enable fauna movement under the road and along the wildlife corridor. [C13.06] Common with Section 4.4.3, Surface Water Hydrology and Water Quality, and Section 4.9.3, Freshwater Ecology. • Develop requirements for ecological watching briefs/wildlife spotter-catchers as well as procedures for addressing ecological issues as they arise during construction, operation and rehabilitation works. [C17.06] • Develop fauna relocation protocols as part of fauna management measures including procedures if fauna is found during clearing activities, including in hollows of trees to be felled.[C17.07] • Prepare a fauna management plan for the project. [C17.08] • Develop weed management measures prior to initiation of construction activities in accordance with local and regional management guidelines and best practice advice prescribed in DNRM's pest control factsheet series. [C17.09] • Liaise with Biosecurity Queensland and Gladstone Regional Council on project biosecurity and pest management programs. Notify Gladstone Regional Council of any new declared or notifiable pest species. These programs should particularly focus on the boundaries of the project site with the Environmental Management Precinct. [C17.10] • Develop and implement a mosquito management plan prior to construction that includes measures to control the occurrence of stagnant pools of water on the site especially after rainfall. [C17.11] • Develop and implement washdown strategies and procedures to prevent the spread of weeds. [C17.12] • Include measures in the pest management plan to control invasive plant species that may colonise the mudflats and degrade remaining habitat. [C17.13] • Prior to initiation of works, clearly mark access tracks to prevent secondary tracks becoming established. Use existing access tracks where practical. Where practical, the location and design of access tracks should avoid sites of high ecological value. [C17.14] • Locate construction equipment, laydown areas, turn-around areas, stockpiles and working areas within areas of existing disturbance where practical. [C17.15] • Implement measures to reduce the impacts of light from the LNG plant and ancillary facilities including: – Shield/direct the light source onto work areas where practical, and avoid light spill on to habitat areas (such as mangroves and Clinton ash ponds) where practical. [C17.16A] Common with Section 4.10.3, Marine and Estuarine Ecology, and Section 4.14.3, Landscape and Visual. – Use long-wavelength lights, where practical, including use of red, orange or yellow lights. [C17.17] Common with section 4.10.3, Marine and Estuarine Ecology. – Lower the height of the light sources as far as practical. [C17.18] Common with section 4.10.3, Marine and Estuarine Ecology.

Table 4.10 Terrestrial ecology management (cont'd)

Implementation strategy (planning and design) (cont'd)	– Avoid planned routine maintenance flaring at night during sensitive turtle-reproductive periods (where practical). [C17.19] Common with section 4.10.3, Marine and Estuarine Ecology. • Design lighting around the perimeter of the LNG plant to minimise impacts on roosting shorebirds, where practical. Lowest possible luminescent globes should be used in sensitive areas, particularly around intertidal zones, where practical. [C17.20] • Design construction lighting on the causeway at the mainland tunnel entry shaft and tunnel spoil disposal area to minimise impacts on roosting shorebirds. The lowest possible luminescent globes should be used in sensitive areas, particularly around intertidal areas, where practical. [C17.21] • Induct all personnel prior to entering a project site, including on measures for managing the impacts on flora and fauna likely to be present. [C17.22] Common with Section 4.9.3, Freshwater Ecology.
Implementation strategy (construction and operations)	• Clearly mark no go zones, where required, including the semi-evergreen vine thicket (*Cupaniopsis*) fenced area on Boatshed Point and the critically endangered EPBC Act listed vine thicket communities on the eastern margin of Hamilton Point and northeast of Boatshed Point. Signage will be erected around the margins of the communities to indicate restricted access. [C17.23A] • Prohibit access to the saltpans and fringing mangroves (RE 12.1.2 and 12.1.3) outside the planned area of disturbance of the mainland tunnel entry shaft and tunnel spoil disposal area. [C17.24] • Conduct preclearance surveys across project areas to be cleared of vegetation. The surveys will aim to determine whether any threatened species are present at each site. Appropriate mitigation measures will be implemented if threatened species are confirmed within the area. [C17.25] • Reduce vegetation clearing where practical and only after all other options such as selective clearing and trimming of vegetation have been considered. [C17.27] • Clearly mark trees for retention to avoid accidental clearing and develop clearance procedures prior to construction. The root zone should be adequately protected. [C17.28] • In areas where trees are planned to be left in place, take care to minimise damage to surrounding trees when felling trees into cleared areas or in natural slots between retained trees. [C17.29] • Inspect plants, soil, fill and any other such materials to be used in construction/rehabilitation works prior to entry to site. If supplied from within the fire-ant restricted area, these materials must be accompanied by a movement certificate or fire-ant declaration form. This also applies for the yellow crazy ant. [C17.30] • Prohibit pets of staff and contractors from entering the project area (unless assistance animals). [C17.31] • Adopt waste control measures to avoid introducing new external seed sources for exotic flora. [C17.32] • Prohibit hunting and trapping unless required for pest management. [C17.33] • Undertake all handling and management of fauna in compliance with permits issued by DERM. [C17.34] • Develop measures to prevent fauna entrapment and implement prior to construction where practical (e.g., the use of pipe caps if piping stored at ground level, string pipes with gaps for wildlife access). [C17.35]

Table 4.10 Terrestrial ecology management (cont'd)

Implementation strategy (construction and operations) (cont'd)	• Develop trench management procedures to prevent access of fauna into trenches. These procedures will include measures such as trench breakers and covers. In addition, inspection procedures will be established in order to remove trapped fauna, create protection and refuge areas for wildlife trapped in the trench and develop methods to assist trapped fauna left in the trench. [C17.36A] • Prohibit construction and operation activities within 'field' areas that are outside of the construction area of disturbance, i.e., areas exposed to bushfire fuels, during days of total fire ban. [C17.37] • Protect the EPBC Act listed community northeast of Boatshed Point and employ low impact methods of weed control within and adjacent to EPBC Act listed communities. [C17.40] • Establish a management buffer of suitable width and of contiguous natural vegetation, around the EPBC Act listed community northeast of Boatshed Point to minimise the potential for edge effects and limit the potential for weed invasion. The buffer will be defined in the Wildlife Corridor Management Plan to be developed prior to construction. [C17.41] • Implement fire control measures to prevent wildfire incursion into the EPBC Act listed communities. This may include construction of firebreaks or asset protection burning outside of the community and its associated buffer. [C17.42] • Detail the need to protect EPBC Act listed communities and explain mitigation measures that are to be implemented in workforce inductions. [C17.43] • Clearly delineate clearing boundaries to avoid unnecessary vegetation loss. [C17.44] • Where practical, stock-pile cleared vegetation in 'wind-rows' around the edge of retained vegetation. In addition to providing shelter, this will also provide some physical barrier reducing edge impact severity and the risk of weed spread. [C17.45] • Minimise the duration trenches are open, ensure daily trench inspections are undertaken by suitably qualified spotter/catchers and ensure that the length of open trench does not exceed that which can be inspected by the available spotter/catchers in any one daily period. [C17.46] Consider measures to minimise light emitted from the LNG plant during the detailed design of the LNG plant including: • Assess the necessity and choice of lighting in the plant area: – Use low-pressure sodium (LPS) lights as a first-choice light source and high-pressure sodium (HPS) lights where LPS is not practical. – Replace short-wavelength light with long-wavelength light and exclude short-wavelength light with the use of filters. – Avoid using halogen, metal halide or fluorescent lights (white lights) where possible, and only use white lights in contained areas where colour rendition is required. – Minimise the number and wattage of lights, and recess lighting into structures where possible. • Use timers and motion-activated light switches. • Use reflective materials to delineate equipment or pathways and use embedded lighting for roads. • Position doors and windows on the sides of buildings facing away from marine turtle nesting beaches and install and use window coverings to reduce light emissions. • Maintain elevated horizons (such as topographic features, vegetation or barriers) to screen rookery beaches from light sources. [C17.47] Common with Section 4.10.3, Marine Ecology.

Table 4.10 Terrestrial ecology management (cont'd)

Implementation strategy (construction and operations) (cont'd)	• If koalas are found during wet season surveys to be undertaken in early 2013 or pre-clearance surveys, develop and implement appropriate mitigations in the species management plan which could include fauna spotter/catchers, limiting vehicle speed limits and habitat rehabilitation.[C17.48]
	• Design infrastructure to reduce impacts on shoreline habitat, where possible, and reduce the risk of unnecessary clearing by demarcating disturbance areas prior to the disturbance commencing. [C17.49] • Reduce lighting wherever possible, in locations where movement between water mouse foraging and nesting habitats (e.g., between mangroves and the supralittoral zone) occurs. [C17.50] • Review the need for an ongoing program to monitor the shorebird population at project sites following the completion of survey work in 2013. [C17.51] • Develop measures to minimise disturbance around important shorebird habitat, during construction and operation. Measures could include exclusion zones or screens as recommended in Rohweder et al., (2011). [C17.52]
Implementation strategy (decommissioning)	• Identify areas to be rehabilitated and develop procedures for restoration and maintenance. [C17.38] • Rehabilitate construction access tracks not required for operations. [C17.39]
Inspection and Monitoring	• Undertake a monitoring regime for the retained area of semi evergreen vine thicket community (Cupaniopsis) on Boatshed Point and the RE 12.2.2 community on Hamilton Point (if the Hamilton Point South MOF is selected) to provide early indication of any degradation in these areas. Monitoring may not be required at RE 12.2.2 if the western haul road option is taken forward. Requirements may change and will be dependent upon the outcomes of Cupaniopsis sp. indet identification. • Inspect areas of cleared vegetation that have been restored post construction to establish the success of rehabilitation. • Develop a detailed site environmental monitoring program will be developed to assess the effectiveness of rehabilitation efforts at the site as part of the decommissioning and rehabilitation management plan. • Develop trench inspection procedures to remove trapped fauna. For pipelines and other activities requiring excavation of long trenches, establish protection and refuge areas for wildlife trapped in the trench.
Auditing	Undertake internal audits as both scheduled and unscheduled activities for implementation of agreed measures and compliance with performance criteria. Conduct regular internal audits throughout the life of the project and spot audits during ad hoc site visits. Undertake external audits when required to evaluate compliance with environment authority conditions and Arrow's HSEMS.
Reporting	Ensure reporting reflects government requirements of the project approval and is undertaken in accordance with Arrow's HSEMS requirements set out in Section 3.5 of this Strategic EMP.
Corrective action	Undertake corrective actions in accordance with the outcomes of incident investigations, audits, monitoring results or advice given by the relevant regulatory authority in accordance with Arrow's HSEMS.

4.9 Freshwater Ecology

This section describes Arrow Energy's approach to managing potential environmental impacts on the ecology of freshwater environments within and surrounding the Arrow LNG Plant.

4.9.1 Existing Environment and Environmental Values

Freshwater ecosystems within the study area include the Calliope River, Larcom Creek, Boat Creek, and numerous minor tributaries of these waterways. There are also numerous small first and second order ephemeral streams. Only a limited number of small farm dams exist and there are no permanent freshwater wetlands, and very few permanent pools. Aquatic habitat within the study area is therefore of very marginal value on a local or regional scale with the majority of waterways providing minimal, low value aquatic habitat with limited connectivity to permanent waterbodies.

Watercourses predominantly consist of lower order ephemeral systems. Systems such as Larcom Creek contain a variety of habitats which are likely to act as temporary refugia during the dry season for aquatic species and a corridor for movement of aquatic species from further upstream. Permanent water is known to occur at Mosquito Creek and Boat Creek.

There are no watercourses on Curtis Island within the vicinity of the LNG plant site, and EHP and DAFF advised that the drainage features in the project area on Curtis Island are not watercourses as defined by the Water Act 2000 (Qld) or DAFF internal guidance. Systems in the vicinity of the LNG plant site consist of a number of predominantly dry poorly defined drainage channels, which carry overland flow during and immediately after rainfall events.

No aquatic flora listed as threatened under the EPBC Act or the Nature Conservation Act was identified within the study area.

Four introduced aquatic flora species were observed, none of which are listed under the Land Protection (Pest and Stock Route Management) Act. The aquatic weed hymenachne (*Hymenachne aplexicaulis*) observed approximately 7 km northwest of TWAF8, represents a range extension for the species and must be considered in weed management plans developed for the project.

No freshwater species listed under the EPBC Act or Nature Conservation Act were identified within the study area. Species such as the water mouse (*Xeromys myoides*) and saltwater crocodile (*Crocodylus porosus*) that are linked to freshwater aquatic ecosystems, but not solely confined to these systems, were identified.

The introduced species, mosquitofish (*Gambusia holbrooki*), was found during project field surveys. Although not listed under the Land Protection (Pest and Stock Route Management) Act, it is known to dominate many habitats where it is introduced, leading to a decline in native fish and frog diversity.

4.9.2 Potential Impacts

The project will not abstract water and no effluent will be discharged directly to freshwater streams on either the mainland or Curtis Island. The only waterway crossing that may be required is of ephemeral streams at TWAF 8 by service pipelines, security fences and access tracks, with

limited associated works. Some riparian vegetation may be lost at crossing sites along this stream, which is part of a corridor through which wildlife pass. The area cleared at crossings will be limited and actions taken to reduce the potential for eroded soils and any contaminants to enter this waterway during construction.

On Curtis Island, the construction of the LNG plant will remove drainage systems that currently pass though the site. Drainage will be diverted west of LNG plant site (an option for diversion to the east is being retained).

4.9.3 Freshwater Ecology Management

Arrow Energy will adopt appropriate mitigation and management measures to address potential impacts on freshwater ecology from the project.

Management measures for all project activities from design and planning through to decommissioning are found in Table 4.11.

Table 4.11 Freshwater ecology management

Element/issue	Potential for all activities to impact on freshwater ecology values.
Environmental and social objectives	• To avoid or reduce the adverse effects on freshwater aquatic ecology values during project construction, operation and decommissioning. • To protect freshwater ecology and associated biodiversity of state and national conservation significance. • To avoid or reduce the loss of aquatic habitat. • To avoid or reduce the potential for adverse effects from sedimentation or contamination from construction, operation and decommissioning activities on watercourses. • To prevent the introduction or spread of new or existing aquatic weeds or plant and animal pathogens. • To avoid or reduce disruption to flow regime as far as practical and to maintain, as far as practical, fish passage through watercourses. • To avoid abstraction of freshwater for project uses, where practical.
Performance criteria	• Compliance with water quality objectives, no permanent impact to waterway geomorphology as a result of project activities. • No unauthorised release of contaminants directly or indirectly into watercourses. • No reported instances of infestations of new or existing exotic aquatic flora or fauna species. • No removal of aquatic or riparian vegetation within protected areas / no-go areas. • Compliance with the Queensland Government Environmental Offsets Policy. • The site contains no long term environmental hazards.
Implementation strategy (planning and design)	• Design TWAF 8 to minimise disturbance to the of concern RE 11.3.4 (‘*Eucalyptus tereticornis* and/or *Eucalyptus* spp. tall woodland on alluvial plains’) to maintain connectivity of habitat along the Targinie Creek riparian zone. [C13.04] Common with Section 4.4.3, Surface Water Hydrology and Water Quality, and Section 4.8.3, Terrestrial Ecology. • Where practical, align the perimeter fence at TWAF 8 to adopt the alignment of the existing fence where it crosses Targinie Creek. [C13.05] Common with Section 4.4.3, Surface Water Hydrology and Water Quality, and Section 4.8.3, Terrestrial Ecology.

Table 4.11 Freshwater ecology management (cont'd)

Implementation strategy (planning and design) (cont'd)	• Design any intra-site access road crossing of Targinie Creek at TWAF 8 to include box culverts (or similar) to enable fauna movement under the road and along the wildlife corridor. [C13.06] Common with Section 4.4.3, Surface Water Hydrology and Water Quality and Section 4.8.3, Terrestrial Ecology.
Implementation strategy (construction and operations)	• Implement strategies and protocols relevant to the protection of freshwater aquatic communities, habitat and processes, as detailed in the Australian Pipeline Industry Association's code of environmental practice for onshore pipelines (APIA, 2009) as part of the project. [C18.01] • Keep the footprint of the mainland tunnel entry shaft and tunnel spoil disposal area to a minimum of 500 m clear of Boat Creek. [C13.07] Common with section 4.4.3, Surface Water Hydrology and Water Quality. • Induct all personnel prior to entering a project site, including on measures for managing the impacts on flora and fauna likely to be present. [C17.22] Common with Section 4.8.3, Terrestrial Ecology. • Where works are required in watercourses, they will be confined to reduced width construction right of ways that preserve, to the extent practical, the integrity of the riparian vegetation and any associated wildlife corridors. [C13.22] Common with Section 4.4.3, Surface Water Hydrology and Water Quality. • Limit the clearing of riparian vegetation to that necessary for safety. [C18.02] • Where waterway crossings are necessary, cross ephemeral streams in preference to permanent streams, where practical. Where pipeline waterway crossings are necessary, approach stream crossings perpendicular to the stream where practical, to reduce bank erosion risk and minimise the footprint within the bed and riparian zone. [C13.16] Common with Section 4.4.3, Surface Water Hydrology and Water Quality. •Avoid works near stream banks during periods of heavy rainfall where practical. If works cannot be timed to avoid heavy rainfall, adopt additional measures, such as the use of berms and silt fences. [C11.09] Common with section 4.2.3, Geology, Landform and Soils, and section 4.4.3, Surface Water Hydrology and Water Quality. • Prevent staff and contractors from camping, fishing or carrying out other recreational activities in waterways in the project area while on shift, to prevent the accidental introduction of aquatic pest species on fishing gear or bait. [18.03] • Undertake earthworks and rehabilitation activities to facilitate drainage and reduce the potential for standing water to accumulate. [C13.20] Common with Section 4.4.3, Surface Water Hydrology and Water Quality. • Avoid discharging tail water from the tunnel spoil disposal area into Boat Creek. [C13.21] Common with Section 4.4.3, Surface Water Hydrology and Water Quality. • Define and adhere to machinery hygiene protocols to prevent the translocation of pest species, particularly weeds such as salvinia, cumbungi and para grass. • Do not abstract freshwater from watercourses, or dispose of effluent directly into freshwater watercourses, except clean stormwater. [C13.15] Common with section 4.4.3, Surface Water Hydrology and Water Quality and section 4.8.3, Terrestrial Ecology.
Inspections and monitoring	Likely inspection and monitoring activities during construction: • Inspect for exotic flora and fauna species within the project area of disturbance and immediately adjacent areas. • Inspect erosion and sediment control measures following significant rainfall events until ground stabilisation is achieved. • Inspect spill containment controls and spill response kits. • Develop a detailed site environmental monitoring program and document in the construction and operations EMPs.

Table 4.11 Freshwater ecology management (cont'd)

Auditing	Undertake internal audits as both scheduled and unscheduled activities for implementation of agreed measures and compliance with performance criteria. Conduct regular internal audits throughout the life of the project and spot audits during ad hoc site visits. Undertake external audits when required to evaluate compliance with environment authority conditions and Arrow's HSEMS.
Reporting	Ensure reporting reflects government requirements of the project approval and is undertaken in accordance with Arrow's HSEMS requirements set out in Section 3.5 of this Strategic EMP.
Corrective action	Undertake corrective actions in accordance with the outcomes of incident investigations, audits, monitoring results or advice given by the relevant regulatory authority in accordance with Arrow's HSEMS.

4.10 Marine and Estuarine Ecology

This section describes Arrow Energy's approach to managing potential environmental impacts on marine and estuarine ecology associated with project activities.

4.10.1 Existing Environment and Environmental Values

The Arrow LNG Plant is located within the Great Barrier Reef World Heritage Area (GBRWHA) and adjacent to the Great Barrier Reef Marine Park (GBRMP). Port Curtis is included in the list of nationally important wetlands in Queensland, and areas in and around Port Curtis provide important habitat for a range of species listed under the EPBC Act and IUCN red list of threatened species (IUCN, 2010).

Physical Environment and Habitat Zoning

A range of physical environments exist within the Port Curtis region, which support and provide habitat for significant biodiversity. These include:

- Benthic Zone within Port Curtis. This supports an array of small and microscopic organisms both on and below the surface of the sediments.
- Reef and Rock Substrate. These areas support a broad range of organisms including bivalves, ascidians, bryozoans, hard corals, scallops, mixed reef communities, algal flora, barnacles, oysters and tubeworms.
- Intertidal Mudflats. These support a high biodiversity and biomass of benthic species and fisheries productivity and act as a feeding ground for migratory birds.

Flora

Saltmarsh, mangroves and seagrass beds are found in Port Curtis and provide important habitat for fauna species. Saltmarsh species include halophytic (salt tolerant) grasses such as salt couch (*Sporobolus virginicus*) and saltmarsh species such as the bead weed (*Sarcocornia quiniqueflora*). Mangrove species recorded in Port Curtis include:

- Red mangrove (Rhizophora stylosa).
- Yellow mangrove (Ceriops tagal).

- Grey or white mangrove (Avicennia marina).
- Myrtle mangrove (Osbornia octodonta).
- Black or river mangrove (Aegiceras corniculatum).

Areas of saltmarsh and mangrove within the project area are classified as regional ecosystems of least concern within the Southeast Queensland bioregion under the Vegetation Management Regulation. Seagrass beds are protected under the Great Barrier Reef Marine Park Act 1975 (Cwlth) and all marine plants are protected under the Fisheries Act 1994 (Qld).

Fauna

Port Curtis and its surrounding waters support a large marine fauna population, including the following species listed under the EPBC Act and the IUCN Red List:

- Dugong (*Dugong dugon*). This species is listed as a protected migratory species under the EPBC Act and as a vulnerable species by IUCN and the Nature Conservation Act. Large populations (14,000 individuals) have been observed within the GBRMP, and their presence has contributed to the area being listed as World Heritage Area. Port Curtis and its adjacent waters have also been declared as part of the Port of Gladstone-Rodds Bay Zone B dugong protection area under the Great Barrier Reef Marine Park Regulations 1983.
- Marine turtles. The flatback turtle (*Natator depressus*), green turtle (*Chelonia mydas*), loggerhead turtle (*Caretta caretta*), hawsbill turtle (*Eretmochelys imbricata*), olive ridley turtle (*Lepidochelys olivacea*) and leatherback turtle (*Dermochelys coriacea*) are thought to occur or have the potential to occur within Port Curtis. All of these species are listed as vulnerable or endangered under the EPBC Act and Nature Conservation Act, and as vulnerable, endangered or data deficient by the IUCN.
- Cetaceans. Thirteen species of cetaceans (i.e., whales, dolphins and porpoises) have known ranges that include the waters of Port Curtis. Of these, ten species are listed under the IUCN Red List. Their listing ranges from ‘least concern’ to ‘near threatened’ and ‘endangered’. Cetaceans most likely to be found regularly within Port Curtis are the Australian snubfin dolphin (*Orcaella heinsohni*) and the Indo-Pacific humpback dolphin (*Sousa chinensis*). Both species are listed on the IUCN Red List as near threatened.
- Fish and shellfish. The estuarine waters around Port Curtis provide spawning, nursing and feeding areas for many recreationally and commercially important fish species.
- Sea snakes. Twelve species of sea snake listed under the EPBC Act have been identified as having a known range which includes the study area and the surrounding region.
- Saltwater crocodile (*Crocodylus porosus*). Protected under the EPBC Act, this species is listed as vulnerable under the schedules of the Nature Conservation (Wildlife) Regulation. While no saltwater crocodiles were identified in field surveys for the project, previous surveys in the region have recorded 434 non-hatchling crocodiles, approximately 10% of the Queensland crocodile population.
- Seahorses and pipefish. Selected species of syngnathid fish (seahorses and pipefish) are listed under the EPBC Act. They have an indicative range which extends into Port Curtis and surrounding regions which was verified during environmental surveys.
- Macrobenthic communities and plankton. Macrobenthic communities have local importance with community total abundance and species evenness similar within the study area and the

wider Port Curtis area. Molluscs (*Mactra abbreviata*), crustaceans (*Corophium cf. Acutum*, and *Ogyrides delli*) and annelid worms (*Glycera sp.* and *Eunice vittata*) are the most abundant of the species within Port Curtis. Plankton have local importance given that many organisms undergo larval life-cycle processes and support ecosystems in Port Curtis.

- Introduced species and pest species. Ten introduced species have previously been recorded in Port Curtis, none of which are recognised as pests. As it is part of the GBRWHA, Port Curtis has a very high sensitivity to introduced or pest species.

4.10.2 Potential Impacts

Impacts are applicable throughout the project area and largely relate to construction and operations activities. Key impacts include:

- Loss and disturbance of marine and estuarine habitat from project infrastructure. Marine and estuarine habitat (such as mangrove, seagrass and saltmarsh vegetation) will be directly removed or buried by the introduction of project infrastructure. Adjacent areas will be affected by the lateral spread of construction-induced increases in turbidity (e.g., from dredging) and by sedimentation from construction equipment outside the footprint area.
- Direct disturbance of marine and estuarine fauna. Key impacts include:
  - Boat strike. Vessel activity in Port Curtis and the Queensland coast may lead to the injury and mortality to marine and estuarine fauna of conservation significance. Most vessels within Port Curtis operate in shallow coastal waters; habitats where dugongs, turtles and cetaceans are commonly found.
  - Underwater noise. Intense human-generated underwater sounds from activities such as seismic surveys and pile driving have the potential to interfere with the behaviour of marine fauna, particularly marine mammals that communicate and/or navigate using sound. Other effects could include damage to swim bladders of fish and mortality to benthic plankton and invertebrates.
  - Lighting. Artificial light could modify natural illumination and cause disruption to visual cues of marine organisms and, in particular, disorientate marine turtles and affect the behaviour of nesting adults and emerging hatchlings.
- Loss of local marine communities from introduced species and pests. LNG carriers servicing the LNG plant and other vessels originating from overseas ports have the potential to introduce pest species through their ballast water. If the pest species is invasive and rapidly increases in population, native and endemic communities could be compromised.
- Displacement or mortality of flora and fauna from shipping activities and accidents. A spillage or discharge of oil, chemicals, sewage, grey or black water and ballast water could occur as LNG carriers travel through the GBRMP and surrounding waters. They also have the potential to generate garbage and collide, ground, anchor or sink in the park. These impacts could displace, smother or lead to the mortality of marine flora and fauna and alter or cause physical damage to habitats.

4.10.3 Marine and Estuarine Ecology Management

Arrow Energy will adopt appropriate mitigation and management measures to address potential marine and estuarine ecology impacts from the project.

Management measures for all project related activities are found in Table 4.12.

Table 4.12 Marine and estuarine ecology management

Element/issue	Potential for all activities to impact on marine and estuarine ecology values.
Environmental and social objectives	• To avoid or reduce potential adverse effects resulting from the project on marine and estuarine ecology, including benthic habitats, pelagic species and migratory cetaceans and marine turtles. • To prevent the introduction and spread of marine pest species.
Performance criteria	• Evidence of measures in place to minimise habitat loss and fauna mortality. • No reported injury or mortality of dugongs, turtles or cetaceans from marine vessel activity associated with the project. • Compliance with the Queensland Government Environmental Offsets Policy. • No reported introductions of exotic or pest species as a result of the project. • No unauthorised release of contaminants directly or indirectly into the marine environment. • Evidence of measures being adopted on site to reduce lighting impacts.
Implementation strategy (planning and design)	• Develop a construction environmental management plan, which contains specific mitigation measures, performance indicators and management actions required to reduce impacts to the marine and estuarine ecological values. [C19.01A] • Develop an Environmental Offsets Operational Management Plan that addresses terrestrial and marine offset requirements in consultation with relevant government stakeholders prior to commencement of construction. The plan will provide details on offset options and opportunities, and details on how the offset meets relevant policies and how it will be managed over the life of the offset. [C17.02A] Common with Section 4.10.3, Marine Ecology. Common with Section 4.10.3, Terrestrial Ecology. • Implement measures to reduce the impacts of light from the LNG plant and ancillary facilities including: – Shield/direct the light source onto work areas, where practical, and avoid light spill on to habitat areas (such as mangroves and Clinton ash ponds) where practical. [C17.16A] Common with Section 4.8.3, Terrestrial Ecology, and Section 4.14.3, Landscape and Visual. – Use long-wavelength lights, where practical, including use of red, orange or yellow lights. [C17.17] Common with Section 4.8.3, Terrestrial Ecology. – Lower the height of the light sources as far as practical. [C17.18] Common with Section 4.8.3, Terrestrial Ecology. – Avoid routine planned maintenance flaring at night during sensitive turtle-reproductive periods (where practical). [C17.19] Common with Section 4.8.3, Terrestrial Ecology. • Develop a dredge management plan that considers the appropriate water and sediment monitoring data (e.g., current WBDD Project data) and will include: [C15.02] – Requirements for monitoring of water quality. [C15.03] – Actions to be taken to minimise impacts of dredging on sensitive areas should water quality monitoring data show performance criteria are exceeded. Finalise specific actions in the dredge management plan. [C15.04] Common with Section 4.6.3, Coastal Processes and Hydrodynamics, and Section 4.7.3, Marine Water Quality and Sediment. • Comply with environmental and legal criteria of the Queensland Government environmental offsets policy as the overarching framework for a specific-issue offset policy. [C19.03]

Table 4.12 Marine and estuarine ecology management (cont'd)

Implementation strategy (construction and operations)	• Contribute to the development of a Port of Gladstone shipping activity strategy and management plan. Comply with all applicable speed limits for the the Port of Gladstone-Rodds Bay Zone B dugong protection area as detailed in the management plan. [C19.04] • Install (where feasible) propeller guards (or equivalent) on high-speed vessels to reduce the impact of injury in the event of a boat strike. [C19.05] • Implement soft-start procedures where a sequential build-up of warning pulses will be carried out prior to commencement of full-power pile-driving activities. [C19.06] Common with Section 4.13.3, Noise and Vibration • Undertake fauna observations prior to and during pile-driving and dredging activities to check for the presence of marine turtles, dugongs and cetaceans. Should fauna be spotted within the area of the works, implement procedures to minimise impact, such as reverting to soft-start piling or stopping temporarily to allow animals to move away from the area. [C19.07] • Keep dredging activities within the identified dredge footprint area. [C19.08] • Maintain a fauna-spotting function (where practical) during dredging activities. Do not commence dredging if marine mammals, turtles or crocodiles are spotted within the area of dredging, and stop temporarily if fauna is spotted within the area of the dredge head. In both cases, resumption of dredging must wait until fauna has moved away. [C19.09] • Project vessels servicing the LNG plant that originate from overseas ports must comply with Commonwealth and local government ballast water management systems and implement Australian Quarantine and Inspection Service hull hygiene measures. [C19.10] • All project vessels must comply with all applicable maritime law, especially when passing through the GBRMP. Project vessels will traverse the marine park via designated navigation routes with pilotage as required within port boundaries. [C19.11] • Establish a system for the recording of opportunistic observation of marine megafauna (turtles, salt-water crocodiles, dugong and cetaceans) spotted during marine operations such as dredging, pile driving and marine transport including where these activities occur within the Calliope River. [C19.12] Common with Section 4.13.3, Noise and Vibration. • Evaluate the use of bubble curtains for each method of piling, and deploy where they are demonstrated to be effective in aiding the rapid attenuation of underwater noise and deterring marine fauna from approaching, or remaining at, pile driving sites. [C19.13] Common with Section 4.13.3, Noise and Vibration. Consider measures to minimise light emitted from the LNG plant during the detailed design of the LNG plant including: • Assess the necessity and choice of lighting in the plant area: – Use low-pressure sodium (LPS) lights as a first-choice light source and high-pressure sodium (HPS) lights where LPS is not practical. – Replace short-wavelength light with long-wavelength light and exclude short-wavelength light with the use of filters. – Avoid using halogen, metal halide or fluorescent lights (white lights) where possible, and only use white lights in contained areas where colour rendition is required. – Minimise the number and wattage of lights, and recess lighting into structures where possible. • Use timers and motion-activated light switches. • Use reflective materials to delineate equipment or pathways and use embedded lighting for roads.

Table 4.12 Marine and estuarine ecology management (cont'd)

Implementation strategy (construction and operations) (cont'd)	• Position doors and windows on the sides of buildings facing away from marine turtle nesting beaches and install and use window coverings to reduce light emissions. • Maintain elevated horizons (such as topographic features, vegetation or barriers) to screen rookery beaches from light sources. [C17.47] Common with Section 4.8.3, Terrestrial Ecology. • A light mitigation plan for construction and operation will be developed and will include specific light management and reduction measures and a commitment to routine light audits. [C19.14] • Arrow Energy will participate in monitoring programs established to assess the impact of current and future industrial lighting in the Gladstone region on hatchlings emerging on the beaches of Curtis and Facing islands. [C19.15]
Inspection and monitoring	Detail the inspection and monitoring procedures to be applied during construction in relevant management plans for the project (including a construction management plan, marine offsets management strategy, dredge management plan, rehabilitation management plan and shipping activity management plan), including: • Periodic monitoring of any habitat replaced as a part of the offset strategy. • Contributing to existing long term monitoring of turtle nesting. • Contributing to Port Curtis-wide monitoring of seagrass habitats. • Statutory water quality monitoring of turbidity thresholds. • Monitoring compliance with ballast water management requirements and hull hygiene measures. • Keeping records of any potential impacts to listed marine fauna from boat strike or noise during construction.
Auditing	Undertake internal audits as both scheduled and unscheduled activities for implementation of agreed measures and compliance with performance criteria. Conduct regular internal audits throughout the life of the project and spot audits during ad hoc site visits. Undertake external audits when required to evaluate compliance with environment authority conditions and Arrow's HSEMS.
Reporting	Ensure reporting reflects government requirements of the project approval and is undertaken in accordance with Arrow's HSEMS requirements set out in Section 3.5 of this Strategic EMP.
Corrective action	Undertake corrective actions in accordance with the outcomes of incident investigations, audits, monitoring results or advice given by the relevant regulatory authority in accordance with Arrow's HSEMS.

4.11 Greenhouse Gas

This section describes Arrow Energy's approach to managing greenhouse gas emissions during project construction, operations and decommissioning.

4.11.1 Existing Environment and Environmental Values

The global greenhouse emissions associated with the consumption of fossil fuels for 2009 (the most recent data available under current Kyoto Protocol accounting provisions) is presented in Table 4.13, along with Australia's energy sector and Queensland's total emissions.

Table 4.13 Australian and global estimates of greenhouse gas emissions

Geographic Area	Source Coverage	Timescale	Emissions per annum (Mt CO2-e/annum)
Global[a]	Consumption of fossil fuels.	2009	30,086
Australia[b]	Energy sector.	2009	420.3
Queensland[c]	Total GHG emissions including land use, land use change and forestry.	2009	155.1

[a]United Nations Statistics Division (UNSD, 2012), millennium development goals indicators: carbon dioxide emissions (CO2), thousand metric tonnes of CO2 (collected by Carbon Dioxide Information Analysis Centre).

[b]DCC (2009) - Energy sector includes stationary energy, transport and fugitive emissions.

[c]DCC (2009) - Emissions including land use change.

Australia's greenhouse gas emissions increased by 9.3% between 1990 and 2007. The largest increase was in the energy sector, with emissions increasing by 42.5% between 1990 and 2007. Queensland has the highest per capita greenhouse gas emissions of all Australian states.

4.11.2 Potential Impacts

The project will contribute to total greenhouse gas emissions in the region, Australia and worldwide. The maximum predicted emissions during operation predicted greenhouse gas CO2-e emissions for the project were equivalent to 0.016% of 2009 global emissions for the worst-case operational year; and the potential impacts associated with climate change directly attributable to the project are negligible.

The maximum level of greenhouse gas emissions from the operation of Arrow LNG Plant have been estimated to be 4.7 Mt CO2-e/annum (excluding start-up flaring). This represents 1.1% of the Australian Government's 2009 energy sector emissions.

4.11.3 Greenhouse Gas Emissions Management

Arrow Energy will adopt appropriate mitigation and management measures to address potential impacts of greenhouse gas emissions from the project.

Management measures for all project-related activities from design and planning through to decommissioning are found in Table 4.14.

Table 4.14 Greenhouse gas emissions management

Element/issue	Contribution to greenhouse gas emissions during construction and operation.
Environmental and social objectives	• To estimate the greenhouse gas emissions resulting from the construction and operation of the Arrow LNG Plant. • To identify methods to economically minimise greenhouse gas emissions associated with construction and operation of the Arrow LNG Plant.
Performance criteria	Measures to reduce greenhouse gas emissions are regularly reviewed.
Implementation strategy (planning, design and construction)	• Develop and implement a greenhouse gas standard as part of Arrow's HSEMS. [C20.01] • Identify and consider measures to reduce emissions intensity and improve the energy efficiency of the different project components throughout the design process. [C20.02] • Minimise greenhouse gas emissions through the progressive clearing of areas and implement rehabilitation as soon as practical. [C20.03]

Table 4.14 Greenhouse gas emissions management (cont'd)

Inspection and monitoring	Monitor the effectiveness of greenhouse gas emission measures adopted as a part of Arrow's HSEMS.
Auditing	Undertake internal audits as both scheduled and unscheduled activities for implementation of agreed measures and compliance with performance criteria. Undertake external audits when required to evaluate compliance with environment authority conditions and Arrow's HSEMS.
Reporting	Report on annual greenhouse gas emissions and energy consumption/production from the project as required under the NGER Act and Energy Efficiency Opportunities program, as well as future carbon price mechanisms.
Corrective action	Undertake corrective actions in accordance with the outcomes of incident investigations, audits, monitoring results or advice given by the relevant regulatory authority in accordance with Arrow's HSEMS.

4.12 Air Quality

This section describes Arrow Energy's approach to managing potential environmental impacts on air quality at the project site and at sensitive receptors.

4.12.1 Environmental Values

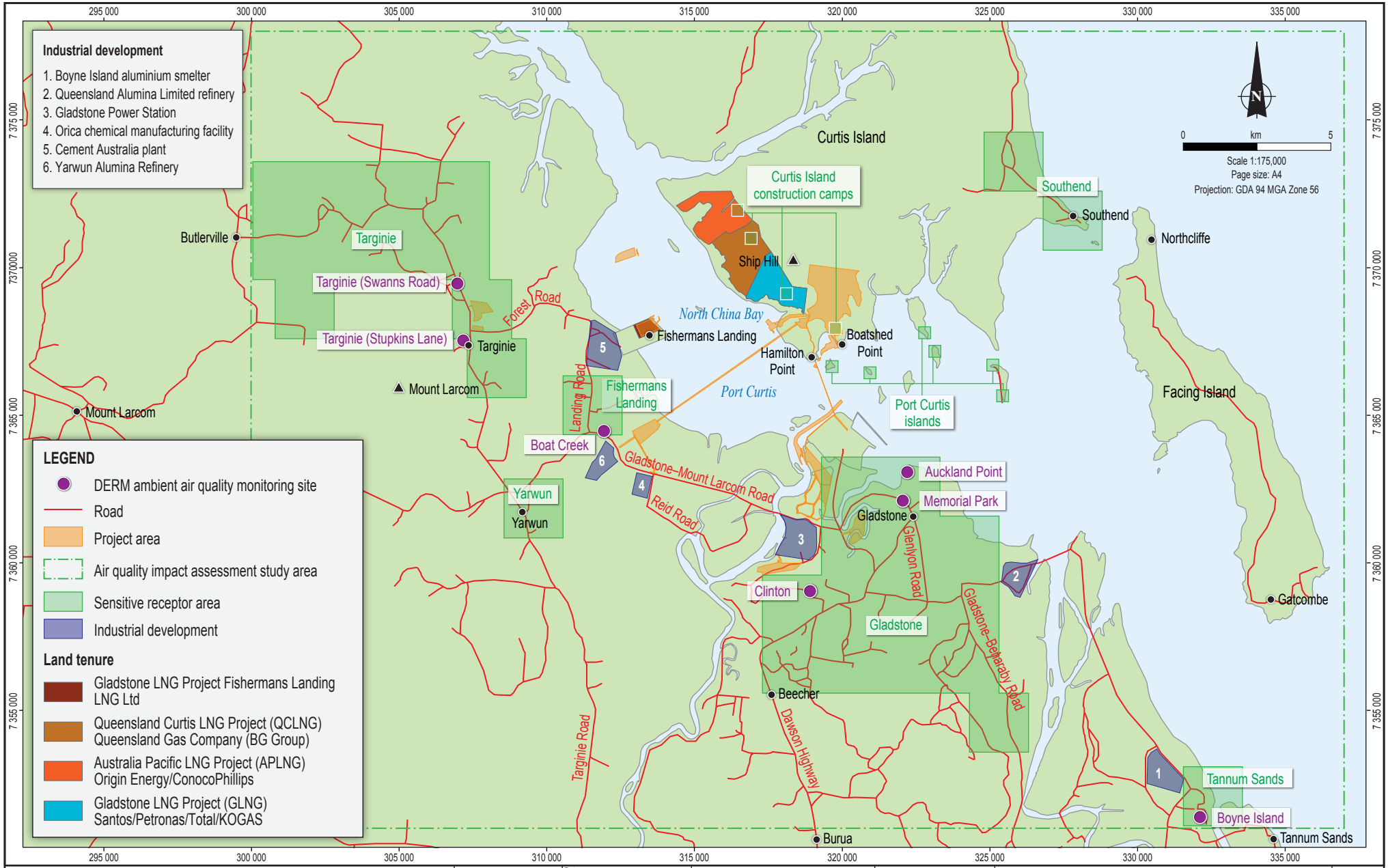
Gladstone is a major industrial centre with numerous chemical and mineral processing facilities currently operating in the region, all of which emit pollutants to the atmosphere and influence the overall quality of air within the region. Emissions include nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), particles as PM10, particles as PM2.5 and volatile organic compounds (VOCs). Other sources of NO_2 and SO_2 in the region include heavy vehicles, machinery and shipping, and sources of dust include bushfires, landfills, transport of raw materials, exposed areas of land, construction activities and traffic.

The wind climate at the LNG plant site provides for relatively good dispersion conditions for emissions sources. The prevailing southeasterly winds at the site will transport emission plumes away from Gladstone and winds likely to carry emissions towards the city occur very infrequently.

EHP operates a network of ambient air quality monitoring stations in the Gladstone region. Data from the monitoring stations was used to establish the baseline air quality conditions in the air quality impact assessment study area.

Sensitive receptor areas close to the LNG plant site include residences and community facilities located on the mainland and Curtis Island as well as residences on islands in Port Curtis. These sensitive receptor locations and DERM monitoring locations are shown in Figure 4.3.

Baseline levels of NO_2 are high in some locations in the study area due to the background effects of existing industry. The Gladstone Airshed Modelling System (GAMS) provides an indication of background pollutant levels, and includes emissions from other existing and proposed industries. Without the inclusion of emissions relating to the Arrow LNG Plant, the GAMS background model indicates an exceedence of air quality criteria in the Gladstone sensitive receptor location.



Source:
Place names and roads from DME.
Ambient air quality monitoring sites from DERM.
Sensitive receptor areas and existing industry from Katestone.
Project area and LNG proponents from Coffey Environments.
Coastline from GBRMPA.

coffey environments

Date: 10.12.2012
MXD: 7033CC_16_GIS122_v1_1
File Name: 7033_EMP_F04.03_GIS_GL

Arrow Energy

Arrow LNG Plant

arrow energy go further

Air quality monitoring locations and sensitive receptor areas

Figure No: 4.3

4.12.2 Potential Impacts

This section describes impacts to air quality during project construction, commissioning, operations and decommissioning.

Construction and Commissioning

Emissions to the atmosphere during the construction period will consist of fugitive dust generated during earthworks (due to vegetation and soil removal and wind erosion of exposed surfaces, soil stockpiles and spoil), together with exhaust emissions from construction vehicles and earthmoving equipment, operation of a concrete batching plant and minor emissions from welding fumes. These sources will temporarily increase the local concentrations of airborne particulate matter and combustion gases.

Compared to operations, combustion gas emission rates during construction are low and short-term in duration and generation of fugitive dust will largely be restricted to site.

Disposal of feed gases via the flare system will be required during commissioning of the LNG plant. Flare emissions during these activities will produce fewer emissions to the atmosphere than those occurring during non-routine flaring events which are assessed below.

Operations

The major pollutants produced during operations are oxides of nitrogen (NO_x) as NO_2 from gas turbine generator emissions from the LNG plant and SO_2 from LNG carriers and tugs used to assist these vessels. Emissions to the atmosphere associated with equipment, materials and personnel transfer at the materials offloading facility and personnel jetty and mainland launch site are relatively minor, and have therefore not been assessed. Table 4.15 summarises all air pollutant compounds emitted to the atmosphere during routine operations and non-routine events, along with their sources. Those which can cause odours are acetaldehyde, NO_2, formaldehyde, toluene, benzene and SO_2.

Table 4.15 Routine operations and non-routine events air pollutants and emission sources

Pollutant source	Pollutant compound
Routine operations	
30 MW gas turbine generators 100 MW gas turbine drives Flare pilot	NO_x, CO, PM_{10}, $PM_{2.5}$, 1,3-butadiene, acetaldehyde, acrolein, benzene, ethylbenzene, formaldehyde, toluene, xylene.
LNG carriers and tug boats	NO_x, SO_2, CO, PM_{10}, $PM_{2.5}$, benzene, ethylbenzene, formaldehyde, toluene, xylene, dioxins and furans.
Non-routine events	
Flare	NO_x, CO, methane, acetylene, ethane, ethylene, propane, propylene.

Emissions during routine operations and those that occur infrequently due to non-routine events can adversely affect air quality environmental values (i.e., the health and biodiversity of ecosystems, human health and wellbeing, aesthetics and agricultural use), particularly if air quality criteria are exceeded in sensitive receptor areas. However results from dispersion

modelling for NO_2, SO_2 and CO, PM10 and PM2.5 during routine operations predict that levels will not exceed criteria within any sensitive receptor areas for the Arrow LNG Plant, except for where the background levels already exceed the criteria. At this location, the exceedence is attributed to existing industrial activity, and the contribution of the Arrow LNG Plant to air quality impacts is negligible. Expected ozone levels and odour concentrations are also not expected to exceed air quality criteria at any of the sensitive receptor areas.

Particulate emissions are not expected to occur during non-routine flaring events and have not been assessed because of their short-term nature.

Decommissioning and Rehabilitation

Emissions to the atmosphere during decommissioning will be similar in type and duration as those occurring during construction activities i.e., generation of fugitive dust and gaseous exhaust emissions resulting in temporary localised elevations in concentrations of airborne particulate matter and combustion gases.

Combustion gas emission rates during decommissioning activities will be low and short-term in duration when compared to operations emissions. The generation of fugitive dust will largely be restricted to project sites.

4.12.3 Air Quality Management

Management and mitigation measures will be adopted to ensure compliance with air quality criteria at sensitive receptor areas.

The primary mitigation measure has been the identification of opportunities to maximise the distance of project development from sensitive receptors to avoid impacts. However where avoidance is not possible, measures to minimise and manage impacts are proposed.

Table 4.16 provides a summary of the appropriate environmental management measures for the project to minimise or avoid potential impact on the environmental qualities of the existing environment.

Table 4.16 Air Quality management

Element/issue	Potential for all activities to impact on air quality values.
Environmental and social objectives	• To avoid or reduce potential adverse effects on air quality in sensitive receptor areas during project construction and operations. • To achieve project air quality objectives (with acknowledgement of baseline conditions) during construction and operations. • To identify mitigation strategies to reduce adverse effects on air quality environmental values to an acceptable level.
Performance criteria	• Achieve project air quality criteria at all sensitive receptors and meet project targets. • Adequate wind erosion control measures in place. • Results of air emission monitoring to be within project air quality criteria at all sensitive receptors and to meet project targets. • Decommissioning to be undertaken as soon as areas are no longer in use and rehabilitated on completion of decommissioning. • All areas affected by the project to be rehabilitated to agreed requirements.

Table 4.16 Air Quality management (cont'd)

Implementation strategy (planning and design)	• Design the LNG plant to comply with the air quality assessment criteria, which are based upon all relevant air quality standards and objectives. Compliance with these criteria will ensure protection of environmental values within the air quality impact assessment study area and all sensitive receptor areas. [C21.01] • Where feasible, apply low-emission technology to equipment with high combustion rates (e.g., gas turbines). [C21.02] • Fit compressors and boil-off gas recovery systems with dry gas seals and where practical hydrocarbon pumps will be fitted with double seals. [C21.03] • Minimise fugitive emissions from sources such as pumps, seals, valves, connectors and pipe work via the application of the latest proven stage of development processes, facilities and methods of operation. These include using closed drainage, where practical, minimising the number of flanges, installing dry gas seals on compressors and vapour recovery systems and where applicable, double seals for hydrocarbon pumps. [C21.04] • Incorporate waste heat recovery units on the compressor drive gas turbine exhausts to provide process heat to use elsewhere in the LNG plant, thereby reducing operational requirements for gas-fired heaters.[C21.05] • Fit all stacks with emissions monitoring ports suitable for continuous monitoring even if continuous monitoring is not currently required to facilitate future monitoring should the need arise.[C21.06]
Implementation strategy (construction)	• Reduce exposure time of bare soils on the ground surface as far as practical, and undertake revegetation of bare surfaces as soon as practical following construction. [C21.07] • Control speed limits on site via posted speed limit signs and confine vehicles generally to marked trafficable areas. [C11.20] Common with Section 4.2.3, Geology, Landform and Soils. • Keep trafficked surfaces damp during construction with sprayed water when conditions are dry to suppress dust generation. Use water of a similar quality to that which is available in the locality and do not spray as concentrated flow. [C11.21] Common with Section 4.2.3, Geology, Landform and Soils. • Maintain construction vehicles and equipment regularly to reduce exhaust emissions. [C21.08] • Where practical, use low-sulfur diesel fuel in diesel-powered equipment (i.e., not more than 0.01% sulfur by mass). [C21.09] • Do not use chlorofluorocarbons (CFC), halogens or related materials listed as banned under the Montreal Protocol in new installations. [C21.10]
Implementation strategy (operations)	• Where practical, limit the volume of hydrocarbons flared or vented to the atmosphere from the LNG plant. Ensure that the flare is luminous and bright (i.e., show smokeless combustion at operating design gas flow rate) and the relative density of emitted smoke does not exceed No.1 Ringelmann Number. [C21.11] • Do not vent boil-off gas to the atmosphere; instead route it to the feed gas inlet for reprocessing or sent to the end flash gas compressor for use in the high-pressure fuel gas system. [C21.12] • Use low-sulfur fuel in diesel-powered generators will (not more than 0.01% sulfur by mass). [C21.13] • Do not use chlorofluorocarbons (CFC), halogens or related materials listed as banned under the Montreal Protocol in new installations. [C21.10] • Maintain equipment in accordance with manufacturer specifications in order to minimise fugitive emissions. [C21.14]

Table 4.16 Air Quality management (cont'd)

Implementation strategy (decommissioning)	• Reduce exposure time of bare soils on the ground surface as far as practical, and revegetation of bare surfaces will be undertaken as soon as practical following construction. [C21.07] • Control speed limits on site via posted speed limit signs and confine vehicles generally to marked trafficable areas. [C11.20] Common with Section 4.2.3, Geology, Landform and Soils. • Keep trafficked surfaces damp with sprayed water to suppress dust generation. Use water of a similar quality to that which is available in the locality and do not spray as concentrated flow. [C11.21] Common with Section 4.2.3, Geology, Landform and Soils, and Section 4.22.3, Waste Management. • Maintain construction vehicles and equipment regularly to reduce exhaust emissions. [C21.08]
Inspection and monitoring	**Construction and decommissioning** Undertake inspections and monitoring in accordance with Arrow's HSEMS and to reflect project approval requirements directed by government departments, and undertaken on an as required basis. Conduct inspections at regular intervals during construction and decommissioning to check that mitigation measures are effective in achieving performance criteria. **Operations** Prepare a leak detection and emissions monitoring plan and implement at the LNG plant site. The plan will include monitoring of pumps, piping and controls, vessels and tanks. Ensure that auditing, monitoring and recording of exhaust stack emissions is in line with good industry practice and provides data to assess performance against air quality criteria.
Auditing	Undertake internal audits as both scheduled and unscheduled activities for implementation of agreed measures and compliance with performance criteria. Conduct regular internal audits throughout the life of the project and spot audits during ad hoc site visits. Undertake external audits when required to evaluate compliance with environment authority conditions and Arrow's HSEMS.
Reporting	Ensure reporting reflects government requirements of the project approval and is undertaken in accordance with Arrow's HSEMS requirements set out in Section 3.5 of this Strategic EMP.
Corrective action	Undertake corrective actions in accordance with the outcomes of incident investigations, audits, monitoring results or advice given by the relevant regulatory authority in accordance with Arrow's HSEMS.

4.13 Noise and Vibration

This section describes Arrow Energy's approach to managing potential environmental impacts on the acoustic environment, including impacts of vibration.

4.13.1 Existing Environment and Environmental Values

The following environmental values for the acoustic environment are identified in the Environmental Protection (Noise) Policy 2008 (Qld) (EPP (Noise)) and are relevant to the enhancement and protection of the existing environment and conducive to health and biodiversity of ecosystems, human health and well-being and amenity. In relation to vibration, the structural and cosmetic integrity of dwellings is to be protected.

The existing noise environment of the Port Curtis area is dominated by marine traffic noise and the sounds of the natural environment, i.e., sound from waves, wind and wildlife. In the urbanised and industrialised areas of Gladstone, local road traffic and existing industry have a greater influence. Background noise and vibration in rural areas west of Gladstone are influenced by road traffic, lighter industry and the sounds of the natural environment.

Existing noise levels measured in the noise and vibration impact assessment area are summarised in Table 4.17 and show the calculated rating background levels for all noise monitoring locations. The monitoring locations are displayed in Figure 4.4.

Table 4.17 Calculated rating background levels

Noise monitoring location	Associated impact assessment location	Rating background level (dB(A))		
		Day[1]	Evening	Night
ML1	AL1, AL6	44	41	43
ML2	AL2	34	34	33
ML3	AL3	42	44	43
ML4	AL4	39	37	35
ML5	AL5	40	36	35

Note[1] - Daytime – 7.00 a.m. to 6.00 p.m., Evening – 6.00 p.m. to 10.00 p.m., Night time – 10.00 p.m. to 7.00 a.m.

The existing vibration levels at all measurement locations are well below the threshold of human perception.

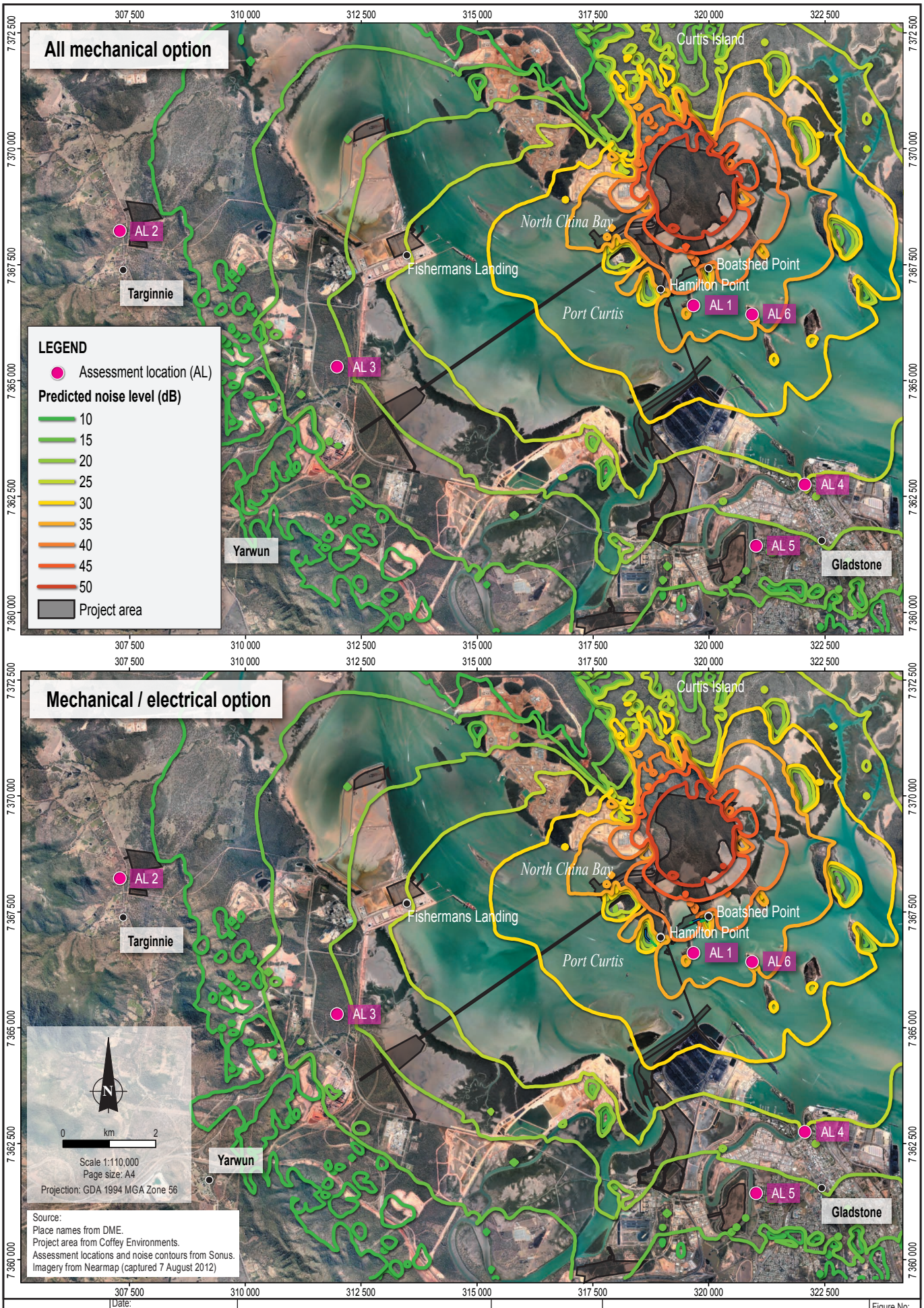
4.13.2 Potential Impacts

Construction noise and vibration sources generally relate to the use of heavy construction vehicles and equipment for site preparation and earthmoving, and facilities and infrastructure installation of the LNG plant site, laydown areas and construction camps, marine facilities, feed gas pipeline and dredging activities. In addition to routine construction noise there may be temporary, intermittent elevations in the noise and vibration profile from blasting. Any blasting events will likely occur at irregular intervals.

Four worst-case scenarios have been assessed for impacts relating to noise and vibration during operations:

- All mechanical option with two LNG trains operating.
- Mechanical / electrical option with two LNG trains operating.
- All mechanical option with four LNG trains operating.
- Mechanical / electrical option with four LNG trains operating.

Table 4.18 identifies construction and noise criteria developed for the project in accordance with the EPP (Noise) and WHO (2009) guidelines for community noise.



coffey environments	Date: 12.12.2012 MXT: 7033CC_16_GIS044_v1_1 File Name: 7033_EMP_F04.04_GIS_FT	Arrow Energy Arrow LNG Plant	arrow energy go further	Noise contours of the predicted noise levels with acoustic treatment	Figure No: 4.4

Table 4.18 Proposed construction and operations noise criteria

Activity	Source	Assessment location	Outdoor noise criterion (dB(A))		
			Day	Evening	Night
Construction	Construction of LNG plant, marine facilities, feed gas pipeline and dredging.	AL 1	All reasonable and practical measures will be implemented to reduce noise impacts.		40[1]
		AL 2			
		AL 3			
		AL 4			
		AL 5			
		AL 6			
Operation (continuous)	LNG plant.	AL 1	33		
		AL 6			
		AL 3	33		
		AL 2	28		
		AL 4	28		
		AL 5			
Operation (intermittent)	LNG carrier movements.	AL 1	50	50	45
		AL 2			
		AL 3			
		AL 4			
		AL 5			
		AL 6			

[1]Criterion reduced from 45 dB(A) to 40 dB(A) as agreed with Department of Environment and Heritage Protection (DEHP).

Predicted noise levels associated with construction and operation activities were modelled based on the internationally recognised Conservation of Clean Air and Water in Europe (CONCAWE) noise propagation model (Manning, 1981), and excluded the mitigation and management measures described below.

Based on the modelled predictions, construction noise levels will achieve the night time project noise criteria of 40 dB(A) at all assessment locations except AL 1 and AL 6. Operational noise levels are predicted to exceed the project noise criteria for all power options at AL 1 and AL 6. Predicted noise levels are modelled without additional acoustic treatment being applied.

Implementation of mitigation and management measures provided in Table 4.19 will result in compliance with project noise criteria (see Figure 4.4).

Vibration levels will be well below the threshold of human detection, due to the large separation distances of all assessment locations from the key project infrastructure – LNG plant, LNG jetty, and the feed gas pipeline.

4.13.3 Noise and Vibration Management

Construction mitigation measures will make use of attenuation devices on machinery, correct handling and usage of noise and vibration making equipment and scheduling and coordination of noisy equipment during daytime periods.

Operation mitigation measures include acoustic treatments applied to the LNG plant and associated infrastructure, which will reduce noise and vibration impacts. Predictive modelling indicates that a range of acoustic treatments will need to be applied to ensure that project noise criteria will be achieved at all sensitive noise receptors. An appropriate combination of acoustic treatments and management measures will be applied to ensure that noise from construction and operations does not constitute an environmental nuisance at sensitive receptor locations AL 1 and AL 6.

The requirement for blasting has not yet been determined. If blasting is considered necessary, standard practices will be followed so that all blasting activities meet the relevant airblast and ground-vibration criteria at sensitive receptor locations. In the event that detailed blasting requirements have not been determined at the time of submission of the detailed statutory EMP, an indicative assessment of blasting on Curtis Island will be included to show that relevant airblast and ground vibration criteria can be met. The assessment will be based on a 500 kg charge weight per delay at the closest point on Curtis Island to sensitive receptors. The predicted airblast overpressure will be compared 120 dB (linear peak) and the predicted ground-borne vibration will be compared with a peak particle velocity of 10 mm/s at sensitive receptor locations.

Mitigation and management measures for all project related activities are outlined in Table 4.19.

Table 4.19 Noise and Vibration management

Element/issue	Noise and vibration impacts to the values associated with the acoustic environment.
Environmental and social objectives	• To minimise the potential for noise and vibration to adversely affect sensitive receptors during project construction and operation. • To achieve relevant environmental noise and vibration criteria during construction and operation. • To minimise noise and vibration impacts on terrestrial animals (including bats) and birds (avifauna) (particularly migratory species).
Performance criteria	Results of noise and vibration emission monitoring are within project criteria (or any legislation, standards or guidelines that supersede this document) to meet targets.
Implementation strategy (planning and design)	• Identify during the detailed design of the LNG plant, specific acoustic treatment to be applied to each noise source. [C22.01]
Implementation strategy (construction)	• Where practical, locate noise-making equipment to maximise the distance between noise sources (e.g., diesel generators) and sensitive receptors. The use of structures or natural topography to create barriers to noise may be used to lessen the noise impacts on sensitive receptors. [C22.02] • Include appropriate methods to manage blasting activities in the construction environmental management plan. If required, carry out blasting activities in accordance with the guidelines for blasting noise and vibration. [C22.03] • If blasting is considered necessary, standard practices will be followed so that all blasting activities will be designed to meet the relevant overpressure and ground-vibration criteria at sensitive receptor locations. [C22.08] • Implement soft-start procedures where a sequential build-up of warning pulses will be carried out prior to commencement of full-power pile-driving activities. [C19.06] Common with Section 4.10.3, Marine Ecology. • Evaluate the use of bubble curtains for each method of piling, and deploy where they are demonstrated to be effective in aiding the rapid attenuation of underwater noise and deterring marine fauna from approaching, or remaining at, pile driving sites. [C19.13] Common with Section 4.10.3, Marine Ecology.

Table 4.19 Noise and Vibration management (cont'd)

Implementation strategy (operations)	• Regularly maintain all machinery and equipment and check for excessive noise generation. [C22.04] • Where noise from a construction activity would exceed the project night time noise criteria of 40 dB(A) at a sensitive receptor, schedule, where practical construction activities to occur between 7.00 a.m. and 10.00 p.m. [C22.05A] • Continually review the timing of construction activities to identify opportunities to reschedule concurrent activities where excessive noise is expected. [C22.06] • Ensure that project related noise generated during operations complies with the project noise criteria at all assessment locations. [C22.07]
Inspection and monitoring	• Establish a system for the recording of opportunistic observation of marine megafauna (turtles, salt-water crocodiles, dugong and cetaceans) spotted during marine operations such as dredging, pile driving and marine transport including where these activities occur within the Calliope River. Common with Section 4.10.3, Marine Ecology. Undertake inspections and monitoring in accordance with Arrow's HSEMS reflecting project approval requirements directed by government departments, and on an as required basis. Develop a detailed site environmental monitoring program and document requirements in the construction and operations management plans.
Auditing	Undertake internal audits as both scheduled and unscheduled activities for implementation of agreed measures and compliance with performance criteria. Conduct regular internal audits throughout the life of the project and spot audits during ad hoc site visits. Undertake external audits when required to evaluate compliance with environment authority conditions and Arrow's HSEMS.
Reporting	Ensure reporting reflects government requirements of the project approval and is undertaken in accordance with Arrow's HSEMS requirements set out in Section 3.5 of this Strategic EMP.
Corrective action	Undertake corrective actions in accordance with the outcomes of incident investigations, audits, monitoring results or advice given by the relevant regulatory authority in accordance with Arrow's HSEMS.

4.14 Landscape and Visual

This section describes Arrow Energy's approach to managing potential impacts on landscape and visual values associated with project activities.

4.14.1 Existing Environment and Environmental Values

The project is located over a variety of landscapes including existing natural landscapes on Curtis Island and a variety of mainland land uses such as open space, rural, strategic port and major industry and infrastructure. Most of the project lies within the GSDA where it is anticipated that, in the near future, large scale industrial land use will occur and change remaining areas of rural or natural landscape characteristics to a landscape characterised by heavy and high impact industrial development.

The existing landscape and visual values within and around the landscape and visual impact assessment (LVIA) study area include sensitive landscape and visual receptors. Designated landscapes include areas of land or particular landscape elements that are valued and protected

due to their character or quality (including visual characteristics). Of particular note are the Great Barrier Reef World Heritage Area, Great Barrier Reef Marine Park, The Narrows, Garden Island Conservation Park, Mount Larcom Range, Islands and Offshore Features listed in the Curtis Island (Curtis Coast Regional Coastal Management Plan (EPA, 2003), and the Curtis Island and The Narrows wetlands.

Eight landscape character types (LCTs) have been identified in the LVIA study area based on an understanding of the natural and cultural processes that have shaped the Gladstone landscape ranging from the forested mountain areas to industrial landscapes and coastal and estuarine plains and waterscapes.

Key sensitive visual receptors anticipated to obtain views of and / or be most affected by the project include recreational users, users of Gladstone CBD, residents, tourists, workers and residents being ferried to nearby islands, and motorists and travellers on roads. The visual baseline is described in terms of views from representative viewpoints selected in a variety of landscape types to represent a range of views and types of viewers likely to be affected by the project. Plate 1 shows the current view from Auckland Point and Plate 2 an artistic impression of the potential view from Auckland Point.

4.14.2 Potential Impacts

Key impacts on the character of the landscape and views during construction will relate to the introduction of construction activities and plant, including:

- Clearance of vegetation.
- Presence of a construction camp, TWAF sites and construction crews.
- Presence of construction infrastructure and plant.
- Introduction into the landscape of construction activities such as topsoil removal, and dredging.
- Presence of temporary construction roads and heavy haul roads and increased traffic.
- Introduction of light sources on Curtis Island including perimeter security lights.

Key impacts on sensitive landscape and visual receptors during operation relate to the introduction of new infrastructure into the landscape and the industrialisation of the landscape setting. Key impacts will include the introduction of new infrastructure such as the LNG plant, LNG storage, stacks, marine infrastructure, buildings and workshops and other visible LNG plant elements and evidence of a disturbed landscape such as the feed gas pipeline operational easement. Lighting will increase through fixed permanent lights (i.e., perimeter fencing, operational lighting and maritime lighting), the pilot light from the flare and intermittent emergency flaring.

Key impacts on sensitive landscape and visual receptors during decommissioning will relate the presence of decommissioning infrastructure including laydown areas and construction equipment and the introduction of a range of decommissioning activities including vegetation planting, creation of stockpiles, cut-and-fill activities, presence of construction crews and increased traffic movement.

4.14.3 Landscape and Visual Management

A range of measures have been incorporated into the Arrow LNG Plant concept design that limit the landscape and visual impacts of the project, such as the use of terracing and protection of areas of vegetation that provide a visual screen.

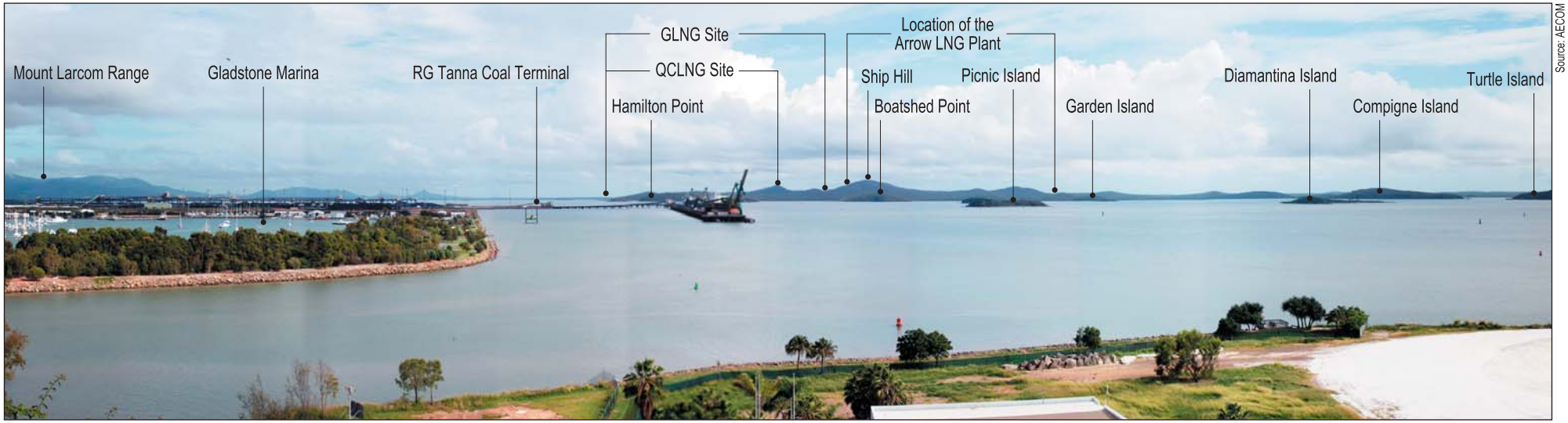


Plate 1 View from Auckland Point (Viewpoint 1)

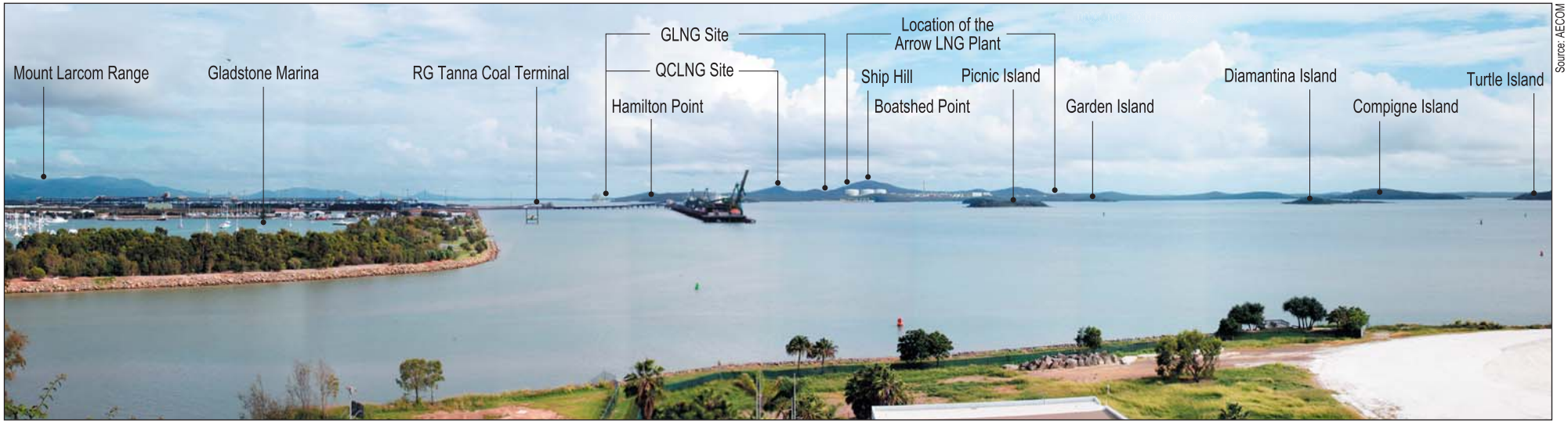


Plate 2 Artistic impression (visualisation) showing potential view from Auckland Point

Note:
The GLNG and QCLNG projects have not been represented as detailed information on these projects required for the visualisation was not available.

Table 4.20 outlines the landscape and visual mitigation and management measures to be applied from planning and design through to decommissioning.

Table 4.20 Landscape and visual management

Element/issue	Potential for project activities to impact on landscape and visual values.
Environmental and social objectives	• To maintain consistency with the landscape objectives within relevant strategic planning documents such as the Development Scheme for the Gladstone State Development Area. • To avoid or minimise major (very high) impacts on landscape features, character and designated landscapes within the study area. • To avoid or minimise major (very high) visual impacts from representative viewpoints.
Performance criteria	• Measures to reduce landscape and visual impacts of the project are incorporated into the detailed design. • Planting and rehabilitation works are undertaken in accordance with landscape rehabilitation plans. • No reported instances of unnecessary removal of vegetation. • No reported grievances from the community over night time lighting impacts. • Evidence of measures being adopted on site to reduce lighting impacts. • Successful restoration and or establishment of an after use for the project area.
Implementation strategy (planning and design)	• Protect the tip of Boatshed Point from clearing and cutting to preserve areas of vegetation that help screen lower parts of the LNG plant and construction camp. [C23.01] • Where practical, retain the vegetation along the eastern boundary of the LNG plant site to provide some screening to views from the east. [C23.02] • Consider potential landscape and visual impacts where there are options for the siting of infrastructure. [C23.03] • Where practical, undertake further modifications to the development footprint during detailed design to minimise cutting into the high ground of the Curtis Island strike ridge system and to assist in maintaining a vegetated backdrop and visually absorbing the built form of the development. [C23.04] • Investigate potential areas for further retention of vegetation cover at all sites where practical. [C23.05] • Investigate opportunities for further planting of a forested landscape buffer around the eastern, southern and western boundaries of the LNG plant site, using bush regeneration techniques and endemic tree species of local provenance consistent, to the greatest extent, with the bushfire strategy. [C23.06] • Select materials that are sensitive to the site context where plant operability is not impacted. [C23.07] • Use a colour palette for built form that blends with the predominant background colours and which reflects natural hues from the surrounding landscape where plant operability is not impacted. [C23.08] • Investigate the use of new insulating paints that may allow greater flexibility in the colour of LNG structures without compromising plant operability or safety aspects. [C23.09] • Undertake the detailed lighting design in line with Australian standards. [C23.10] • Design aviation lighting to be consistent with the Gladstone Airport Obstacle Limitation Surface Plan (Randl, 2011). [C23.11] • Design shore protection to reflect natural forms, where practical. [C23.12]

Table 4.20 Landscape and visual management (cont'd)

Implementation strategy (construction)	• Use industry standards for the construction camp to minimise landscape and visual impacts. [C23.13] • Develop landscape and rehabilitation plans for all project sites, particularly the selected TWAF site, which will require remediation after the first construction phase. [C23.14] • Consider visibility of stockpiles when siting these within laydown areas, i.e., use laydown areas that are more enclosed in preference to more open areas, wherever practical. [C23.15] • Investigate planting at the top, toe and on the retaining structure where terracing is undertaken. [C23.16] • Consider planting of bands of screening vegetation parallel with the shoreline between elements of the LNG plant if terracing is considered impractical on Curtis Island. [C23.17] • Remove temporary structures following completion of construction works and where appropriate, undertake detailed grading of disturbed surfaces to achieve appropriate ground levels. [C23.18] • Shield/direct the light source onto work areas where practical, and avoid light spill on to habitat areas (such as mangroves and Clinton ash ponds) where practical. [C17.16A] Common with Section 4.8.3, Terrestrial Ecology and Section 4.10.3, Marine and Estuarine Ecology. • Undertake planting rehabilitation works at the earliest opportunity to minimise erosion and the presence of areas of bare soil (except where technical studies indicate an alternative approach). [C23.19]
Implementation strategy (operations)	• Minimise night-time working and associated lighting impacts for activities (including construction of the LNG plant). Limit construction activities that need to be highly lit to daytime hours (to the greatest extent practical. [C23.20] • Shield/direct the light source onto work areas where practical. [C17.16] Common with Section 4.8.3, Terrestrial Ecology and Section 4.10.3, Marine and Estuarine Ecology. • Use 'passive' lighting methods, where practical. These include reflective roadway markers, lines, warnings or information signs and furnishing reflectors. [C23.21] • Consider use of solar-powered LED studs, or similar, in roadways and paths of travel as an alternative to permanent lighting, where practical. [C23.22]
Implementation strategy (decommissioning)	• As part of the decommissioning plan to be developed for the project, investigate an appropriate after use of project areas including any rehabilitation requirements as appropriate. [C23.23]
Inspections and monitoring	Focus inspection activities on checking for the implementation and success of landscape and rehabilitation plans developed for the project sites, particularly within those areas that assist in integrating the project into its landscape context through screening. Monitor and record any complaints from the public.
Auditing	Undertake internal audits as both scheduled and unscheduled activities for implementation of agreed measures and compliance with performance criteria. Conduct regular internal audits throughout the life of the project and spot audits during ad hoc site visits. Undertake external audits when required to evaluate compliance with environment authority conditions and Arrow's HSEMS.
Reporting	Ensure reporting reflects government requirements of the project approval and is undertaken in accordance with Arrow's HSEMS requirements set out in Section 3.5 of this Strategic EMP.

Table 4.20 Landscape and visual management (cont'd)

Corrective action	Undertake corrective actions in accordance with the outcomes of incident investigations, audits, monitoring results or advice given by the relevant regulatory authority in accordance with Arrow's HSEMS.

4.15 Indigenous Cultural Heritage

This section describes Arrow Energy's approach to managing potential environmental impacts on Indigenous cultural heritage associated with project activities.

4.15.1 Existing Environment and Environmental Values

The types of Indigenous cultural heritage most likely to be present in the project area have been identified based on the results of a detailed cultural heritage assessment, comprising a detailed desktop assessment and site-specific survey results. These include places commonly referred to as 'archaeological sites', containing stone artefacts, scar trees, hearths and ovens, axe-grinding grooves, quarries, wells, shell middens, burials, rock art and stone arrangements.

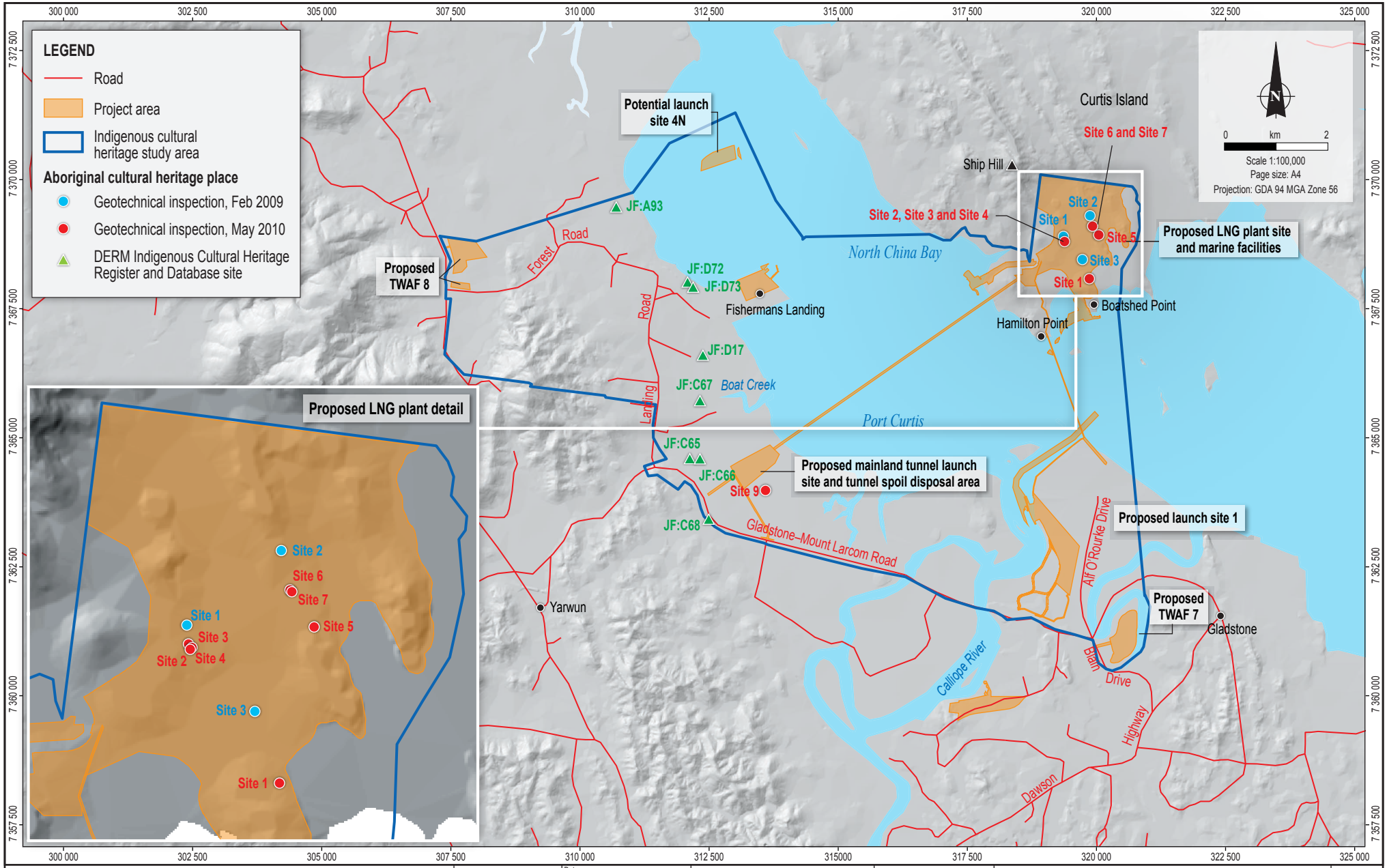
The Great Barrier Reef region, listed on the UNESCO World Heritage List and on the Australian Government's National Heritage list and the Register of the National Estate, extends over the project area. The listings acknowledge the presence, generally, of Indigenous cultural heritage values within the Great Barrier Reef region, although the Great Barrier Reef World Heritage Area only listed for four criteria of its natural values.

Indigenous places previously recorded in the region are concentrated in the coastal development strip to the north of Gladstone and, given the extent of industrial development in the study area, are relatively low in number. Sites include scar trees, stone artefacts and a shell midden. No currently identified sites lie within the project area.

Two cultural heritage inspections undertaken for the project identified 22 Indigenous cultural heritage sites, including a low-density artefact scatter, a single unmodified siltstone flake, stone artefacts and a shell midden. Eight sites were located within the project area on Curtis Island and the mainland (Figure 4.5).

The sites currently identified, when measured against registered sites and those recorded in other literature, are neither unrepresented elsewhere, nor of such order to be described as outstanding examples of site-types the loss of which would be scientifically unacceptable. Central Queensland Cultural Heritage Management also noted that this observation does not diminish the significance of the identified sites to the Aboriginal parties. Arrow Energy is sensitive to the fact that contemporary Aboriginal people take seriously the responsibilities they have to their ancestors, spiritual entities and hero figures, and to the management and protection of Indigenous cultural heritage places and objects inherited from them.

Further sites may be uncovered when a comprehensive examination is undertaken of the areas to be disturbed by the project with the Aboriginal parties. Some project areas on Curtis Island were considered by ARCHEO Cultural Heritage Services to possess greater potential for further cultural heritage material to be uncovered.



Source:
Aboriginal cultural heritage places from CQCHM and DERM.
Indigenous cultural heritage study area from CQCHM.
Place names and roads from DME.
Project area and digital elevation model from Coffey Environments.

coffey environments

Date: 03.12.2012
MXD: 7033CC_16_GIS116_v1_1
File Name: 7033_16_F04.05_GIS_FT

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Recorded Aboriginal cultural heritage

Figure No: 4.5

Within these areas, elevated areas in the vicinity of major creek lines and those close to both the tidal flats and creeks and swamps would have provided easy access to essential resources for Indigenous people. Isolated and scattered artefacts are expected to be the most likely site-type remaining due to historic land clearing, with only a small likelihood that shell middens will be located on the coastal fringe. Regardless of their scientific significance, as yet unidentified cultural heritage areas and objects may be of particular significance to the Aboriginal parties.

4.15.2 Potential Impacts

This section describes impacts to Indigenous cultural heritage during project construction, operations and decommissioning. Potential impacts for each phase are:

- Construction. Indigenous cultural heritage places and objects are situated within, or in close proximity to, areas that will be disturbed by the project. Further Indigenous cultural heritage material may be identified during future detailed investigations of the area of disturbance and again during construction. While no sites of 'national significance' have been identified, places or objects may hold significance to local Aboriginal parties.

  Many of the archaeological sites identified in the project area can be found elsewhere in the region and include numerous, directly comparable examples with scientifically low-order sites, many of which offer far more opportunity for detailed investigation and analysis than those currently known to exist within the study area. If avoidance is not possible, the loss of sites in the study area would be offset by a suitable program of mitigation that ensures data that the sites may hold is collected and preserved in accordance with management measures agreed with the appropriate Aboriginal parties.

- Operations. Potential impacts during operations will be dependent upon the outcome of detailed site inspections conducted during the construction stage. For example, operational issues may relate to the ongoing conservation and management of sites identified during construction.

- Decommissioning. Potential impacts during decommissioning will be dependent upon the outcome of detailed site inspections conducted during the construction stage, as well as ongoing conservation and management arrangements for any identified sites during operations. For example, decommissioning issues may relate to ensuring protection of cultural sites during rehabilitation.

4.15.3 Indigenous Cultural Heritage Management

The Aboriginal Cultural Heritage Act 2003 (Qld) places a 'duty of care' on any person or company whose activities may harm or threaten Aboriginal cultural heritage. The duty of care for the project can be met through either a suitable native title agreement that does not expressly exclude cultural heritage, such as an ILUA, or an approved cultural heritage management plan (CHMP) under Part 7 of the Aboriginal Cultural Heritage Act 2003 (Qld).

Arrow Energy's cultural heritage arrangements under an ILUA or approved CHMP will generally include development of a set of overarching principles, an initial cultural heritage assessment, cultural heritage management strategies, and a post-construction heritage agreement.

Table 4.21 summarises the Indigenous cultural heritage management measures that will be applied to the project.

Table 4.21 Indigenous cultural heritage management

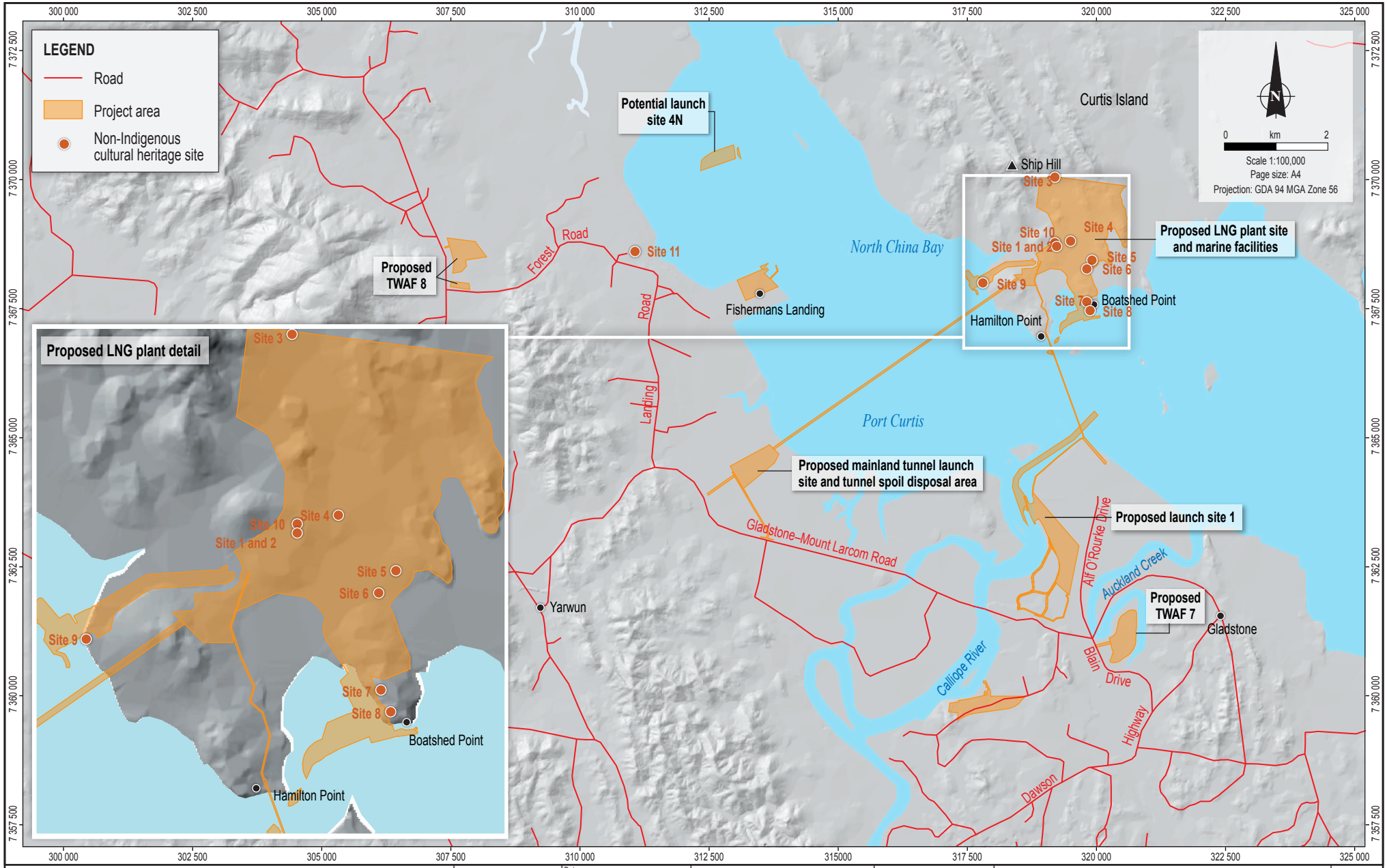
Element/issue	Potential for project activities to impact on Indigenous cultural heritage.
Environmental and social objectives	To comply with the Aboriginal cultural heritage duty of care through the development and implementation of an approved cultural heritage management plan or Indigenous land use agreement that addresses cultural heritage for the project in consultation with the endorsed Aboriginal parties/native title parties for the project area.
Performance criteria	Arrow Energy will work with the Aboriginal parties to develop key performance indicators to promote the implementation of best practice cultural heritage management. Methods for measuring performance against key performance indicators will be detailed in the CHMP.
Implementation strategy (planning and design)	• Develop an approved CHMP or a native title agreement that addresses Aboriginal cultural heritage in consultation with the endorsed Aboriginal parties for the project. [C24.01] • Comply with the approved CHMP or native title agreement that addresses Aboriginal cultural heritage. [C24.02] • Consider the cultural heritage management principles set out in Section 7.2.3 of Appendix 18, Indigenous Cultural Heritage Impact Assessment, completed for the project when developing a CHMP or native title agreement that addresses Aboriginal cultural heritage. Agree final principles with the relevant Aboriginal parties/native title parties. [C24.03]
Inspections and Monitoring	Undertake inspections and monitoring in accordance with the approved CHMP or a native title agreement that addresses Indigenous cultural heritage.
Auditing	Undertake auditing in accordance with the approved CHMP or a native title agreement that addresses Indigenous cultural heritage.
Reporting	Undertake reporting in accordance with the approved CHMP or a native title agreement that addresses Indigenous cultural heritage.
Corrective action	Undertake corrective actions in accordance with the outcomes of incident investigations, audits, monitoring results or advice given by the relevant regulatory authority in accordance with Arrow's HSEMS.

4.16 Non-indigenous Cultural Heritage

This section describes Arrow Energy's approach to managing potential environmental impacts on non-Indigenous cultural heritage associated with project activities.

4.16.1 Existing Environment and Environmental Values

There are no registered non-Indigenous cultural heritage sites of national, state or local significance within or near the project area. Eleven known or likely unregistered sites of non-Indigenous cultural heritage are located within the project area. All sites have a local heritage significance or local historical interest. These sites are listed in Table 4.22 and shown in Figure 4.6.



Source:
Place names, roads and watercourses from DME.
Non-Indigenous cultural heritage sites from Heritage Consulting.
Project area and digital elevation model from Coffey Environments.
Western Basin Dredging Master Plan from Gladstone Ports Corporation.

coffey environments

Date: 10.10.2012
MXD: 7033CA_16_GIS117_v1_1
File Name: 7033_EMP_F04.06_GIS_FT

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Non-Indigenous cultural heritage sites

Figure No: 4.6

Table 4.22 Known and likely unregistered non-Indigenous cultural heritage sites

Site No.	Description	Location
1.	"Birkenhead" outstation site.	Curtis Island – central section of the LNG plant site.
2.	Grave at "Birkenhead" outstation.	Curtis Island – central section of the LNG plant site.
3.	Post-cutting site.	Curtis Island – north of the LNG plant site.
4.	Old yards.	Curtis Island – mid western section of the LNG plant site.
5.	Stock enclosure.	Curtis Island – southern section of the LNG plant site.
6.	Historic fence line.	Curtis Island – north Boatshed Point.
7.	Pre-1870 track alignment.	Curtis Island – Boatshed Point.
8.	Ruins of rendered brick building.	Curtis Island – Boatshed Point.
9.	China Bay yards.	Curtis Island – North China Bay.
10.	Former dairy site/fisherman's hut.	Curtis Island – central section of the LNG plant site.
11.	Various fence alignments (Targinnie).	Mainland – in the vicinity of Targinnie (proximate to the TWAF 8 site).

Areas of high sensitivity to highlight areas where additional (unknown) sites of non-Indigenous cultural heritage are likely to occur were mapped within the project area for non-Indigenous cultural heritage. Areas of high sensitivity are located on Boatshed Point and the northern section of Hamilton Point; around the rendered brick building and the "Birkenhead" outstation sites respectively. Areas of moderate sensitivity occur around these areas of high sensitivity, and at North China Bay around the China Bay yards.

4.16.2 Potential Impacts

Potential impacts to non-Indigenous cultural heritage sites (including damage or destruction to a site) could occur through vegetation clearing and earthworks associated with the construction of the Arrow LNG Plant. While some identified sites cannot be avoided, other unknown sites could be uncovered through chance find discoveries and accidentally impacted.

There is little potential for disturbance to non-Indigenous cultural heritage sites during the operation or decommissioning of stage of the project.

4.16.3 Non-Indigenous Cultural Heritage Management

Arrow Energy will adopt appropriate mitigation and management measures focused on reducing the significance of the residual impacts to non-Indigenous cultural heritage values. The standard heritage practice measures for managing impacts on non-Indigenous cultural heritage sites encompass avoidance, relocation, salvage, archival recording and interpretation.

Management measures for all project related activities associated are found in Table 4.23. There are no specific management measures relating to the operations and decommissioning and rehabilitation phases of the project due to the minimal potential for disturbance to sites during these phases.

Table 4.23 Non-Indigenous cultural heritage management

Element/issue	Potential for project activities to impact on the values associated with non-Indigenous cultural heritage.
Environmental and social objectives	• To manage impacts to non-Indigenous cultural heritage during project construction and operation. • To record the non-Indigenous cultural heritage values in the study area.
Performance criteria	• Evidence of compliance with the heritage management plan developed for the project.
Implementation strategy (planning, design and construction)	• Prepare a heritage management plan prior to construction and which specifies how known and unknown heritage sites are to be managed during construction. [C25.01] • Record the following sites in detail prior to construction and destruction: – Site No. 3: Post-cutting site. – Site No. 4: Old yards. – Site No. 5: Stock enclosure. – Site No. 6: Historic fence line. – Site No. 7: Pre-1870 track alignment. – Site No. 8: Ruins of rendered brick building. – Site No. 11: Various fence alignments (Targinnie). [C25.02] • Map the “Birkenhead” outstation (Site No. 1) and record in detail prior to construction activities. Archaeological traces of this site may exist and remote sensing and excavation may be employed prior to construction to identify the extent of cultural heritage. [C25.03] • The location of the grave (Site No. 2) at “Birkenhead” outstation is unknown. Employ remote sensing techniques prior to construction to try to locate the grave. Relocate the grave to an alternative location if discovered, to protect it from construction activities. [C25.04] • If the grave is not discovered prior to construction, implement a procedure for accidental discovery of remains in this area. [C25.05] • Include in the heritage management plan prepared prior to construction, requirements for accidental discovery and management of cultural heritage items or human remains. Conflict resolution and other contingencies will also be addressed in the plan. [C25.06]
Inspection and monitoring	Regularly inspect project activities to check for compliance with the procedures set out in the heritage management plan.
Auditing	Undertake internal audits as both scheduled and unscheduled activities for implementation of agreed measures and compliance with performance criteria. Conduct regular internal audits throughout the life of the project and spot audits during ad hoc site visits. Undertake external audits when required to evaluate compliance with environment authority conditions and Arrow’s HSEMS.
Reporting	Ensure that reporting reflects government requirements of the project approval and will be undertaken in accordance with Arrow’s HSEMS requirements set out in Section 3.5.
Corrective action	Undertake corrective actions in accordance with the outcomes of incident investigations, audits, monitoring results or advice given by the relevant regulatory authority in accordance with Arrow’s HSEMS.

4.17 Social

This section describes Arrow Energy's approach to managing potential adverse social impacts associated with project activities and enhancing social benefits.

4.17.1 Existing Environment and Environmental Values

Gladstone city is one of the fastest growing local government areas in Queensland. It experienced an average annual population growth of 3.2% from 2006 to 2010. The rental market vacancy rates for the March quarter of 2011 were 1.4%, well below the preferred rate suggested by the Queensland Department of Communities of 3%. The median house price increased 7.2% in the 12 months to December 2010, while units increased 13.3%.

Manufacturing is the biggest provider of employment in the region followed by construction and retail. Community facilities and services are predominantly focussed within the Gladstone CBD, with relatively poor provision of facilities and services in other suburbs. High quality inter-regional rail and bus services link Gladstone to other urban centres across Queensland.

4.17.2 Potential Impacts

The project will stimulate economic activity at a regional, state and national level, both directly (via construction activities and the production and export of LNG) and indirectly (e.g., through increased household consumption and government fees and taxation revenues). Although the majority of workers will be sourced from outside Gladstone, between 5% and 20% of the construction workforce will be sourced locally and approximately 30% of operations staff will be sourced locally.

This variation in the local population from workers sourced outside the region will result in changing demand for housing and accommodation, and fluctuations in housing costs. Changing demand in the Gladstone region can place pressure on rental and purchase costs whilst the market takes time to meet fluctuating demand through incremental changes in housing supply, and the project has potential to further contribute to these pressures.

There will be a direct increase in employment opportunities and creation of training opportunities, although this will potentially result in competition for, and a drain on, local workers. There may be a high staff turnover at some local businesses during project construction.

Demand may also increase on local and regional infrastructure and services, including the airport, childcare and educational facilities, health care facilities, waste facilities, policing and emergency services, and water and electricity utilities.

4.17.3 Social Impact Management

Arrow Energy will adopt appropriate mitigation and management measures to address potential adverse social impacts associated with project activities and enhance social benefits.

Management measures for all project-related activities from design and planning through to decommissioning are found in Table 4.24.

Table 4.24 Social impact management

Element/issue	Potential for project activities to impact on social values.
Environmental and social objectives	• To make a positive contribution to community wellbeing and liveability through supporting community values and lifestyles. • To minimise the effects on the community of escalating housing and accommodation costs. • To maximise the positive benefits of the project from employment and training opportunities and opportunities for local businesses. • To minimise additional demands from the project on existing services and social infrastructure.
Performance criteria	Refer to the Social Impact Management Plan (SIMP) (Attachment 4 to the SREIS).
Implementation strategy (planning, design, construction and operations)	Refer to the SIMP.
Inspections and Monitoring	Refer to the SIMP.
Auditing	Refer to the SIMP.
Reporting	Refer to the SIMP.
Corrective action	Refer to the SIMP.

4.18 Economics

This section describes Arrow Energy's approach to managing potential adverse economic impacts from the project and enhancing beneficial economic impacts.

4.18.1 Existing Environment and Environmental Values

The Gladstone regional economy is export-oriented and prone to fluctuations in global economic factors such as global demand, exchange rates and commodity prices. The economy is dominated by heavy industry with manufacturing being the dominant employer. The labour force consists of approximately 31,634 people (based on data from the September quarter of 2010). In the September quarter of 2010, Gladstone had an unemployment rate of 5.4%, compared to an unemployment rate of 5.6% recorded for Queensland. Technicians and trade workers are the largest occupational grouping in the region (based on 2009-10 data).

Gladstone is one of Queensland's fastest growing areas, with population growth projected to rise approximately 50% faster than the Queensland average over the next 20 years. It supports a sizeable transient population with a number of major infrastructure projects in the region utilising a fly-in fly-out (FIFO) workforce and is well serviced by key infrastructure including major road, rail, air and port facilities.

Medium house and unit/townhouse prices recorded a rise between 2009 and the end of 2010 and average weekly rental prices in the region have risen over 30% between 2006 and 2010. There are low vacancy rates within the rental market.

In Queensland more generally, coal seam gas, mining and LNG industries are experiencing occupational skills shortages in a range of disciplines (including various engineering disciplines, engineering and production managers, process plant operators, transport and logistics trades, general and specialist electricians). The construction industry is also experiencing state wide skills shortages, notably in regional areas, and in particular skill sets required for construction of the LNG plant (i.e., welders, mechanical and pipe fitters and electricians).

4.18.2 Potential Impacts

Key adverse economic impacts associated with the project are expected to include:

- Competition for, and draw of labour to the Arrow LNG Plant and its supply chain will exacerbate regional skills shortages and may increase labour costs for local businesses.
- Increases in housing costs (due to demand generated by previous projects) could be sustained during the project, with housing less available and affordable for local residents.

Key economic benefits associated with the project are expected to include:

- Diversification of the regional, state and national economies and advancement of Queensland and Australia as a global energy producer through substantial and sustained investment in the Gladstone and Queensland economies.
- Contribution to the growth in Gladstone's economy through increased employment opportunities (directly through job creation at the LNG plant, and indirectly through the provision of goods and services), stimulation of other industry development, and supporting the viability of some local small businesses.

4.18.3 Economic Impact Management

Arrow Energy will adopt appropriate mitigation and management measures to address potential economic impacts from the project.

Management measures for all project-related activities from design and planning through to decommissioning are found in Table 4.25.

Table 4.25 Economic impact management

Element/issue	Potential for project activities to impact on economic values of the region and state.
Environmental and social objectives	• Identify and mitigate project impacts on property and labour markets and local industry. • Maximise opportunities for local businesses arising from the project. • Promote the development of the skill base at the local and regional level to support the coal seam gas industry.
Performance criteria	• Evidence of measures being taken to facilitate local industry participation. • Evidence of measures being taken to improve the skill base of the local labour force. • Maximise the proportion of the initial construction labour force sourced from the Gladstone region. • Maximise the proportion of operational staff sourced from the Gladstone region.

Table 4.25 Economic impact management (cont'd)

Implementation strategy (planning and design)	Refer to the SIMP for common commitments. Further commitments include: • Engage and collaborate with Construction Skills Queensland to identify potential strategies for increasing the capacity of local job seekers to develop appropriate skills for construction. [C27.01] • Inform and advise stakeholders of project goods and services requirements, and of opportunities and requirements for securing service provision and supply contracts. This will include implementation of a Local Content Strategy to aid suitable businesses in the tender process. [C27.02] • Inform council and economic development organisations of goods and services required by the Arrow LNG Plant that are not currently available or are under-serviced from within Gladstone to attract investment and develop the supply chain. [C27.03] • Investigate options to develop relevant networks to connect local business and enable collaboration in meeting service supply requirements of the LNG industry. [C27.04] • Develop a detailed worker accommodation plan to accommodate workers during the period between final investment decision and commissioning of the construction camps. This will include continuing to liaise with the other proponents, housing providers and state and local government to determine the cumulative housing demand and cooperative strategies which address this demand. [C27.05]
Implementation strategy (construction and operations)	• Develop construction worker camps as soon as practical following final investment decision. [C27.06] • Make the local residential development market aware of the scale and timing of project accommodation requirements and construction and operations activities. [C27.07]
Inspection and monitoring	Implement monitoring and inspection measures throughout construction of the project to enhance regional economic values and minimise adverse economic impacts. A Social Impact Management Plan (SIMP) has been developed for the project. The SIMP articulates action plans which include requirements for monitoring and evaluation of the effectiveness of these plans in managing adverse impacts. Specific action plans which address key economic impact areas are the: • Workforce and Training Action Plan. • Local Content and Investment Action Plan. • Housing and Accommodation Action Plan.
Auditing	Undertake internal audits as both scheduled and unscheduled activities for implementation of agreed measures and compliance with performance criteria. Conduct regular internal audits throughout the life of the project and spot audits during ad hoc site visits. Undertake external audits when required to evaluate compliance with environment authority conditions and Arrow's HSEMS.
Reporting	Ensure reporting reflects government requirements of the project approval and is undertaken in accordance with Arrow's HSEMS requirements set out in Section 3.5 of this Strategic EMP.
Corrective action	Undertake corrective actions in accordance with the outcomes of incident investigations, audits, monitoring results or advice given by the relevant regulatory authority in accordance with Arrow's HSEMS.

4.19 Traffic and Transport

This section describes Arrow Energy's approach to managing potential transport impacts associated with project activities.

4.19.1 Existing Environment

The Gladstone region has an extensive road network that services major industry and allows heavy materials transport in a manner that seeks to minimise impacts to dense population areas. A number of state-controlled roads are within the study area, and will be used during the construction and operation of the project including the Bruce Highway, Dawson Highway, Gladstone-Benaraby Road, Gladstone-Mount Larcom Road and Gladstone-Port Access Road. local government-controlled roads that will be utilised by the project include Blain Drive, Forest Road, Glenlyon Road, Hanson Road / Glenlyon Road, Kirkwood Road, Landing Road, Philip Street, Red Rover Road / Don Young Drive and Reid Road (see Figure 4.7). The study area also contains a series of approved B-double (lengths of 23 m and 25 m) freight routes servicing Gladstone.

Other transport services include rail (which is currently not planned to be used but remains under consideration) and air services. The Gladstone rail network moves a significant amount of freight, including freight to and from the Port of Gladstone.

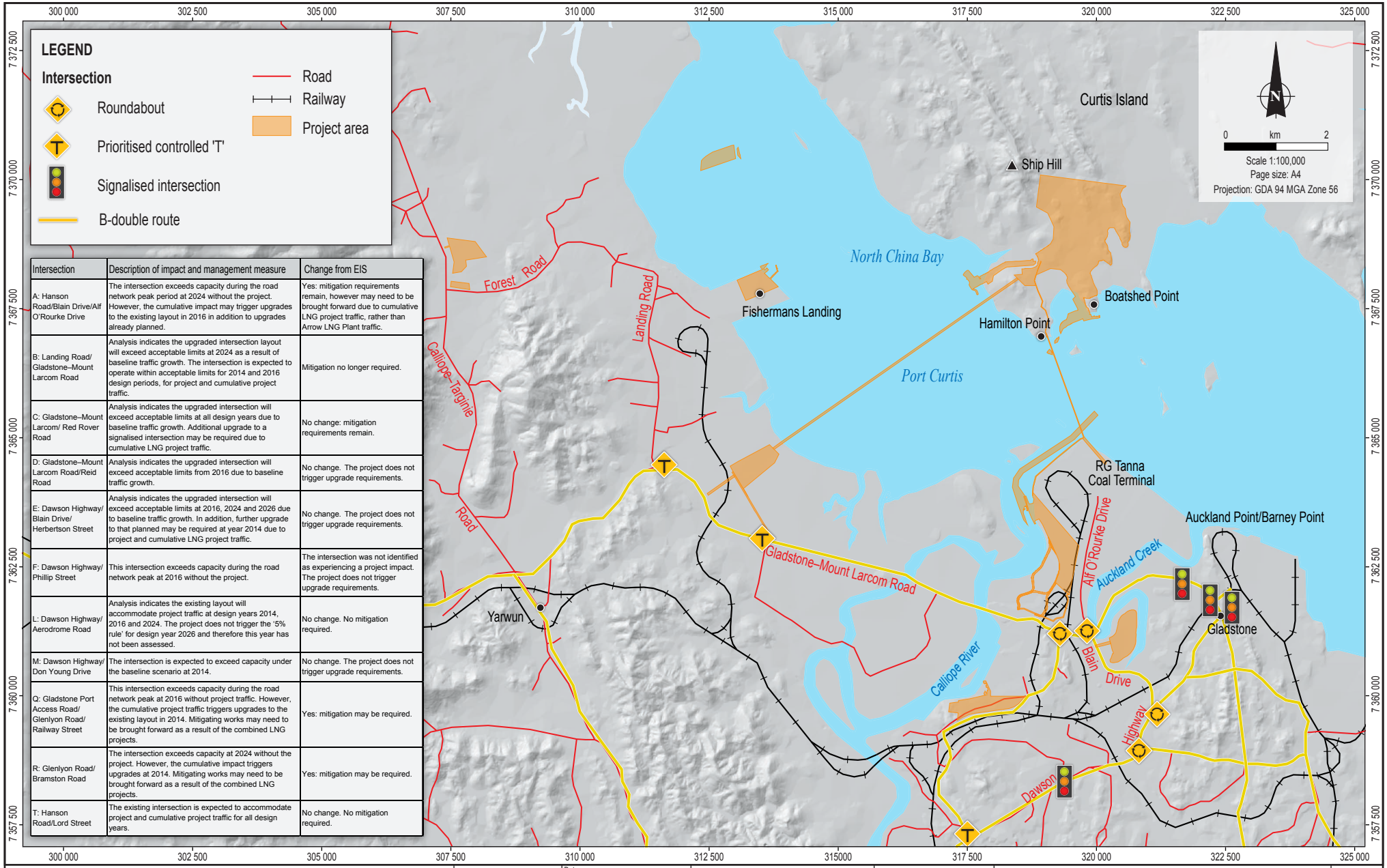
The Gladstone Airport is located on Aerodrome Road, close to the Dawson Highway, approximately 7 km southwest of the Gladstone CBD. QantasLink operates most scheduled services, utilising Dash-8 Q400 aircraft (74 passengers). Virgin Australia commenced services from Brisbane to Gladstone in October 2011 utilising ATR72 aircraft (78 passengers). During September 2011, the other three LNG proponents and Arrow Energy committed to provide $10.5 million in funding to upgrade the airport's instrument landing system.

The Port of Gladstone is Queensland's largest multi-commodity port and comprises six wharfs. The Port can accommodate vessels up to 220,000 dead weight tonnes. It receives bulk carriers, chemical/oil products tankers and general cargo ships, and approximately 1,500 vessels enter the port each year. Gladstone marina and Southend on Curtis Island are commonly used by the public as ports for access to a range of onshore and offshore recreational and commercial fishing activities. The Port of Gladstone is currently undergoing expansion, involving the reclamation of 150 ha of land, extending northwards from the existing Fishermans Landing Port facility. This will enable the construction of an additional six wharves to cater to future demand for transport, storage and loading facilities.

Local transport options providing alternatives to travel by private passenger vehicles include bus passenger services taxis and pedestrian and cycle networks.

4.19.2 Potential Impacts

The movement of the project workforce and construction and operations materials and equipment will generate additional road, air and shipping traffic in the Gladstone region.



Intersection	Description of impact and management measure	Change from EIS
A: Hanson Road/Blain Drive/Alf O'Rourke Drive	The intersection exceeds capacity during the road network peak period at 2024 without the project. However, the cumulative impact may trigger upgrades to the existing layout in 2016 in addition to upgrades already planned.	Yes: mitigation requirements remain, however may need to be brought forward due to cumulative LNG project traffic, rather than Arrow LNG Plant traffic.
B: Landing Road/ Gladstone–Mount Larcom Road	Analysis indicates the upgraded intersection layout will exceed acceptable limits at 2024 as a result of baseline traffic growth. The intersection is expected to operate within acceptable limits for 2014 and 2016 design periods, for project and cumulative project traffic.	Mitigation no longer required.
C: Gladstone–Mount Larcom/ Red Rover Road	Analysis indicates the upgraded intersection will exceed acceptable limits at all design years due to baseline traffic growth. Additional upgrade to a signalised intersection may be required due to cumulative LNG project traffic.	No change: mitigation requirements remain.
D: Gladstone–Mount Larcom Road/Reid Road	Analysis indicates the upgraded intersection will exceed acceptable limits from 2016 due to baseline traffic growth.	No change. The project does not trigger upgrade requirements.
E: Dawson Highway/ Blain Drive/ Herbertson Street	Analysis indicates the upgraded intersection will exceed acceptable limits at 2016, 2024 and 2026 due to baseline traffic growth. In addition, further upgrade to that planned may be required at year 2014 due to project and cumulative LNG project traffic.	No change. The project does not trigger upgrade requirements.
F: Dawson Highway/ Phillip Street	This intersection exceeds capacity during the road network peak at 2016 without the project.	The intersection was not identified as experiencing a project impact. The project does not trigger upgrade requirements.
L: Dawson Highway/ Aerodrome Road	Analysis indicates the existing layout will accommodate project traffic at design years 2014, 2016 and 2024. The project does not trigger the '5% rule' for design year 2026 and therefore this year has not been assessed.	No change. No mitigation required.
M: Dawson Highway/ Don Young Drive	The intersection is expected to exceed capacity under the baseline scenario at 2014.	No change. The project does not trigger upgrade requirements.
Q: Gladstone Port Access Road/ Glenlyon Road/ Railway Street	This intersection exceeds capacity during the road network peak at 2016 without project traffic. However, the cumulative project traffic triggers upgrades to the existing layout in 2014. Mitigating works may need to be brought forward as a result of the combined LNG projects.	Yes: mitigation may be required.
R: Glenlyon Road/ Bramston Road	The intersection exceeds capacity at 2024 without the project. However, the cumulative impact triggers upgrades at 2014. Mitigating works may need to be brought forward as a result of the combined LNG projects.	Yes: mitigation may be required.
T: Hanson Road/Lord Street	The existing intersection is expected to accommodate project and cumulative project traffic for all design years.	No change. No mitigation required.

Source:
Place names, roads and railway from DME.
Intersections and B-double routes from GTA.
Project area and digital elevation model from Coffey Environments.

coffey environments

Date: 12.12.2012
MXD: 7033CC_16_GIS107_v1_1
File Name: 7033_16_F04.07_GIS_VS

Arrow Energy

Arrow LNG Plant

arrow energy go further

Intersections of relevance to the project

Figure No: 4.7

Increased traffic on the road network associated with the project, along with the cumulative impacts of other projects will affect existing road users and the existing road network. The options for mainland launch sites to transport workers to Curtis Island, are located north of Gladstone CBD and main residential areas, however project traffic and/or cumulative LNG project traffic may contribute to unsatisfactory performance of some intersections during project peak times. Arrow Energy will develop a traffic management plan in consultation with the Department of Transport and Main Roads, Gladstone Regional Council and other LNG proponents to minimise project and cumulative impacts to the road network, and may contribute to intersection upgrades.

Construction of the Arrow LNG Plant will result in project personnel flying in and out of Gladstone, and may increase demand for air services. Additional flights may be required to accommodate these passengers and Arrow Energy will consult with providers of air services to Gladstone. The potential for charter flights to maintain crew change rosters may be considered, if required.

Increased shipping movements in Port Curtis due to construction and operations may impact existing vessel movements, including commercial shipping, commercial fishing and recreational boat users, and create a perceived safety risk with changed harbour conditions.

4.19.3 Traffic and Transport Management

Management of traffic and transport will be conducted in accordance with implementation strategies, with the aim of addressing identified impacts and meeting environmental and social objectives.

Table 4.26 identifies the broad requirements to ensure appropriate environmental management of identified traffic and transport values and will be conducted throughout all stages of the project.

Table 4.26 Traffic and transport management

Element/issue	Potential for project activities to impact on traffic and transport values.
Environmental and social objectives	• To assess the impacts of the Arrow LNG Plant on road and rail network infrastructure and air services. • To assess the impacts of the Arrow LNG Plant on shipping within and outside the Port of Gladstone. • To identify avoidance, mitigation and transport management strategies that will be implemented for the project.
Performance criteria	• No shipping accidents or major spills associated with vessels on the project. • No reports of a lack of compliance with road and maritime safety rules on the project.
Implementation strategy (planning, design, construction and operations)	• Develop a traffic management plan for the project in consultation with DTMR and Gladstone Regional Council. Methods to ensure public safety at project sites, avoid obstruction to other road users, address seasonal weather influences on transport arrangements and manage any issues including driver fatigue will be detailed in the plan. The traffic management plan will address the movement of oversized loads. [C28.01] Common with Section 4.20.3, Hazard and Risk. • Undertake a pavement intersection assessment and bridge capacity assessment when preferred transport routes are identified. [C28.02] • Implement a formal local workforce car-pooling or busing strategy to minimise the number of local project personnel using the roads during peak hour and to maximise usage of accommodation on Curtis Island. A busing strategy may comprise a number of small buses travelling from areas central to where personnel live. A staff matching or car-pooling strategy will also be considered. [C28.03]

Table 4.26 Traffic and transport management (cont'd)

Implementation strategy (planning, design, construction and operations) (cont'd)	• Use DTMR/Gladstone Regional Council preferred freight routes where practical. [C28.04] • Separate pedestrian access from vehicle access in access to construction and operational work sites (where practical). [C28.05] • Consult DTMR and Gladstone Regional Council on the scope and timing of already identified upgrades and project-specific upgrades (including potential contributions) that may be required when final routes for freight and workforce bus routes are confirmed. This process will take place during the preparation of the detailed Traffic Management Plan for the project and may include, subject to final TWAF/mainland launch site selection and completion of the detailed logistics strategy: – Timing of Gladstone-Mount Larcom Road upgrades and whether upgrades need to be brought forward. – Design of a new intersection accessing the proposed tunnel entry site from Gladstone-Mount Larcom Road. – Intersection A: Hanson Road/Blain Drive/Alf O'Rourke Drive (all transport scenarios). DTMR have identified works to this intersection however the project may necessitate additional works. Timing of DTMR works may need to be brought forward. – Intersection B: Gladstone-Mount Larcom Road/Landing Road (transport scenario 3). The existing intersection layout is not expected to accommodate project related traffic at 2024 and 2026. DTMR has identified works at this intersection (four lanes required between 2020 and 2030). Timing of DTMR works may need to be brought forward to early in the 2020 to 2030 period to accommodate project traffic. – Intersection C: Gladstone-Mount Larcom/Red Rover Road (transport scenario 3). DTMR have identified works to this intersection however the project may necessitate additional works. Timing of works may need to be brought forward due to the project. [C28.06] • Consult with providers of air services to Gladstone on the timing of construction and operations weekly shifts to aid commercial decision-making by service providers on the frequency of services and capacity of aircraft. [C28.07] • Provide a share of funding toward the new instrument landing system at Gladstone Airport upon project FID. [C28.08] • Develop a marine activity management plan (incorporating a Port of Gladstone shipping activity strategy and management plan) in consultation with Gladstone Regional Council, Gladstone Ports Corporation, Maritime Safety Queensland and all contractors operating within the Gladstone Port. [C28.09A] Common with Section 4.20.3, Hazard and Risk. • Operators of project vessels, Arrow Energy staff and contractors, to comply with the Gladstone Port Procedures Manual, which details LNG operating parameters. [C28.10] • Ensure that operators of project vessels, Arrow Energy staff and contractors comply with the marine activity management plan if/when this plan is agreed between Maritime Safety Queensland, Gladstone Ports Corporation and the other LNG proponents. [C28.11A] Common with Section 4.20.3, Hazard and Risk. • Ensure that operators of project vessels, Arrow Energy staff and contractors comply with Arrow Energy rules for marine vessels and LNG shipping operations in addition to following the Oil Companies International Marine Forum (OCIMF) and Society of International Gas Tanker and Terminal Operators guidelines (SIGTTO). Rules will address crew competencies, a three-stage approvals process for each LNG vessel (i.e., vetting of ships and operators prior to engagement to transport LNG), scheduling and other requirements and quality assurance. For the construction period, additional rules will address safety and competency requirements of smaller marine vessels and vessel operators involved with the project. [C28.12] • Provide support for tug and LNG carrier pilot training organised by all proponents, the Gladstone Ports Corporation, Maritime Safety Queensland and SMIT tugs. [C28.13]

Table 4.26 Traffic and transport management (cont'd)

Inspection and monitoring	Undertake inspections and monitoring to reflect project approval requirements directed by government departments. Inspection activities will focus on staff and contractor compliance with relevant procedures in various plans and documents including: • Traffic management plan for the project. • Port Procedures Manual (Maritime Safety Queensland). • LNG Marine Operations Maritime Safety Management Plan (if agreed). • Arrow Energy Rules for marine vessels and LNG shipping operations.
Auditing	Undertake internal audits as both scheduled and unscheduled activities for implementation of agreed measures and compliance with performance criteria. Conduct regular internal audits throughout the life of the project and spot audits during ad hoc site visits. Undertake external audits when required to evaluate compliance with environment authority conditions and Arrow Energy's HSEMS.
Reporting	Ensure reporting reflects government requirements of the project approval and is undertaken in accordance with Arrow Energy's HSEMS requirements set out in Section 3.5 of this Strategic EMP.
Corrective action	Undertake corrective actions in accordance with the outcomes of incident investigations, audits, monitoring results or advice given by the relevant regulatory authority in accordance with Arrow Energy's HSEMS.

4.20 Hazard and Risk

This section describes Arrow Energy's approach to managing potential hazards and risks associated with the project.

4.20.1 Existing Environment and Environmental Values

The only residential community located on Curtis Island is at Southend, approximately 9 km east-northeast of the LNG plant site. Private residential properties are located on adjacent islands, including Tide, Turtle and Compigne islands. On the mainland, the region making up the Gladstone Regional Council has a population of approximately 59,402 (as of 30 June 2011), with the majority of residents living in the city of Gladstone.

Curtis Island consists of a range of land uses including rural grazing, pasture, an industrial precinct and national park and reserves.

The Gladstone region lies to the south of Queensland's main area of tropical cyclone occurrence although has experienced a number of cyclones. Small fires are also known to occur in summer around Gladstone associated with the rural interface areas of Gladstone's urban areas. The project area on Curtis Island is not impacted by river floods.

The environmental values relating to hazard and risk that are to be protected relate to the health and safety of people, property and the wider community, and the ecosystems within and surrounding the project area that could potentially be affected by the project.

4.20.2 Potential Risks

The Arrow LNG Plant is likely to be classified as a major hazard facility under the Dangerous Goods Safety Management Act 2001 (Qld) as the stored quantities of LNG will exceed the prescribed quantity of 200 tonnes. As a major hazard facility, Arrow Energy will be required to implement a range of controls to reduce the likelihood and impacts of a major accident.

Risks associated with the project relate to the potential exposure of people (including the general public and workforce) to hazards inherent in the project and the potential for property and environmental damage. Potential hazards and risks during construction, operation and decommissioning of the project relate to the:

- Storage, handling and transport of hazardous substances such as feed gas and LNG or refrigerants such as propane leading to a fire, explosion, injury and/or destruction to property and impacts to the environment.
- External events such as land subsistence, cyclone, storm or earthquake leading to plant damage, and a loss of containment of flammable gas and fire or explosion.
- Personal safety hazards associated with the project workforce such as work at heights, in confined spaces or near electrical systems leading to injury or death of workers.
- Accidents, spills and abnormal events associated with the LNG plant or an LNG carrier leading to injury and/or pollution of the receiving environment.

4.20.3 Hazard and Risk Management

Safety hazards associated with the project are being managed through the application of engineering and site selection controls during design wherever practical, followed by behavioural controls and then any specific site controls where required. Preliminary hazard assessments and quantitative risk assessments have been undertaken to inform key elements of the design and ensure that target risk criterion set for the project are met.

Table 4.27 outlines the mitigation and management measures relevant to hazard and risk from project design and planning through to decommissioning.

Table 4.27 Hazard and risk management

Element/issue	Potential for project activities to create hazards and risks to human health, safety, property and the environment.
Environmental and social objectives	• To minimise potential risks to people, the environment and property.
Performance criteria	• Compliance with applicable hazard and risk legislation such as the *Petroleum and Gas (Production and Safety) Act 2004* and the *Dangerous Goods Safety Management Act 2001*. • Compliance with relevant Australian standards.
Implementation strategy (planning and design)	• Undertake qualitative and quantitative hazard and risk assessments (including process safety studies) in accordance with applicable regulations and standards as a part of the ongoing design process and throughout the life of the project. [C29.01] • Consult with relevant Queensland government agencies including emergency services organisations and maritime safety authorities on the management of hazards and risks in accordance with relevant legislative requirements, codes and standards. [C29.02]

Table 4.27 Hazard and risk management (cont'd)

Implementation strategy (planning and design) (cont'd)	• Develop a traffic management plan for the project in consultation with DTMR and Gladstone Regional Council. Methods to ensure public safety at project sites, avoid obstruction to other road users, address seasonal weather influences on transport arrangements and manage any issues including driver fatigue will be detailed in the plan. The traffic management plan will address the movement of oversized loads. [C28.01] Common with Section 4.19.3, Traffic and Transport. • Develop a marine activity management plan (incorporating a Port of Gladstone shipping activity strategy and management plan) in consultation with Gladstone Regional Council, Gladstone Ports Corporation, Maritime Safety Queensland and all contractors operating within the Gladstone Port. [C28.09A] Common with Section 4.19.3, Traffic and Transport.
Implementation strategy (construction and operations)	• Ensure that operators of project vessels, Arrow Energy staff and contractors comply with the marine activity management plan if/when this plan is agreed between Maritime Safety Queensland, Gladstone Ports Corporation and the other LNG proponents. [C28.11A]. Common with Section 4.19.3, Traffic and Transport.
Inspections and Monitoring	Undertake inspections and monitoring in accordance with the requirements of relevant legislation, Australian standards, Arrow's HSEMS and the Shell Group Health, Safety, Environment, Security and Social Performance Control Framework.
Auditing	Undertake internal audits as both scheduled and unscheduled activities for implementation of agreed measures and compliance with performance criteria. Conduct regular internal audits throughout the life of the project and spot audits during ad hoc site visits. Undertake external audits when required to evaluate compliance with environment authority conditions and Arrow's HSEMS.
Reporting	Ensure reporting reflects government requirements of the project approval and is undertaken in accordance with Arrow's HSEMS requirements set out in Section 3.5 of this Strategic EMP.
Corrective action	Undertake corrective actions in accordance with the outcomes of incident investigations, audits, monitoring results or advice given by the relevant regulatory authority in accordance with Arrow's HSEMS.

4.21 Land Use and Planning

This section describes Arrow Energy's approach to managing potential land use and planning impacts associated with project activities.

4.21.1 Existing Environment and Environmental Values

Ecological, cultural, social and economic uses and connections to the land all contribute to the environmental values relating to land use within the Gladstone region. Land use within the region is valued for its environmental and cultural sensitivity, recreational and commercial fishing resources, extractive and mining tenements, residential areas, agricultural land, industrial areas and infrastructure such as infrastructure links, railway lines, powerlines and pipelines.

The majority of the study area, both on the mainland and Curtis Island, comprises freehold land, with several parcels of state forest (Targinie State Forest and Mount Stowe State Forest) located on the mainland.

Much of this regional area is administered by the Gladstone Regional Council, with development assessed against the Calliope Shire Planning Scheme 2007. North of Gladstone city, including in the vicinity of the Arrow LNG Plant project area, is the Gladstone State Development Area, administered by the Coordinator-General under the State Development and Public Works Organisation Act 1971 (Qld), with development assessed against the Development Scheme for the GSDA.

In July 2008, the Queensland Government declared the southwest portion of Curtis Island as the Curtis Island Industry Precinct of the GSDA, set aside for LNG production and export. The precinct is adjacent to strategic port land, administered by the Gladstone Ports Corporation, at Hamilton Point, which may be used to expand port operations.

4.21.2 Potential Impacts

Project infrastructure on Curtis Island will be located within the Industry Precinct.

Mainland infrastructure will be located in several other precincts defined in the Gladstone State Development Area Development Scheme including the Boat Creek Sub-Precinct of the Materials Transportation and Services Corridor Precinct, Yarwun Precinct and the Clinton Precinct.

The project may disrupt existing land uses and restrict access to land used for a variety of activities within the region. However, the project will be designed, constructed and operated in accordance with relevant land use and planning legislation, policy, and statutory instruments. Compliance with design codes and standards of the project components during construction, operation and decommissioning will be assessed and determined through a range of post EIS applications for approvals and permits.

4.21.3 Land Use and Planning Management

Arrow Energy will adopt appropriate mitigation and management measures to address potential land use and planning impacts from the project.

All project-related activities from design and planning through to decommissioning are found in Table 4.28.

Table 4.28 Land Use and Planning Management

Element/issue	Potential for all activities to impact on land use values.
Environmental and social objectives	To minimise land use conflicts with other existing and proposed human land use activities.
Performance criteria	• Compliance with relevant legislative requirements, guidelines, design codes and standards. • Feedback from landowners is taken into account in developing measures to reduce potential impacts on their assets and minimise disruption to their use of the land. • No instances of fire escaping the project area.

Table 4.28 Land Use and Planning Management (cont'd)

Implementation strategy (planning, design, construction and operations)	• Design the feed gas pipeline to minimise the project land requirement and extent of potential disruption to existing and alternate land uses. [C30.01] • Site, design, construct and operate project components having regard to legislation, policy, and statutory instruments and guidelines. Compliance with design codes and standards of the project components during construction, operation and decommissioning will be assessed and determined through a range of post EIS applications for approvals, permits and licences. [C30.02] • Establish exclusion zones around the LNG plant and maritime areas to ensure the safety of LNG personnel, the public, shipping and maritime assets and do not unnecessarily prevent public access to areas of coastline. [C30.03] • Prior to construction, consult landowners within the project area on the potential direct impacts to their assets, land use activities, and any temporary disruption to supporting utility services and infrastructure. This consultation will inform the final property-specific design and mitigation measures. [C30.04] • Liaise with the Regional Harbour Master of Gladstone on the potential for telecommunications devices to affect aids to navigation infrastructure or services. [C30.05]
Inspection and monitoring	Carry out ongoing checks for compliance with agreements with landholders and infrastructure operators regarding facilities construction and operation (feed gas pipeline, tunnel operations, TWAF and mainland launch site).
Auditing	Undertake internal audits as both scheduled and unscheduled activities for implementation of agreed measures and compliance with performance criteria. Conduct regular internal audits throughout the life of the project and spot audits during ad hoc site visits. Undertake external audits when required to evaluate compliance with environment authority conditions and Arrow's HSEMS.
Reporting	Ensure reporting reflects government requirements of the project approval and is undertaken in accordance with Arrow's HSEMS requirements set out in Section 3.5 of this Strategic EMP.
Corrective action	Undertake corrective actions in accordance with the outcomes of incident investigations, audits, monitoring results or advice given by the relevant regulatory authority in accordance with Arrow's HSEMS.

4.22 Waste Management

General waste is defined as anything that is left over, or an unwanted by-product, from an industrial, commercial, domestic or other activity. Regulated waste is defined as waste that is commercial or industrial waste, whether or not it has been immobilised or treated.

Waste types generated by the Arrow LNG Plant will include general and regulated wastes in solid, liquid and gaseous forms. This section describes Arrow Energy's approach to managing waste associated with the project.

4.22.1 Existing Environment and Environmental Values

Existing waste facilities in the Gladstone Regional Council area include:

- **Licensed landfills**. The largest landfill in the area is the Benaraby Regional Landfill with an operating life of approximately 30 years plus a potential for an additional 30 years.

- **Wastewater treatment facilities**. There are two main wastewater treatment facilities located in the city of Gladstone; the Calliope River Sewage Treatment Plant and the South Trees Sewage Treatment Plant, both operated by the Gladstone Regional Council. The Calliope River Sewage Treatment Plant treats approximately 97% of Gladstone's wastewater.
- **Recycling facilities**. Recycling collection facilities exist within the Gladstone Regional Council area for wastes such as oils, concrete, tyres, paper and cardboard, glass, and some plastics. Collection points are located at transfer stations and landfills and are generally for the domestic market. Recyclable waste from commercial producers is typically collected by waste contractors who transport the recyclables for a fee to locations designated by the client, or store the recyclables at their depots until there is sufficient quantity to transport to processing facilities in southeast Queensland.
- **Commercial waste management contractors**. Several large commercial waste management contractors currently service the needs of large industrial operations located in and around Gladstone.

4.22.2 Potential Impacts

Waste management issues and impacts associated with project activities include the uncontrolled releases of waste through the failure to manage waste storage and containment systems (with potential to contaminate in soil and water and impacts to visual amenity) and the controlled releases of waste or emissions. Discharge of wastewater and air emissions could potentially lead to adverse health and ecological impacts e.g., discharge of sewage and generation of air pollutants. Table 4.29 indicates the likely types of wastes and quantities of wastes generated during the different project stages. Construction estimates have been developed using best available information in FEED. Operations estimates have been derived from experience operating similar sized LNG plants around the world.

Table 4.29 Construction and operation waste generated, estimated quantities, management and disposal methods

Waste Type	Generation Point or Source	Waste Group	Construction		Operation	Management Strategies	Disposal Methods
			Trains 1 and 2	Trains 3 and 4	Trains 1 to 4		
Solid Waste							
Green waste	Site preparation activities.	General waste	16,186 t	Minimal	Minimal	Mulched or chipped for use on site.	Re-use on site.
General waste (including food waste)	Offices and workshops, accommodation and canteen.	General waste	1,200 tpa	781.3 tpa	76.3 tpa	Non-recyclable waste will be stored in wheelie bins at the accommodation camp and lidded Merrill or skip bins at other locations. Waste will be collected on a weekly basis and removed by a licensed contractor.	Licensed landfill.
Medical wastes	LNG plant and accommodation.	Regulated	0.75 tpa	0.625 tpa	Minimal	Stored in clearly labelled sharps and clinical waste containers for periodic removal by a licensed waste contractor.	Licensed medical waste disposal facility by a commercial waste management contractor.
Waste clothes and fabric	Personal protective equipment.	General waste	3.75 tpa	3.125 tpa	0.75 tpa	Collected for removal.	Licensed landfill.
Waste polyethylene lining	Construction of pipelines and storage vessels.	General waste	20 tpa	18.75 tpa	12 tpa	Re-used or recycled where possible. Excess waste will be collected for removal.	Licensed landfill.
Waste photographic and x-ray film	Construction of pipelines and storage vessels.	General waste	8 tpa	8 tpa	Minimal	Collected for removal.	Licensed landfill.
Paint and adhesive wastes	Construction and general maintenance of plant and equipment.	Regulated	1.2 tpa	1.25 tpa	2 tpa	Waste paint and adhesives will be stored in bunded areas on site (in clearly labelled sealed containers) for removal by a licensed contractor.	Licensed waste disposal facility by a commercial waste management contractor.

Table 4.29 Construction and operation waste generated, estimated quantities, management and disposal methods (cont'd)

Waste Type	Generation Point or Source	Waste Group	Construction		Operation	Management Strategies	Disposal Methods
			Trains 1 and 2	Trains 3 and 4	Trains 1 to 4		
Solid Waste (cont'd)							
Process wastes (e.g., molecular sieve, ceramic balls, spent activated carbon, silica gel filters, waste zeolite)	Dehydration unit, acid-gas removal unit and mercury removal unit in the liquefaction process.	Regulated	Minimal	Minimal	154 tpa	Spent filtration/adsorption materials will be replaced in their units periodically. Waste will be collected from units, stored in sealed containers in a bunded area, and removed from site by a licensed waste contractor.	Analysis of the material may need to be undertaken to ascertain acceptable disposal location.
Concrete wastes	Construction of infrastructure.	General waste	2,000 tpa	1,000 tpa	30 tpa	Stockpiled in laydown area until there is a sufficient quantity to mobilise the plant to site to crush and screen waste.	In order of preference: • Re-use as fill for road base on site. • Recycling facility. • Licensed landfill.
Glass	Offices, workshops, accommodation.	Recyclable	4 tpa	3 tpa	0.6 tpa	Dedicated collection bins will be located at the LNG plant and accommodation. Bins will be collected as required by a contractor.	Recycling facility in Gladstone or southeast Queensland, if feasible.
Dust	Mercury removal unit in the liquefaction process.	Regulated	Minimal	Minimal	Minimal	Collected for removal.	Licensed landfill.
Oily rags and filters (drained)	General maintenance of plant and equipment.	Regulated	Minimal	Minimal	3 tpa	Stored in bunded areas on site (in clearly labelled sealed containers) for removal by a licensed contractor.	Licensed waste disposal facility by a commercial waste management contractor.
Ferrous and non-ferrous metal	Maintenance activities.	Recyclable	37.8 tpa	26.2 tpa	151.3 tpa	Collected on site and stored in collection bins or at a laydown area (for larger items) until there is a sufficient quantity to transport.	Recycling facility (specifically a scrap metal recycler).

Table 4.29 Construction and operation waste generated, estimated quantities, management and disposal methods (cont'd)

Waste Type	Generation Point or Source	Waste Group	Construction		Operation	Management Strategies	Disposal Methods
			Trains 1 and 2	Trains 3 and 4	Trains 1 to 4		
Solid Waste (cont'd)							
Tyres	Vehicles.	Regulated	20 tpa	12.5 tpa	7.5 tpa	Stored in dedicated waste management area until there is a sufficient quantity for a licensed waste contractor to transport.	Licensed waste disposal facility by a commercial waste management contractor.
Batteries (wet cell and alkaline)	Plant and equipment.	Regulated	2.2 tpa	1.25 tpa	4.1 tpa	Alkaline batteries to be stored separately from wet cell batteries in lidded and sealed containers in a bunded area.	Recycling facility.
Timber	Packaging and carpentry off-cuts.	General waste	40 tpa	24 tpa	36 tpa	Mulched or chipped for use on site. Millable timber may be made available to local community if there is a demand.	In order of preference: • Re-use or recycling on mainland. • Licensed landfill (subject to approval).
Oil-contaminated steel drums	Packaging.	Regulated	2 tpa	1.25 tpa	Minimal	Drums to be emptied and stored in a covered bunded area for periodic removal by waste contractor.	Re-use or licensed waste disposal facility by a commercial waste management contractor.
Insulation and slag wool	Insulation for cryogenic pipelines, tanks, ducts and load out lines to jetty.	General waste	0.75 tpa	0.5 tpa	Minimal	Collected for removal.	Licensed landfill.
Quarantine waste	Importation of materials during construction.	Quarantine	Unknown	Unknown	Unknown	Stored and managed in approved facility.	Supervised deep burial or incineration by a commercial waste management contractor.

Table 4.29 Construction and operation waste generated, estimated quantities, management and disposal methods (cont'd)

Waste Type	Generation Point or Source	Waste Group	Construction		Operation	Management Strategies	Disposal Methods
			Trains 1 and 2	Trains 3 and 4	Trains 1 to 4		
Solid Waste (cont'd)							
Paper and cardboard	Offices, workshops and accommodation.	Recyclable	80 tpa	50 tpa	30 tpa	Dedicated collection bins will be located at the accommodation camp and the LNG processing facility. Bins will be collected as required by a contractor.	Recycling facility in Gladstone or southeast Queensland, if feasible.
Biosolid sludge (dewatered)	Effluent treatment plant.	Regulated	812 to 1,280 tpa	812 to 1,280 tpa	550 to 1,100 tpa	To be pumped out periodically and tested to determine if the biosolids meet landfill disposal criteria, then transported off site by a licensed contractor.	Licensed waste disposal facility by a commercial waste management contractor.
Topsoil	Site preparation activities.	General waste	867,000 m^3	86,000 m^3	Minimal	Stored in stockpiles for use during rehabilitation.	Re-use on site.
Overburden	Site preparation activities.	General waste	43,000 m^3	Minimal	Minimal	Excess to be stockpiled on site and managed to ensure runoff is controlled and erosion is minimised.	Re-use on site.
Liquid Waste							
Used grease, lubricants and oils	Maintenance activities.	Regulated	80 tpa	40 tpa	42.3 tpa	Stored on site at the LNG plant in a bunded containment tank for removal by a licensed contractor.	Recycled at a licensed waste disposal facility by a commercial waste management contractor.
Grease trap waste	Accommodation.	Regulated	57.4 tpa	57.4 tpa	10.3 tpa	Pumped out of grease trap sump once a month, or more regularly if required, by a licensed waste contractor.	Licensed waste disposal facility by a commercial waste management contractor.
Sulfuric acid	Batteries.	Regulated	1.6 tpa	1 tpa	0.4 tpa	Stored in bunded areas on site (in clearly labelled sealed containers) for removal by a licensed contractor.	Licensed waste disposal facility by a commercial waste management contractor.

Table 4.29 Construction and operation waste generated, estimated quantities, management and disposal methods (cont'd)

Waste Type	Generation Point or Source	Waste Group	Construction		Operation	Management Strategies	Disposal Methods
			Trains 1 and 2	Trains 3 and 4	Trains 1 to 4		
Liquid Waste (cont'd)							
Hydrochloric acid	Spills in demineralisation plant.	Regulated	Minimal	Minimal	Minimal	Spills will drain to the controlled discharge facility where the first flush will be monitored.	Diverted to the effluent treatment plant or discharged to the marine outfall, depending on the quality of the effluent.
Regeneration effluent[1]	Demineralisation plant.	Regulated	Nil	Nil	216 m3/d	Diverted to observation pond where it is monitored regularly.	Untreated effluent discharged to Port Curtis.
Spent triethylene glycol, engine coolant, cleaning agents and water treatment chemicals	Vehicle, plant and equipment maintenance and operation.	Regulated	40 tpa	32 tpa	111.6 tpa	Waste chemicals will be stored in bunded areas on site (in clearly labelled sealed containers). Incompatible chemicals will be separated. Chemicals will be transported off site by a licensed contractor and treated if necessary.	Licensed waste disposal facility by a commercial waste management contractor.
Sewage and greywater[1]	Pioneer camp on Curtis Island (60 people).	Regulated	60 m3/d	Nil	Nil	Collected for disposal.	Licensed wastewater treatment plant.
	Construction workforce in Gladstone and at temporary workers accommodation facility (TWAF).	Regulated	300 m3/d	300 m3/d	Nil	Collected for disposal.	Licensed wastewater treatment plant.
	Construction workforce for tunnel, feed gas pipeline and dredging (215 people).	Regulated	64.5 m3/d	Nil	Nil	Collected for disposal.	Licensed wastewater treatment plant.
	Construction workforce on Curtis Island (2,500 people at peak).	Regulated	750 m3/d	750 m3/d	Nil	Pumped or gravity fed to the effluent treatment plant.	Effluent treatment plant for treatment, and subsequently irrigated to land.

Table 4.29 Construction and operation waste generated, estimated quantities, management and disposal methods (cont'd)

Waste Type	Generation Point or Source	Waste Group	Construction		Operation	Management Strategies	Disposal Methods
			Trains 1 and 2	Trains 3 and 4	Trains 1 to 4		
Liquid Waste (cont'd)							
Sewage and greywater (cont'd)	Typical operational workforce on Curtis Island (450 people).	Regulated	Nil	Nil	170 to 350 m^3/d	Pumped or gravity fed to the effluent treatment plant.	Effluent treatment plant for treatment, and subsequently irrigated to land.
Effluent treatment plant effluent for irrigation (design flow rate) [1]	Effluent treatment plant.	Regulated	1,246 m^3/day	1,246 m^3/day	1,246 m^3/day	Stored in a tank then treated to a level suitable for irrigation to land (Class A quality) by the effluent treatment plant, then discharged to land via irrigation system or used for toilet flushing.	Irrigation system discharge to land or re-used for toilet flushing.
Brine[1]	Reverse osmosis facility.	Regulated	1,872 m^3/d	3,744 m^3/d	3,744 m^3/d	Discharged to Port Curtis via a diffuser pipeline. Discharge will be a sufficient distance offshore to promote effective dispersion of effluent.	Diffuser pipeline discharge to Port Curtis.
Hydrostatic test water	Testing LNG storage tanks and pipeline.	Regulated	97,000 m^3 per tank	97,000 m^3 per tank	Nil	Stored in pipelines or tanks that are being tested. Water will be re-used on site for additional hydrotesting (where necessary) and discharged to Port Curtis (if water quality meets discharge guidelines) or to the effluent treatment plant or sewer mains for treatment.	Re-used on site and discharged to Port Curtis or effluent treatment plant.
Gas turbine washwater[1]	Periodic gas turbine washing.	Regulated	365 m3/d	365 m3/d	730 m3/d	Diverted to the effluent treatment plant for treatment.	Effluent treatment plant.
Ballast water	Shipping.	Regulated	Unknown	Unknown	Unknown	Managed in compliance with the International Convention for the Prevention of Pollution from Ships (MARPOL) and the Australian Quarantine and Inspection Service's Australian Ballast Water Management Requirements (AQIS, 2008).	As per MARPOL and AQIS (2008) requirements.

Note: tpa = tonnes per annum.

[1] Preferred option is for waste water and effluent to be disposed of through sewer mains, which will not require direct discharge to land, Port Curtis or effluent treatment plant.

4.22.3 Waste Management

Arrow Energy will adopt appropriate mitigation and management measures to address potential waste management impacts from the project.

All project-related activities from design and planning through to decommissioning are found in Table 4.30.

Table 4.30 Waste management

Element/issue	Management of general and regulated wastes generated by the project.
Environmental and social objectives	• To minimise the generation of waste through avoidance, reuse, recycling, and treatment and disposal activities. • To preserve the integrity, ecological function and environmental values of air, land and water environments through effective waste management strategies.
Performance criteria	• No contamination of land, air or water from the inappropriate management of waste. • No community complaints from the inappropriate management of waste.
Implementation strategy (planning, design, construction and operations)	**Avoidance and Minimisation** • Implement employee training and other programs that encourage employees to reduce waste. [C31.01] • Ensure that contractors comply with Arrow's Health, Safety and Environmental Management System (HSEMS) and implement a waste management plan in accordance with the procedure. [C31.02] • Substitute raw materials or inputs with an equivalent, less hazardous or toxic material, where practical. [C31.03] • Institute good housekeeping and operating practices, including substituting materials for an equivalent and more environmentally friendly option and inventory control to reduce the amount of waste resulting from materials that are out of date, off specification, contaminated, damaged, or excess to project needs. [C31.04] • Implement stringent waste segregation processes to prevent the co-mingling of water and waste streams. [C31.05] • Clear the smallest construction footprint practical, thereby reducing the generation of greenwaste, acid sulfate soils, overburden, topsoil and greenhouse gases. [C31.06] **Recycling and Re-use** • Evaluate waste production processes and identify potentially recyclable materials. [C31.07] • Identify and recycle products that can be reintroduced into the process or activity at the site. [C31.08] • Establish recycling objectives and formal tracking of waste generation and recycling rates. [C31.09] • Install dedicated skip bins for designated wastes around the construction site. [C31.10] • Establish a dedicated waste sorting or laydown area early in the project. Store inert material such as concrete in this area and periodically crush and screen when sufficient quantity has been gathered. Use crushed material as rock base and fill, or dispose to landfill. [C31.11] • Mulch leaves, branches and timber on site and use this for site stabilization or erosion control and landscaping. [C31.12]

Table 4.30 Waste management (cont'd)

Implementation strategy (planning, design, construction and operations) (cont'd)	• Collect and recycle ferrous and non-ferrous metals, paper and cardboard, glass, spent sulfuric acid and batteries and waste oils. Dispose of solid wastes that cannot be recycled or reused at a landfill or licensed facility. [C31.13] • Require suppliers to consider measures and options to reduce packaging and increase recycling. Include this requirement in the tendering and contracting process. [C31.14] **Storage and Handling** • Store wastes in a manner that prevents the co-mingling of, or contact between incompatible wastes and that allows for inspection between containers to monitor leaks or spills. [C31.15] • Provide adequate ventilation where volatile wastes are stored. [C31.16] • Provide hardstanding surfaces at oil storage areas, fuel filling points and the mechanical repair shop. [C31.17] • Store fuels, chemicals and hazardous wastes in appropriately sized bunded storage facilities (in leak proof sealed containers). [C1404] Common with Section 4.2.3, Geology, Landform and Soils. • Install drainage and sump systems in appropriately sized bunded compounds to assist with the removal of any waste materials released into the containment system. [C31.18] • Locate stockpiles of waste materials (such as concrete, tyres and waste polyethylene) in dedicated laydown areas with appropriate drainage. [C31.19] • Label all storage containers for clear identification of the contents as per the appropriate regulations. [C31.20] • Develop appropriate spill prevention and response plans to cover project activities and the types and quantities of fuel, oil and chemicals held at each site. [C13.12] Common with Section 4.4.3, Surface Water Hydrology and Water Quality, and Section 4.5.3, Groundwater. • Train all relevant personnel in spill response and recovery procedures. [C13.13] Common with Section 4.4.3, Surface Water Hydrology and Water Quality, and Section 4.7.3, Marine Water Quality and Sediment. • Cover waste storage bins for domestic and food wastes. [C31.21] • Use an appropriately licensed contractor to collect (on a regular basis) waste generated from accommodation quarters. [C31.22] • Strip topsoil from areas of planned soil disturbance to provide material for rehabilitation, where practical. [C31.23] • Stockpile excess overburden (that is not suitable for hardstand use or site fill) on site, where practical. Overburden will be managed to ensure run-off is controlled and erosion is minimised. [C31.24] • Handle waste chemicals in accordance with the appropriate material safety data sheet (MSDS). [C31.25] • Provide sufficient space to allow for the segregation and storage of wastes. [C31.26] **Treatment** • Treat the following wastes in the effluent treatment plant, with the exception of sewage from the pioneer camp and the TWAF: – Contaminated or potentially contaminated stormwater from process areas at the LNG plant. – Dry weather flow such as water from wash down bays and liquids wastes from the laboratory.

Table 4.30 Waste management (cont'd)

Implementation strategy (planning, design, construction and operations) (cont'd)	– Effluent from LNG operations such as wastewater and slops oil from the boil- off gas compressor area and the flare knock- out water. – Gas turbine wash water. – Oily water from the slops oil tank. – Sewage and greywater from the accommodation areas and the LNG plant. [C31.27] • Collect sewage and greywater generated from the pioneer camp in portable disposal units or other mobile collection facilities. Use a licensed waste contractor to service the sewage facilities and dispose of effluent at a licensed waste management facility. Dispose of sewage from the mainland TWAF through a connection to the local sewerage network or ensure that it is collected in portable disposal units or other mobile collection facilities. [C14.08] Common with Section 4.5.3, Groundwater. • Design the effluent treatment plant package units to meet the final effluent discharge requirement. [C31.28] • Design the effluent treatment plant based on the first 30 minutes of peak rainfall flow estimation from process areas. [C31.29] • Monitor treated effluent and reroute any discharge that is off-specification back to the effluent treatment plant for retreatment. [C31.30] • Make alternative storage and disposal options available during times of system failure and in conditions preventing discharge to land such as rain events. Distribute the effluent treatment plant discharge to tanks for reuse on site. The tanks can be by-passed and the treated effluent discharged to the marine outfall if necessary. [C31.31] • Maintain records of inspection, maintenance, sampling, and cleaning of the effluent treatment plant. [C31.32] **Disposal** • Do not dispose of any waste in landfills or by incineration on Curtis Island. [C31.33] • Irrigate to land or reuse on site treated wastewater from the effluent treatment plant. [C31.34] • Develop a recycled water management plan for the project. Undertake a site assessment and desktop study to select appropriate sites, vegetation and irrigation methods to support the development of the plan. [C31.35] • Direct brine from the reverse osmosis plant into Port Curtis via a diffuser outfall pipe located a sufficient distance offshore to ensure free flowing current conditions to adequately disperse the brine. [C31.36] • Collect the clean catchment run off through peripheral drains at the LNG plant site discharging to Port Curtis. [C31.37] • Design of the discharge outfall from the LNG plant will include a three-port diffuser at the end of the pipeline located close to the water surface (or the ports angled towards the surface) to maximise dilution of the negatively buoyant discharge stream. [C16.01] Common with Section 4.7.3, Marine Water Quality and Sediment. • Install signs on site clearly indicating drains that discharge directly to the marine environment. [C31.38] • Transport excess concrete to the mainland for disposal or re-use if there is no use for the material on site. [C31.39] • Manage all surface water generated from the LNG plant site by a stormwater treatment system to ensure discharged water complies with regulatory requirements. [C13.10] Common with Section 4.4.3, Surface Water Hydrology and Water Quality

Table 4.30 Waste management (cont'd)

Implementation strategy (planning, design, construction and operations) (cont'd)	• Engage an appropriately licensed waste contractor (on an as-required basis) to remove from site those specific liquid wastes that cannot be processed on site. [C31.40] • Engage an appropriately licensed waste contractor to transport off site all solid waste that cannot be reprocessed or recycled on site, for disposal at a recycler, reprocessor or other waste management facility such as a landfill. The majority of the solid waste will be disposed of at the Benaraby Regional Landfill. Agreement for the disposal of solid waste at this landfill will be obtained from Gladstone Regional Council. [C31.41] **Transportation** • Ensure all vehicles entering and leaving Curtis Island are clean and loads securely stowed, and covered where practical. [C31.42] • Record all regulated wastes removed from the site in a waste register. [C31.43] Other Management Measures • Dispose of all regulated wastes at licensed waste management sites within Queensland, unless a specialised treatment is required that is not available in Queensland at the time treatment and disposal is required. [C31.44] • Transport all regulated wastes by a waste transporter with the appropriate DERM authority to collect and dispose of the waste. [C31.45] • Ensure that vehicles transporting regulated waste are licensed to carry the particular type of waste and that operators complete appropriate waste tracking documentation. [C31.46] • Develop an emergency response plan for the project and include spill contingency or emergency measures. Make material safety data sheets available at the LNG plant and other project sites to aid in the identification of appropriate spill clean-up and disposal methods. [C31.47] • Ensure that specific spill prevention procedures cover the unloading and loading activities at the LNG jetty and MOF in accordance with applicable international standards and guidelines. Spill prevention procedures will specifically address advanced communications and planning with the receiving terminal. [C31.48] • Manage combustible wastes and ignition sources appropriately to eliminate fire hazards. [C31.49] • Divert firewater generated in process areas or other areas draining to the controlled discharge facility to the effluent treatment plant. Additional firewater will be directly discharged through the marine outfall. [C31.50]
Inspection and monitoring	Inspection and monitoring strategies and processes designed to reduce the potential impacts generated from project wastes will include the following: • Review the actual quantities and types of wastes compared to predicted waste streams and quantities, with a view to implementing improvements to waste management practices. • Regularly inspect waste storage, containment and laydown areas, waste segregation bins and stockpiles, and levels of windblown litter. Document the findings of such inspections.
Auditing	Undertake internal audits as both scheduled and unscheduled activities for implementation of agreed measures and compliance with performance criteria. Conduct regular internal audits throughout the life of the project and spot audits during ad hoc site visits. Undertake external audits when required to evaluate compliance with environment authority conditions and Arrow's HSEMS.

Table 4.30 Waste management (cont'd)

Reporting	Record and report the wastes generated by the project, including tracking of regulated wastes, and reporting on National Pollutant Inventory substances. Ensure reporting reflects government requirements of the project approval and is undertaken in accordance with Arrow's HSEMS requirements set out in Section 3.5 of this Strategic EMP.
Corrective action	Undertake corrective actions in accordance with the outcomes of incident investigations, audits, monitoring results or advice given by the relevant regulatory authority in accordance with Arrow's HSEMS.

5. DECOMMISSIONING AND REHABILITATION

This chapter provides a general overview of the options, general processes, objectives, indicators and completion criteria associated with decommissioning and rehabilitation of areas that will be disturbed by project infrastructure.

The project infrastructure has a design life of approximately 25 years. Regular maintenance and refurbishment of the LNG plant and ancillary facilities is expected to extend the life of the plant beyond that timeframe. The petroleum facility and pipeline licences required for the project will be issued for 30 years, although Arrow Energy may apply to extend these licenses under the relevant provisions of the Petroleum and Gas (Production and Safety) Act. Alternatively, the infrastructure may be sufficient to support another industrial use. This will influence when decommissioning and final rehabilitation works that occur.

Details of final land uses following decommissioning and rehabilitation are currently unknown and therefore site specific objectives, indicators and completion criteria cannot be developed at this time. The site will be used in accordance with the relevant zoning and regulatory framework at the time.

Impacts on environmental values and corresponding management measures relating to the decommissioning and rehabilitation phase of the project are presented in Chapter 4 of this Strategic EMP.

5.1 Decommissioning and Rehabilitation Goals

The goals of decommissioning and rehabilitation are to ensure that the project area is:

- Safe to humans, wildlife and animals.
- Non-polluting.
- Stable (landforms).
- Able to sustain an agreed land use.

Prior to decommissioning, detailed objectives, criteria and performance indicators will be developed for each of the above goals in consultation with the appropriate regulatory agency and landowners and based on the future proposed use of the land.

5.2 Rehabilitation Phases

Rehabilitation of disturbed areas will be undertaken in two phases: during construction and operation, and following decommissioning. The requirements are essentially the same, to produce a stable self-sustaining landform that supports the end use. The scope of these activities does vary.

Progressive rehabilitation will occur during construction, operation and maintenance to stabilise work areas that are no longer required for construction or operational purposes, and to remediate land disturbed by maintenance activities. Consequently, it will typically preserve landforms created during construction and use vegetation communities and plant species that are compatible with the current use.

Final rehabilitation occurs post decommissioning (as part of that phase) and involves, where necessary to the final land use, reshaping the site to produce a stable landform. Revegetation will reflect the end use and may involve establishment of a vegetation community using endemic species of local provenance that is reflective of adjacent ecological communities. Some infrastructure may be suitable to support the future land use at the time and may therefore remain in place and become the responsibility of the future land user.

5.3 Progressive Rehabilitation Management Measures

Rehabilitation will be undertaken progressively to reduce prolonged exposure of soils. Batters and embankments will be rehabilitated and revegetated as soon as practical after excavation and final shaping. Endemic and/or sterile grasses and mulch will be used to stabilise batters and embankments.

Long-term stockpiles will be protected from erosion through the installation of erosion control structures and, where appropriate, revegetated with endemic or sterile grasses.

Following construction and start-up, the site will be cleaned up and temporary work sites no longer required for future development rehabilitated. Some temporary work sites will remain in place so they can be used during construction of stage 2 of the project. This progressive rehabilitation will involve the removal of construction waste materials, surplus material and scrap, temporary buildings, construction equipment and the remediation of any contamination. Project areas that are no longer required for construction or support services will be reinstated and revegetated, initially with sterile grasses and then with perennial grasses to establish a stable landform and cover that satisfies safety and the site's security requirements.

Where practical, revegetation will use endemic species propagated from seed collected at the site prior to vegetation clearing. Ecosystems, flora and wildlife habitats protected from construction activities (e.g., semi-evergreen vine thicket and Cupaniopsis sp. at Boatshed Point) will be monitored for weed invasion and weed control undertaken if infestations are detected.

Areas that will remain exposed until construction of LNG trains 3 and 4 (e.g., lay down areas, LNG train bench and quarantine area) will be stabilised to prevent erosion of exposed soils. Surface water and stormwater runoff collection and discharge systems will be regularly inspected to ensure they are functioning effectively, and that there is adequate capacity in settling and retention ponds to contain and control the discharge of runoff in a storm event.

Rehabilitated areas will be regularly inspected and remedial works undertaken to address any failed or failing works or revegetation.

5.4 Decommissioning and Final Rehabilitation Management Measures

A decommissioning and final rehabilitation plan will be prepared and approved by the relevant authority at least 12 months prior to the planned closure of the LNG plant. The plan will adopt standards and good industry practices applicable at that time. It will prescribe performance criteria and a warranty period that will include inspection and monitoring to ensure the desired outcome – a stable self-sustaining landform – is achieved.

The following section provides a brief summary of the decommissioning activities that will be implemented as a part of the closure of the LNG plant, marine facilities and feed gas pipeline.

Decommissioning of LNG Plant

The LNG plant will be decommissioned in accordance with the decommissioning plan. Current expectations are that equipment that can be salvaged will be reused or resold. 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.

Prior to removal, equipment will be depressurised, purged and flushed of hydrocarbons and other products to prevent uncontrolled releases of hazardous materials, potentially leading to an explosion or site contamination.

A contaminated land site assessment, commensurate with the level of risk, will be undertaken prior to site reinstatement works to ensure any contamination is not disturbed and spread throughout the site. If any contamination is discovered, a remediation program consistent with applicable Queensland standards will be prepared and implemented.

Foundations will be excavated and removed, or demolished to at least one metre below the intended final surface. The site will be reshaped to a stable landform that, where practical, reflects the natural contours and landforms of the adjacent land. Where practical, drainage lines will be reinstated. All drainage lines will be designed and constructed to perform within the normal variation expected of watercourses on Curtis Island. The site will be revegetated with endemic species using seed collected from, or adjacent to, the site, where practical.

The overall aim of decommissioning will be to obtain agreement from the Queensland Government that the site has been decommissioned to agreed standards, and that the site poses negligible risk to public safety and the environment, and fulfils community expectations.

Decommissioning of Marine Facilities

The LNG jetty and loading facilities are expected to be decommissioned in a similar fashion to the LNG plant, should a future use for these facilities not be identified. The LNG jetty will be dismantled and the piles cut off at the seafloor. The structure and piles will be removed as scrap. Debris from the concrete deck and building foundations will be removed for disposal on land.

The MOF and shore protection works at the LNG jetty will be left in place. Local benthic habitat and associated flora and fauna will have adapted to the presence of these structures over the operational life of the project. In addition, the removal of these facilities is a major undertaking and would result in a greater environmental disturbance than leaving them in place.

Demolition of the mainland launch site will only occur if another use was not identified.

Decommissioning of the Tunnel

Potential third party uses of the concrete-lined tunnel under Port Curtis will be investigated as part of the decommissioning and final rehabilitation plan. These may include ongoing use of the tunnel for utilities and services, including retention of the gas pipeline for an alternative use.

If the tunnel is not required by a third party, electricity cables will be made safe and severed at the tunnel launch and reception shafts. Sewage pipes, if installed, will be flushed to remove any

residual material. The feed gas pipeline will be purged with an inert gas and made safe. Recyclable materials may be removed from the tunnel (e.g., copper-core electricity cables) if safe to do so and economically viable.

The ultimate method for rehabilitation of the tunnel will be determined through a risk assessment that will consider the long-term integrity of the structure, activities that might occur in the area and the risk of subsidence should the structure fail. Options for decommissioning the tunnel structure assume in-situ treatment.

One option involves sealing the tunnel at the launch and reception shafts with concrete plugs. Another option involves filling the tunnel, and launch and reception shafts with grout, a concrete slurry that sets to a solid sealing the void. In both cases all aboveground infrastructure, including the upper parts of the launch and reception shafts will be removed to ground level and possibly below ground level dependent on future land use. At the completion of the construction phase, the tunnel launch site and tunnel spoil disposal areas will be shaped to create a stable self-sustaining, free draining landform that will be revegetated with endemic species of local provenance. Any disturbances to this area during decommissioning of the tunnel will be rehabilitated.

Decommissioning of Feed Gas Pipeline

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

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

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

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