29. HAZARD AND RISK

This chapter identifies the key hazards and risks associated with the construction, operation and decommissioning of the Arrow LNG Plant. It focuses on hazards and risks to people and property from potentially significant incidents. The chapter focuses on the operation of the liquefied natural gas (LNG) plant and feed gas pipeline as the key hazards and risks relate to this phase of the project.

The hazards and risks discussed in this chapter have been drawn from a series of technical studies and assessments:

- Preliminary hazard and risk assessments undertaken for the LNG plant (Appendix 24).
- Preliminary Safety Management Study in Accordance with AS2885.1 of Arrow Energy's LNG Project: Feed Gas Pipeline, prepared by Planager Pty Ltd (Appendix 25).
- Arrow LNG Plant Health Impact Assessment, prepared by Arup Pty Ltd (Appendix 27).

The chapter also draws on key findings from the hazard and risk assessments contained within Appendix 29, Waste Impact Assessment, prepared by Coffey Environments Australia Pty Ltd, Appendix 26, Bushfire Hazard and Risk Assessment, prepared by Eco Logical Australia and the Appendix 15, Plume Rise Assessment, prepared by Katestone Environmental Pty Ltd.

The chapter outlines key environmental risks of potentially significant incidents associated with the project. The in-depth analysis of environmental risks arising from the project is covered in the following chapters: Chapter 10, Climate and Climate Change Adaption, Chapter 13, Surface Water Hydrology and Water Quality, Chapter 15, Coastal Processes, Chapter 16, Marine Water Quality and Sediment, Chapter 17, Terrestrial Ecology, Chapter 18, Freshwater Ecology, Chapter 19, Marine and Estuarine Ecology, Chapter 28, Traffic and Transport, and Chapter 31, Waste Management.

29.1 Arrow's Approach to Health and Safety

The Arrow LNG Plant will operate under Arrow Energy Holdings Ltd's (Arrow) Health, Safety and Environmental Management System (HSEMS) and the Shell Group Health, Safety, Security, Environment and Social Performance (HSSE & SP) Control Framework.

Arrow's HSEMS will provide the overarching framework to protect people, assets and the environment during the construction and operation of the project. Shell's HSSE & SP Control Framework will directly apply to all works associated with the design of the LNG plant. Shell's HSSE & SP Control Framework incorporates their experience in delivering some of the world's largest and most complex LNG projects over the last 40 years and includes a range of systems and procedures designed to maintain health, process safety, personal safety and environmental standards throughout the LNG plant's operation.

29.1.1 Arrow's Health, Safety and Environmental Management System

Arrow is committed to the sound management of health, safety and the environment throughout all of its business activities. The HSEMS framework is shown in Figure 29.1.

Indicates the overall HS&E objectives, expectations and intentions of the Company. Aligns with the Company's philosophy, commitments and values.

This document describes the requirements for HS&E leadership, organisational structure, planning of HS&E activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining the Arrow Energy HS&E Policies.

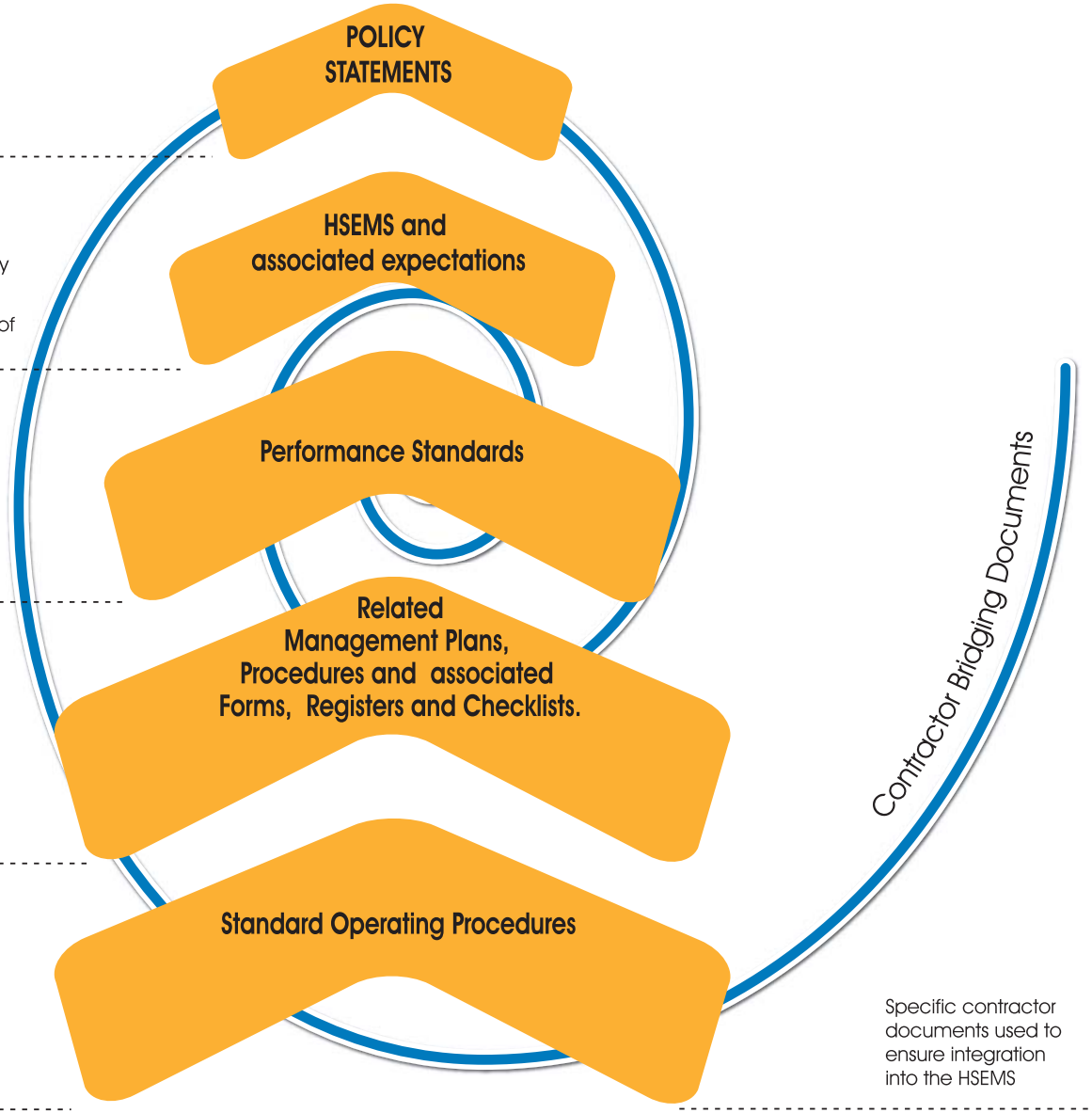
In doing so this document provides for the systematic management of the risks associated with business activities and operations.

A minimum criteria setting a standard within which Arrow Energy activities and tasks are conducted.

These documents cover various HS&E topics and are necessary to meet legislative requirements.

Provides a step-by-step guide on how to carry out and/or record a specific task.

Describe any material, equipment, documentation, etc, to be used and when.



Specific contractor documents used to ensure integration into the HSEMS

Source: Data from Arrow Energy	coffey environments	Job No: 7040	Arrow Energy	arrow energy go further	Arrow Energy's HSEMS framework	Figure No: 29.1
		File Name: 7033_07_F29.01_GL	Arrow LNG Plant			

The HSEMS is underpinned by an Occupational Health and Safety (OHS) Policy which commits the company to maintaining high standards of occupational health and safety protection and ensuring that it receives equal prominence with other business considerations in decision-making processes.

Arrow's OHS Policy also sets out the company's expectations on health and safety. These include the following:

- Personnel are 'fit for duty' and protected from all occupational injuries and illnesses.
- Operations are conducted, at a minimum, in compliance with current applicable occupational health and safety legislation and company-adopted best practices.
- The management system for occupational health and safety establishes a process to develop objectives and targets that support continual improvement.
- All aspects of occupational health and safety management are documented, transparent and assessed against performance indicators.

The Arrow HSEMS exceeds best practice standards on occupational health and safety including AS 4801:2001: Occupational Health and Safety Management Systems, and the International Occupational Health and Safety Management System Specification, OHSAS 18000 (OHSAS, 1999), and incorporates the principles of the international standard AS/NZS ISO 14001:2004: Environmental Management Systems. The HSEMS is structured around 11 key themes designed to support the target of zero harm. These relate to:

- Leadership and Commitment.
- Risk Management.
- Change Management.
- People.
- Incident and Emergency Management.
- Asset Management.
- Information Management.
- Customers, Contractors and Suppliers.
- Communication and Consultation.
- Performance Monitoring, Measurement and Reporting.
- Systems Review.

The HSEMS comprises a set of performance standards and a range of standard operating procedures designed to control and guide all aspects of work by Arrow employees and contractors.

Arrow embeds safe practices in the day to day thinking of the workforce through the application of the 12 Life Saving Rules, which are designed to support the company in implementing the requirements of the HSEMS. The rules encompass the following controls:

- All staff to work with a valid permit where required.
- Gas tests to be conducted where required.
- Verification of isolation prior to work commencing and use of specified life protecting equipment.
- Authorisation is to be obtained prior to entering a confined space.

- Authorisation is to be obtained prior to overriding or disabling any critical safety equipment.
- All persons are to protect themselves against a fall when working at a height.
- No walking under a suspended load.
- No smoking outside designated areas.
- No alcohol or drugs whilst working or driving.
- No phones to be used whilst driving and speed limits not to be exceeded.
- Seat belts to be worn at all times.
- Prescribed Journey Management Plan to be followed.

The Arrow Life Saving Rules apply to all employees and contractors engaged by the company. Disciplinary action is applicable for non-compliance with these rules. The rules clearly apply practices that protect life and the personal safety of the workforce on a day-to-day basis. The application of controls such as these by all members of the workforce also helps to build and maintain a safe work culture that will apply to other aspects of operations beyond those explicitly mentioned in the rules.

29.1.2 Shell's Health, Safety, Security, Environment and Social Performance Control Framework

Shell's HSSE & SP Control Framework, which will apply to works associated with the design of the LNG plant, is made up of:

- Group policy and commitment.
- Group standards for health, security, safety, the environment and social performance.
- Specific manuals.

The Shell Group Health, Safety, Security and Environmental Policy requires that every Shell company:

- Has a systematic approach to HSSE management designed to ensure compliance with the law and to achieve continuous performance improvement.
- Sets targets for improvement and measures, appraises and reports performance.
- Requires contractors to manage HSSE in line with this policy.
- Requires joint ventures under its operational control to apply this policy, and uses its influence to promote it in its other ventures.
- Includes HSSE performance in the appraisal of staff and rewards.

The Shell Group Commitment to Health, Safety, Security and the Environment outlines the Group commitment to:

- Pursue the goal of no harm to people.
- Protect the environment.
- Use material and energy efficiently to provide our products and services.
- Develop energy resources, products and services consistent with these aims.
- Publicly report on our performance.
- Play a leading role in promoting best practice in our industries.

- Manage HSSE matters as any other critical business activity.
- Promote a culture in which all Shell employees share this commitment.
- Respect our neighbours and contribute to the societies in which we operate.

The aim is to achieve HSSE performance to be proud of, to earn the confidence of customers, shareholders and society at large, to be a good neighbour and to contribute to sustainable development.

Shell's HSSE & SP Control Framework contains a series of manuals, which detail the various standards and procedures to ensure that health, safety, security and environmental hazards and risks are effectively managed.

29.1.3 Health and Safety Principles on the Project

The project will pursue the goal of no harm to people by ensuring that risks meet the target risk criterion set for the project. As described in this chapter, quantitative risk assessment will continue to be used to identify hazards and risks on the project.

The principal design objective for the project has been an LNG facility that is safe and meets environmental, regulatory, constructability and operability requirements. Safety hazards are being managed through the application of engineering and site-selection controls during design wherever possible, supplemented by procedural and behavioural controls and then any specific site controls where required. The LNG plant will be designed to maintain integrity during all foreseeable operating conditions (e.g., start up, shut down, and normal operation) so that no uncontrolled loss of containment will occur. Further information on the design and safety controls to be applied is provided in Section 29.4.

Project-specific HSSE plans will be developed by Arrow Energy and the front end engineering and design (FEED) contractor to supplement information provided in the HSSE & SP Control Framework and HSEMS, and will detail health, safety and environment (HSE) principles and minimum standards to be applied during the design, construction and operational phases of the project.

29.1.4 Training, Awareness, Competence and Well Being of Personnel

Arrow Energy will employ trained and qualified personnel for all work associated with the design, construction, operation and decommissioning of the project. HSE 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 will:

- Review standard operating procedures.
- Review hazards and control measures.
- Present consequences and impacts of departure from hazard and control measures.
- Reinforce the role of hazard and control measures in achieving company and business unit objectives and targets.
- Cover all emergency response procedures.
- Be regularly evaluated to ensure the required learning outcomes are being achieved.

Retraining and other professional development activities will be identified and implemented as necessary to ensure that personnel have the capacity to adequately perform their duties.

A range of policies and programs will be implemented on the project to maintain the wellbeing of personnel. These will include:

- Provision of welfare and recreation facilities.
- Provision of a counselling service (including drug and alcohol services).
- Implementation of a range of Arrow policies including the OHS Policy, Drug, Alcohol and Contraband Policy, Duty to Stop Work Policy and Fit for Duty Policy.
- Enforcement of smoking regulations on site.
- Restrictions on working hours to reduce worker fatigue.
- Provision of nutritionally balanced food to all personnel working on site.

29.1.5 Safety in the LNG Industry

The LNG industry has a favourable safety record. The physical and chemical properties of LNG itself enable hazards and risks to be easily defined and incorporated into technology and operational controls. The broad set of standards, codes and regulations that now apply to the LNG industry also assist in maintaining a high safety record. The small number of serious accidents and fatalities that have occurred at onshore facilities, particularly in the early years of the industry, have led to improvements in design and the introduction of more stringent regulatory requirements.

In over 40 years of LNG storage and terminal operations world wide, there have been no significant offsite public injuries or property damage. Millions of tonnes of LNG have also been transported, stored and used in the past 40 years, without any serious public exposure.

29.2 Legislative Context and Standards

This section describes the key legislation, policy and standards relevant to hazard and risks associated with the project.

29.2.1 Commonwealth and State Legislation

The following Commonwealth and Queensland legislation are relevant to the project:

- *Maritime Transport and Offshore Facilities Securities Act 2003* (Cwlth). This act aims to safeguard against unlawful interference with maritime transport and offshore facilities and reduce the vulnerability of ships to terrorist attacks and other unlawful activities. It establishes a regulatory framework for the development of security plans for ships, other maritime transport operations and offshore facilities. Should the Port of Gladstone be declared a security operated port and Arrow Energy a port facility operator, the company would be required to prepare a maritime security plan in accordance with the act.
- *Navigation Act 1912* (Cwlth). The act and associated Navigation (Collision) Regulations 1982 set out the measures to be observed to prevent collisions at sea in accordance with the international regulations for preventing collisions at sea. The act also requires the consignor to give notice of the shipping of dangerous goods.
- *The Airports Act 1996* (Cwlth). This act establishes the system for regulating airports and protecting airspace at and around airports. Any activity that intrudes into the protected airspace of an airport (including tall stacks and buoyant plumes from industrial facilities) is

considered a controlled activity requiring approval. Predictions of plume heights for the project have been undertaken as a part of this EIS (see Appendix 15, Plume Rise Assessment).

- *Petroleum and Gas (Production and Safety) Act 2004* (Qld). This act, administered by the Department of Employment, Economic Development and Innovation, facilitates the development of a safe, efficient and viable petroleum industry in Queensland. Licences are required under the act to construct and operate the LNG plant and feed gas pipeline.
- *Dangerous Goods Safety Management Act 2001* (Qld). This act provides an overarching framework that together with the Dangerous Goods Safety Management Regulation 2001, outline the requirements for the safe management, storage and handling of hazardous materials. The Arrow LNG Plant is likely to be classified as a major hazard facility under the act as the stored quantities of LNG would exceed the prescribed quantity of 200 tonnes. Under the act, a major hazard facility is required to have in place a safety management system, a safety report and emergency management plan.
- *Workplace Health and Safety Act 1995* (Qld). This act sets out the obligations and requirements for risk minimisation and health and safety management for workplaces, work activities and the use of plant and substances in Queensland. It seeks to protect the health and safety of people at a workplace, while undertaking work activities or using plant and substances. The act applies to the construction, operation and commissioning of the LNG plant.
- *Transport Infrastructure Act 1994* (Qld). This act aims to provide a regime for effective integrated planning and efficient management of transport infrastructure. It includes provisions for the management of road transport (e.g., for oversized equipment during construction activities) and for transport within ports (in this case for LNG maritime transport). Approvals under this act will be required for the transport of oversized loads.
- *Fire and Rescue Service Act 1990* (Qld). This act and associated regulations provide for the prevention of and response to fires and other incidents endangering persons, property or the environment. Bushfire risks associated with the Arrow LNG Plant will need to be managed in accordance with this act. An assessment of the hazard and risk of bushfires (Appendix 26, Bushfire Hazard and Risk Assessment) has been undertaken as a part of this EIS to assess and manage bushfire risk for the project.
- *Electrical Safety Act 2002* (Qld). This act sets the obligations and requirements for electrical safety during work on electrical equipment and includes work by electricity suppliers. The requirements of the act will apply to all electrical work carried out on the project.

29.2.2 Policies and Strategies

The following polices and strategies are relevant to the project:

- State Planning Policy (SPP) 1/02: Development in the Vicinity of Certain Airports and Aviation Facilities. SPP 1/02 provides controls on development and land use in the vicinity of aeronautical installations to ensure that the safety and operational efficiency of aviation facilities are not affected and the public is not exposed to any risks. The closest airport (Gladstone Airport) is located approximately 9 km from the Arrow LNG Plant.
- SPP 1/03: Mitigating the Adverse Impacts of Flood, Bushfire and Landslide. SPP 1/03 details requirements to consider natural hazards such as flood, bushfire and landslide when making decisions about development. In accordance with this policy, the Arrow LNG Plant will be

required to minimise the potential adverse impacts of flood, bushfire and landslide on people, property, economic activity and the environment

- Queensland Counter-Terrorism Strategy 2008–2010 (Queensland Government, 2007b). This strategy aims to prevent terrorist attacks, reduce the vulnerability of the state to terrorist attacks, and minimise the impact of any potential terrorist incident. The strategy provides the strategic direction for the development and implementation of counter-terrorism initiatives across government.

  The Arrow LNG Plant is likely to be classified as a major hazard facility under the Dangerous Goods Safety Management Act. As such it will receive special government attention in relation to security and will need to demonstrate that measures are being put in place to reduce its vulnerability to, and potential impact of a terrorist attack.

29.2.3 Codes and Standards

The following codes and standards are relevant to the project:

- NOHSC:1014(2002). National Standard for the Control of Major Hazard Facilities. This standard aims to prevent major accidents and near misses and to minimise the effects of any major accidents and near misses by requiring operators of major hazard facilities to:
  - Identify and assess all hazards and implement controls to reduce the likelihood and impacts of a major accident.
  - Provide information to the relevant public authority, community and other closely located facilities on the nature of hazards at a major hazard facility and emergency procedures that apply in the event of a major accident.
  - Report and investigate any major accidents and near misses and take the appropriate corrective action.
  - Record and discuss lessons learnt and the analysis of major accidents and near misses with employees and their representatives.

  The Arrow LNG plant is likely to be classified as a major hazard facility and will need to be operated to comply with this standard.

- NOHSC:2016(1996). National Code of Practice for the Control of Major Hazard Facilities. This code provides a practical guide on how to comply with the requirements of NOHSC:1014.

- AS 2885-2007. Pipelines: gas and liquid petroleum. This suite of standards outlines the requirements for the design, construction, operations and maintenance of pipelines and associated piping and components used to transmit gas and liquid petroleum. The feed gas pipeline will be designed in accordance with these standards.

- AS/NZS ISO 31000:2009. Risk Management – Principles and Guidelines (Standards Australia, 2009). This standard provides guidelines and principles for identifying hazards and assessing and minimising risk. The standard replaces AS/NZ 4320:2004 on risk management (referred to in the Terms of Reference).

- AS 3961-2005. The Storage and Handling of Liquefied Natural Gas. This standard provides requirements for the design, construction and operation of installations for the storage and handling of LNG. It applies to two types of installations: the installation of atmospheric-type tanks for supplying marine tanker terminals and pipeline peaking and the installation of

pressure tanks. The storage and handling of LNG at the LNG plant will need to be undertaken in accordance with these standards.

- NFPA 59A Standard for Production, Storage and Handling of Liquefied Natural Gas. This code provides minimum fire protection, safety, and related requirements to inform the location, design, construction, security, operation, and maintenance of LNG plants.
- EN 1473:2007. Installation and Equipment for Liquefied Natural Gas – Design of Onshore Installations. This standard provides functional guidelines for LNG installations including procedures and practices to achieve the safe and environmentally acceptable design, construction and operation of LNG plants.

Other standards relevant to the project include:

- AS 1940-2004. The Storage and Handling of Flammable and Combustible Liquids.
- AS 3780-2008. The Storage and Handling of Corrosive Substances.
- AS 1692-2006. Steel Tanks for Flammable and Combustible Liquids.
- AS 3959-2009. Construction of Buildings in Bushfire-Prone Areas.

29.3 Assessment Method

The principles of AS/NZS ISO 31000:2009 Risk Management were adopted in the preliminary hazard and risk assessments undertaken for the project. While the specific methodology utilised has varied according to the needs and objectives of the particular specialist risk assessment, the assessment of hazard and risk involved the following key steps (in accordance with AS/NZS ISO 31000:2009):

- **Hazard identification.** A review of potential hazards and the identification of possible causes of potential incidents.
- **Consequence and effect analysis.** An assessment of the consequences of identified hazards.
- **Frequency analysis.** An estimation of the frequency or likelihood of a potential incident occurring.
- **Risk analysis.** An analysis of the risk of each incident occurring using qualitative or quantitative techniques that define risk as follows:

  Risk = Consequence x Likelihood.

  The analysis assumes that standard operating conditions and industry control measures will be in place. Table 29.1 presents the Arrow Energy qualitative risk assessment matrix used to rank risks associated with the LNG plant and shipping activities. Risks associated with the feed gas pipeline and tunnel were assessed using the risk matrix from AS2885.1-2007 (Table 29.2). For the quantitative risk analysis, the total risk was obtained by adding together the results from the risk calculations for each incident (i.e., the total risk is the sum of the risk calculated for each scenario.
- **Risk reduction.** The identification of risk reduction controls and measures.

Table 29.1 Arrow Energy risk matrix

Consequence		Rare or Practically Impossible	Not Likely, Uncommon	Has Occurred in the Past but not Common	Likely, has Occurred in Recent History	Common or Almost Certain
Operational Health and Safety impact		**Practically Impossible**	**Not Likely**	**Could Happen**	**Has Happened**	**Common**
1 or more fatalities	**Catastrophic**	15	19	22	24	25
Permanent disability	**Major**	10	14	18	21	23
Medical treatment	**Serious**	6	9	13	17	20
Minor injury	**Minor**	3	5	8	12	16
No injury	**Insignificant**	1	2	4	7	11

Risk ranking and reporting requirements	**Very High (23-25)**	Risks reported to the Board (through the (project) management structure and Risk Committee) on a monthly basis.
	High (18-22)	Risks reported to the Board (through the (project) management structure and Risk Committee) on a monthly basis.
	Medium (9-17)	Risks reported to the Risk Management Committee (through the (project) management structure).
	Low (4-8)	Risks handled by normal (project) management structure.
	Very Low (1-3)	Risks handled by normal (project) management structure.

Table 29.2 Risk matrix based on AS2885.1-2007 Pipelines – Gas and Liquid Petroleum – Design and construction

Consequence Ranking Table			Consequences				
			Catastrophic	**Major**	**Severe**	**Minor**	**Negligible**
Receptors	**People**		Multiple fatalities.	Few fatalities or several people with life threatening injuries.	Injury or illness requiring hospital treatment.	Injuries requiring first aid treatment.	Minimal impact on health.
	Supply		Long term interruption.	Prolonged interruption or long-term restriction.	Short term interruption or prolonged restriction.	Short term interruption or restriction but shortfall met from other sources.	No interruption or restriction.
	Environment		Effects widespread, viability of ecosystem or species affected, permanent major changes.	Major off-site impact or long-term severe effects or rectification difficult.	Localised (<1 ha) and short term (<2 yr) effects, easily rectified.	Effect very localised (<0.1 ha) and very short term (weeks), minimal rectification.	No effect or minor on site effects rectified immediately with negligible residual effect.
Risk Matrix			**Consequences**				
Frequency	**Frequent**	Expected to occur several times (1 in 10 events).	Extreme	Extreme	High	Intermediate	Low
	Occasional	May occur occasionally (0.1 – 10 events).	Extreme	High	Intermediate	Low	Low
	Unlikely	Unlikely to occur but possible (0.1% - 10%).	High	High	Intermediate	Low	Negligible
	Remote	Not anticipated for this pipeline at this location (0.001 – 0.1% probability).	High	Intermediate	Low	Negligible	Negligible
	Hypothetical	Theoretically possible but has never occurred on a similar pipeline (<0.001% probability).	Intermediate	Low	Negligible	Negligible	Negligible

The following standards, policies and guidelines were also used to guide the hazard and risk assessment method for particular technical studies:

- AS 2885-2007: Pipelines – Gas and Liquid Petroleum. This standard informed the assessment of hazards and risks associated with the feed gas pipeline.
- SPP 1/03: Mitigating the Adverse Impacts of Flood, Bushfire and Landslide. This policy informed the Bushfire Hazard and Risk Assessment.
- The Civil Aviation Safety Authorities' Guidelines for Conducting Plume Rise Assessments (CASA, 2004). This guideline informed Appendix 15, Plume Rise Assessment.

29.4 Key Findings

This section outlines the findings of the analysis into hazards and risks associated with the construction, operation and decommissioning of the Arrow LNG Plant. Emphasis is given to the potential exposure of people (including the general public and workforce) to hazards inherent in the project. The project design incorporates extensive safety controls as a part of its compliance with engineering standards and this section therefore focuses on the residual risks associated with the project.

29.4.1 LNG Plant

This section outlines the key hazards and risks associated with the LNG plant based on the preliminary risk assessments undertaken for the project.

Hazardous Materials

The key hazards associated with the operation of the LNG plant relate to the production, handling and storage of large quantities of flammable coal seam gas, LNG and refrigerants. Table 29.3 contains a preliminary listing of the anticipated (typical) inventories and yearly consumption of hazardous materials to be used during operation. These substances have the potential to cause injury or exposure to people in the vicinity or in the event of a release and to contaminate land and water resources.

Table 29.3 Potentially hazardous materials to be utilised, stored and transported on site

Chemical/Product	Area of Use	Anticipated Storage Quantity
Coal seam gas (Dangerous Goods Class 2.1 flammable gas)	Gas transmission pipeline and onsite pipelines to the liquefaction unit.	No onsite storage of natural gas. Inventories in process piping and vessels. Pressurised pipeline.
LNG (Dangerous Goods Class 2.1 flammable gas)	Storage tanks (two, with one optional future tank).	2 x (up to) 90,000 t with an option for one additional (up to) 90,000 t tank. Stored liquefied under cryogenic conditions.
Refrigerants (Dangerous Goods Class 2.1 flammable gas)	Refrigeration gas for the liquefaction unit.	2,100 m^3 of propane. 450 m^3 of ethylene. Stored liquefied under pressure.

Table 29.3 Potentially hazardous materials to be utilised, stored and transported on site (cont'd)

Chemical/Product	Area of Use	Anticipated Storage Quantity
Oil, lubricant and diesel fuel (no dangerous goods code, combustible liquid)	Rotating machinery, firefighting pump, the back-up generator and other rotating machinery.	Oil and lubricant: Up to 180 m^3 (initial fill) with a yearly consumption of up to 45 m^3. Diesel fuel: 300 to 600 m^3. Stored under atmospheric conditions.
Amine (Dangerous Goods Class 3 flammable liquid)	Gas conditioning (carbon dioxide removal).	1,200 to 2,400 t (yearly consumption: 250 to 400 t). Stored under atmospheric conditions.
Corrosive liquid, including sodium hydroxide, sodium hypochlorite, sulfuric acid (Dangerous Goods Class 8 corrosive liquid)	Water treatment.	10 to 20 m^3 (yearly consumption: 50 to 320 m^3). Stored under atmospheric conditions.
Various laboratory chemicals (various dangerous goods classes)	Laboratory.	Less than 5 m^3. Stored under atmospheric conditions.

Coal seam gas is a buoyant, flammable gas, which is held under pressure in pipelines and process plant pipes. It is lighter than air and, on release into the atmosphere, tends to rise rapidly and disperse to below hazardous concentrations unless it encounters an ignition source. Potential hazards associated with coal seam gas include fire, boiling liquid expanding vapour explosion (BLEVE) and asphyxiation.

LNG is a cold (minus 163°C) flammable liquid, which would boil and rapidly vaporise at atmospheric temperatures. Potential hazards associated with LNG include fire, vapour cloud explosion, asphyxiation, cryogenic burn from direct contact and cold metal brittle fracture.

Refrigerants used in the liquefaction process will be composed of a mixture of commercially available hydrocarbons such as propane and ethylene. The refrigerant cycle includes the vaporisation and condensation of the refrigerant under pressure. Potential hazards associated with refrigerant include fire, explosion, cryogenic burn from direct contact and cold metal brittle fracture.

Potentially Hazardous Incidents

A preliminary risk assessment was undertaken in accordance with the principles of AS/NZS ISO 31000:2009 into the key hazards and risks associated with the construction, operation and decommissioning of the LNG plant. Table 29.4 outlines the potentially hazardous incidents associated with the production, handling and storage of large quantities of flammable coal seam gas, LNG and refrigerants as well as other potentially hazardous incidents associated with the LNG plant. Typical design and safety controls and residual risks are also identified.

Table 29.4 LNG plant hazards and safety controls

Potential Hazard	Typical Design and Safety Controls	Residual Risk
Construction		
Ignition of flammable or combustible material used in construction leads to a fire incident, injury and/or destruction to property, the environment.	Hazard and Effect Management Plan (HEMP) for construction and commissioning will include requirements for safe handling of flammable and combustible material and control of ignition sources - undertaken through a combination of hardware features (e.g., bunding, separation, isolation, clean up, segregation, train separation) and procedural controls. The construction camp will be located well away from the hazardous effects of fires and explosions.	High
Purging and start-up results in a release of gas, which catches fire.	All purging activities during construction and commissioning will be conducted using inert gas (such as nitrogen or other). A pre start up audit will be carried out before the introduction of any hydrocarbons, as part of the construction philosophy. Construction personnel to be located well away from the hazardous effects of an ignition of any flammable gases during commissioning and start-up activity. Train separation, isolation and procedural controls will apply.	Medium
Health and safety when working at heights, under heavy loads, in confined spaces, with hazardous materials, exposure to dangerous insects and wildlife, excessive noise leads to injury or death of workers.	The HEMP for construction and commissioning will include requirements for training, lock out/tag out, isolation, personal protective equipment and Job Safety Environmental Analysis (JSEA) for all work at height or work under heavy load and measures to mitigate against slip-trip and fall injuries. An environmental management plan will be developed for offsite risks. Confined space and electrical work to comply with relevant Australian standard. Mosquito and vector-borne disease management controls will be put in place to control the potential for disease.	Low – High
Operation		
Leak in pipe or equipment handling coal seam gas, LNG or refrigerants leads to loss of containment of flammable gas or LNG and fire or vapour cloud explosion.	The LNG plant will be designed in accordance with relevant Australian standards and codes. A preventative maintenance and inspection program will be adopted and include a non-destructive testing regime. Gas and fire detectors with alarms will be installed throughout the LNG plant to detect any upset operating conditions. Emergency response procedures will be adopted. A leak detection system with alarm will be in place to detect any potential accumulation of LNG.	High
Uncontrolled release from an LNG storage tank (mechanical impact, overfill, over pressure, under pressure, stratification) leads to localised cold metal brittle failure, asphyxiation and cold burn, fire and explosion.	The storage tanks will be designed and assembled in accordance with relevant Australian standards and codes. Quality control and tests will be undertaken during the construction of the tanks. Spills will be directed away from the tank to the trench and sump. The spacious site layout limits places where gas can accumulate. Gas and fire detectors with alarms will be installed throughout the LNG plant to detect any upset operating conditions. Emergency response procedures will be adopted. A leak detection system with alarm will be in place to detect any potential accumulation of LNG.	High

Table 29.4 LNG plant hazards and safety controls (cont'd)

Potential Hazard	Typical Design and Safety Controls	Residual Risk
An uncontrolled release or BLEVE associated with a refrigerant storage tank leads to a hazardous event and injury and/or destruction to property, the environment.	The storage tank will be designed and assembled in accordance with relevant Australian standards and codes. Quality control and tests will be undertaken during the construction of the tanks. Spills will be directed away from the tank to the trench and sump. The sspacious site layout will limit places where gas can accumulate. Gas and fire detectors with alarms will be installed throughout the LNG plant to detect any upset operating conditions. Emergency response procedures will be adopted.	High
Maintenance failure creates ingress of air into natural gas piping and vessels and subsequent start-up without adequate purging resulting in an explosion and injury and/or destruction to property, the environment.	A range of start-up, shutdown and maintenance procedures, including purging procedures will be adopted. A limited amount of gas will be present in process piping isolated for maintenance to minimise potentially damaging effects if an incident were to occur. Emergency response procedures will be adopted.	Medium
Gas turbine failure leads to a fire or explosion and injury and/or destruction to property, the environment.	The gas turbines will be maintained in accordance with a preventative maintenance schedule developed. Gas and fire detectors with alarms will be installed throughout the LNG plant to detect any upset operating conditions. Ventilation systems will be appropriately designed and maintained. Emergency response procedures will be adopted.	Medium
Health and safety when working at heights, under heavy loads, in confined spaces leads to injury or death of worker.	The LNG plant will be designed to limit health and safety hazards to workers on site (e.g., areas where cryogenic/asphyxiant gas may accumulate in the event of a loss of containment). All maintenance works will be undertaken in accordance with relevant standards and codes. The safety management system will include requirements for a JSEA for all hazardous or non-routine work. All work will be required to comply with the permit to work system. Appropriate training of personnel will be provided.	Low-Medium
Environmental pollution from failure to contain environmentally polluting materials such as heating fluid, amine, mercury, lubrication oil, diesel and fire water lead to pollution of the receiving environment.	Chemicals will be stored and handled in accordance with the relevant Australian standard and Arrow's chemical management procedure. Piping, vessels, storage tanks will be designed in accordance with relevant standards and codes. Alternative storage and disposal options will be available during times of system failure and in conditions preventing discharge to land such as rain events. Spills will drain to the site drainage systems and surface water directed through a treatment system designed to remove oil and grease. Emergency response procedures will be adopted.	Low

Table 29.4 LNG plant hazards and safety controls (cont'd)

Potential Hazard	Typical Design and Safety Controls	Residual Risk
External incidents cause road transport accident that leads to the release of flammable material or the intrusion of flares and other tall stacks into protected airspace lead to an aircraft crash.	Specific approval will be sought for protruding tall structures, if required. The handling of dangerous goods will be undertaken in accordance with Australian Dangerous Goods Code requirements. Access roads to the site and access at local intersections will be appropriate for use and well maintained. A detailed traffic management plan will be prepared. Ethylene and propane ISO containers will be equipped with emergency shutdown systems.	Low - Medium
Intentional acts threaten security threat or terrorism leads to damage to LNG plant or associated infrastructure.	The LNG plant will be designed in accordance with relevant Australian standards and codes. The LNG plant will be fenced and access controlled. Security measures will comply with major hazard facility and Queensland Counter-Terrorism Strategy requirements. Gas and fire detectors with alarms will be installed throughout the LNG plant to detect any upset operating conditions.	Medium
Natural events including flooding, storm surge, bushfire, seismic activity, land subsidence and/or lightning strike lead to damage of plant, loss of containment of flammable gas and fire or explosion.	SPP 1/03 Mitigating the Adverse Impacts of Flood, Bushfire and Landslide and Queensland's Coastal Policy will be complied with. Structures and equipment will be designed in accordance with relevant Australian and International standards for the management of seismic and lightning risks. The integrity of foundations for the LNG storage tank, as well as the subsurface integrity, will be assessed prior to construction. Waterway diversions and associated flood corridors will be designed to manage a minimum of a 1:100 year average recurrence interval event. An emergency response plan will be developed which details areas of responsibility and procedures to be following in the event of an emergency.	Medium
Road transport incident in which a third party vehicle or load falls off third party haul road in the state corridor and leads to uncontrolled release of flammable gas or LNG or significant electrical hazard and injury and/or destruction to property, the environment due to impact at LNG gas and power lines.	Safety barriers will be installed along haul road where adjacent to loading lines to prevent vehicles leaving road formation. Vehicle access and speed limits will apply. Haul road will be constructed to safely carry anticipated loads. Distance from safety barriers to loading lines will be greater than height of largest module. The culvert will be extended to protect loading lines at haul road crossing. A detailed traffic management plan will be prepared. Emergency response procedures will be adopted.	Medium

Table 29.4 LNG plant hazards and safety controls (cont'd)

Potential Hazard	Typical Design and Safety Controls	Residual Risk
Decommissioning		
Spill(s) during construction, operation result in contaminated soil, injury and/or environmental pollution at decommissioning.	A decommissioning safety management plan will be developed and include a JSEA with specific risk controls. Liquids such as flammable, combustible and corrosive liquids will be captured in bunds or drain to site drainage systems (LNG and refrigerants will evaporate). A contaminated land assessment and risk assessment will be undertaken prior to rehabilitation works commencing to understand the potential for any contaminated soil and manage these risks.	Low

Note: Hazards identified during construction are also relevant to the decommissioning phase.

Analysis of Key Risks

As outlined in Table 29.4, the key potential hazards and risks relate to the operation of the LNG plant. The highest risks identified relate to a loss of containment of flammable gas or LNG (due to a leak in a pipe or equipment handling LNG or LNG storage tank) leading to a fire or vapour cloud explosion. These risks have been assessed as high residual risks.

During construction, the key risks relate to the potential ignition of flammable or combustible material used in construction leading to a fire, incident or injury as well as health and safety hazards associated with work at a height or under a heavy load leading to injury. These hazards have been assessed as having high residual risks.

This section provides further detail on the key potential hazards and risks identified in Table 29.4 and the typical design and safety controls to be applied.

As described above, design and safety controls incorporate engineering and site selection controls in the first instance, followed by procedural and behavioural controls, and then any specific site controls where required.

Loss of Containment

A key potential hazard outlined in Table 29.4 is a leak or uncontrolled release during handling of gas, LNG or refrigerant that could cause a loss of containment of flammable gas or LNG and risk causing injury or damage if there was ignition. While this is unlikely to occur, it is considered a high risk given the potential catastrophic consequences.

Risks to Residents

Fatality risk contours were developed to represent the likelihood of fatality to notional individuals at locations outside the LNG plant site in the event of a fire or explosion due to a loss of containment. Individual risk at a given location is generally expressed as the peak individual fatality risk, i.e., the risk of fatality to the most exposed individual situated at a location for 24 hours of the day for 365 days of the year. Table 29.5 outlines the individual risk criteria utilised. These criteria are based on the NSW Department of Planning Hazardous Industry Planning Advisory Paper No 4: Risk Criteria for Land Use Planning (NSW Department of Planning, 2011) also adopted in the Guidelines for Major Hazard Facilities, C – Systematic Risk Assessment (Queensland Government, 2008a).

Table 29.5 Individual risk criteria

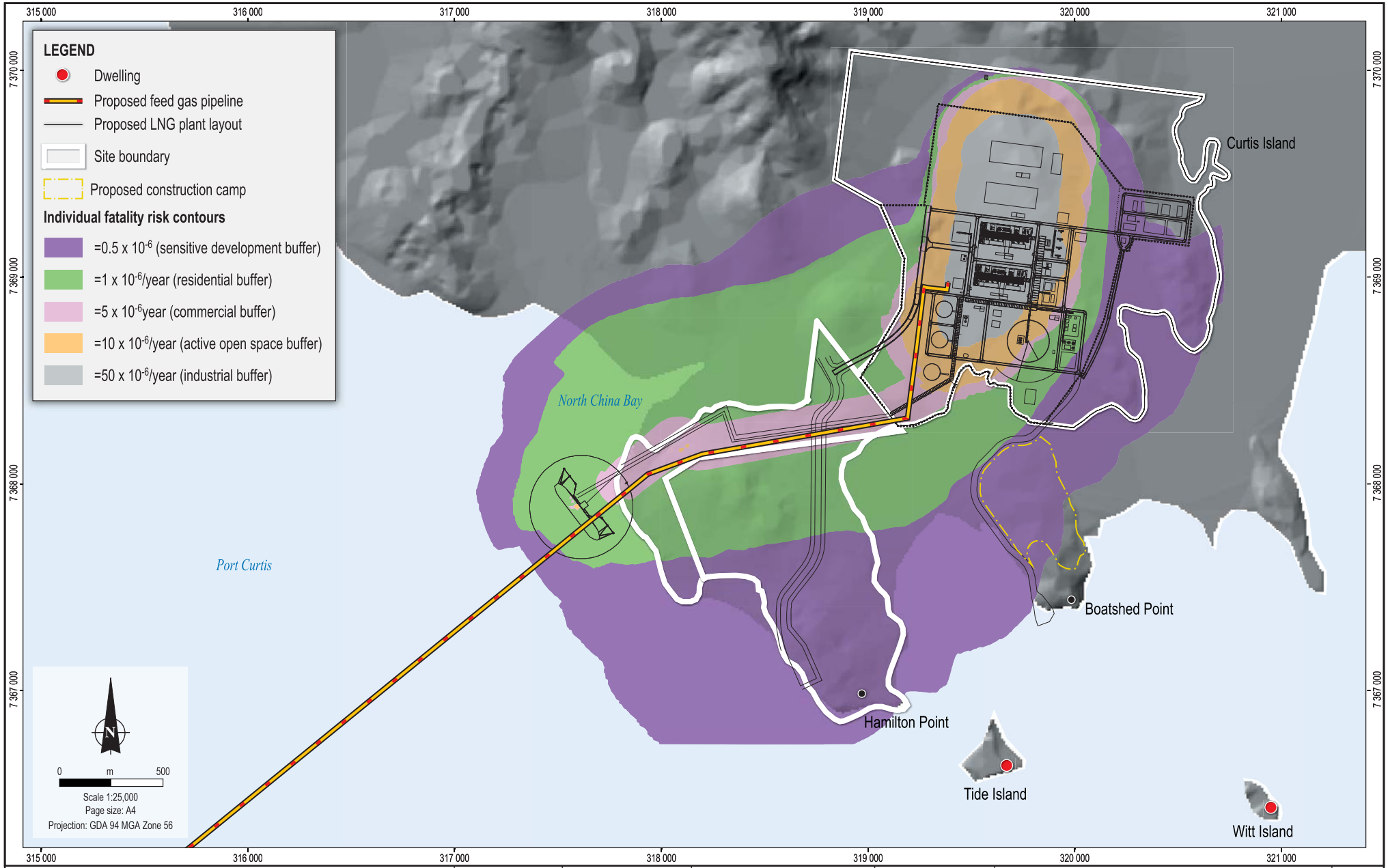
Land Use	Individual Risk Criteria (risk in a million per year)
Sensitive development (hospitals, schools, child-care facilities, old age housing)	0.5
Residential (and hotels, motels, tourist resorts)	1
Business (commercial developments including retail centres, offices and entertainment areas)	5
Active open space (including sporting complexes)	10
Boundary of an industrial site (facility generating risk) (max risk at boundary of the site which generates the risk)	50
Injury risk criteria (4.7 kW/m^2 and for 7 kPa)	50
Propagation risk criteria (23 kW/m^2 and for 14 kPa)	50

Figure 29.2 presents the individual risk contours for the LNG plant and associated LNG carrier loading and unloading. They represent the total risk due to fires (all types), explosions and BLEVE for a situation where all four LNG trains, all three LNG storage tanks, and the loading/unloading pipelines are in operation.

A comparison of the individual fatality risk results with the established risk criteria is provided below:

- The risk contour for industrial facilities, 50 x 10^{-6} per year, representing the buffer zone required to neighbouring industrial facilities, is contained within the boundary of the site.
- The risk contour for active open space (sporting complexes and recreation areas), 10 x 10^{-6} per year, representing the buffer zone required for active open space, is contained within the boundary of the site.
- The risk contour for commercial development, 5 x 10^{-6} per year, representing the buffer zone required for commercial development, is largely contained within the LNG plant site boundary but follows the LNG loading lines towards the berth where it crosses the GLNG Project haul road and encroaches into third-party-owned land and a small portion of water near the berth. No commercial developments should be located within this contour.
- The risk contour for residential areas, 1 x 10^{-6} per year, representing the buffer zone required for residential areas, extends up to 300 m in the westerly and easterly directions but remains within the site boundaries in the northerly and southerly directions. The risk contour does not encroach into any residential areas (the nearest residence is 1,660 m from the LNG plant). The risk of fatality at the nearest residence is very low and well below the maximum tolerability criteria for residential or sensitive development.
- The risk contour for sensitive development, 0.5 x 10^{-6} per year, extends beyond the site boundary up to 300 to 400 m in the westerly, southerly and easterly directions but stays within site boundaries in the northerly direction. The risk of fatality at the nearest sensitive receiver (a residence 1,660 m from the LNG plant boundary) is very low and well below the maximum tolerability criteria for sensitive development.

The injury risk of exposure to heat radiation (4.7 kW/m^2) of 10 x 10^{-6} and 50 x 10^{-6} per person per year is contained within the site boundary. The risk of injury is well below the criterion for new installations of fifty chances of risk per million years.



Source:
Place names from DME.
Site boundary and individual fatality risk contours from Shell Global Solutions, 2010.
Proposed LNG plant layout, proposed ancillary facilities and marine infrastructure from Arrow Energy.
Dwellings, proposed feed gas pipeline and digital elevation model from Coffey Environments.
Note: This figure shows pre-front end engineering design and will be updated during the front end engineering design phase

coffey environments

Date: 17.11.2011
MXD: 7033CA_07_GIS256_v1_1
File Name: 7033_07_F29.02_GIS_GL

Arrow Energy

Arrow LNG Plant

arrow energy go further

Individual fatality risk

Figure No: 29.2

The 10×10^{-6} and the 50×10^{-6} per year risk contours for injurious levels of exposure to explosion overpressure (7 kPa) are contained within the site boundary with the exception of the excursion on the northern boundary of the site where it extends into the bushland area. However, it does not extend into any residential areas and hence the injury risk criterion is not exceeded.

The 50×10^{-6} per year risk contour for propagation to neighbouring industrial facilities from heat radiation and overpressure (23 kW/m^3 and 14 kPa respectively) are also contained within the site boundary.

The societal risk was not calculated as there is currently no population within range of the calculated hazards from the site and the risk at any future neighbouring facility currently planned for Curtis Island is very low.

Risks to Workers

The qualitative risk evaluation showed that the risks to personnel or contractors during construction, operation or decommissioning will be managed through use of well-established and recognised mitigation measures, including hardware and procedural controls.

A preliminary quantitative risk assessment was undertaken of the risk to construction and process workers from a loss of containment of flammable gas or LNG during the production and storage of LNG, the transfer of LNG to LNG carriers, and the shipment of LNG. The individual risk per annum (IRPA) calculations are used to represent the risk of fatality for an individual worker (company or contractor) from all company-induced hazards relating to a work activity. The target risk criterion for the contribution to IRPA due of process-related events for the LNG plant is set at 1×10^{-4}per year. This is applicable for a construction or process worker who is properly trained to respond to an emergency and to be aware of the hazards while working on site. The IRPA calculations showed that the overall layout of the LNG plant (Figure 6.3) will adhere to the target risk criterion set for the project and will not expose personnel or contractors to undue risk during the operational phase.

For construction workers, the highest risk of 1×10^{-3}per year was found at the process equipment, which forms part of the LNG train. Away from the LNG train equipment, the risk is quickly reduced, to reach approximately 1×10^{-4}per year at a distance of 90 m from the LNG train. As most construction workers will spend the majority of their time outside of this higher risk area, their IRPA will be below the target risk criterion.

Assuming four trains are operational and the typical process worker spends 40 hours per week of their time within one train, the IRPA for this process worker has been calculated to be 1.3×10^{-4} per year. A conservative assumption is that a field worker will spend 50% of the week outside in the field and the rest of their time in either the control room or other areas outside the LNG train. Under this assumption, the IPRA would reduce to 0.65×10^{-4}per year, which is less than the target risk criterion of 1×10^{-4}per year set for the project.

To ensure a tolerable societal risk during the construction phase, construction personnel will be located well away from the hazardous effects of possible fires, explosions or BLEVEs during purging and start-up activity, ensuring minimal risk from these events. Additionally, the construction camp will be located well away from these hazards while the LNG plant is operational (Figure 29.2).

Design and Safety Controls

Appropriate risk management measures will be incorporated into the design of the LNG plant, construction methods, safety equipment and operational procedures to reduce the potential for a loss of containment and flammable release.

Safety in design (or inherent safety principles) for the project will be determined using a multi-phased approach that progresses from concept design through to detailed (final) design, construction and commissioning, operation and decommissioning.

The first phase (identify, select and pre-FEED) phase covered the project up to the end of the pre-FEED phase. The Concept Design HSE Case was prepared during this phase, providing an overview and status of HSE risks and activities for the project. The other main activities at the concept design phase included defining of the technical HSE concepts such as defining site selection, concept layout, technology selection, modelling of major accident hazards, physical effects and completing the preliminary quantitative risk assessment. The HSE Activity Plan, prepared in the concept design phase, sets the HSE activities required for subsequent phases of the project.

The second (FEED) phase covers the project up to the end of the FEED phase. In this phase registers and documentation prepared in the concept design phase will be updated as the LNG Plant design and site layout is further refined. Specifically the detailed quantitative risk assessments will be updated and a number of safety risk studies completed, including physical effects modelling (fire and explosion analysis), and fire safety review. This phase also includes a number of technical safety reviews, including a process safety report, layers of protection analysis (LOPA), hazardous area classification and drawings, and instrumented protective systems classification. At this phase, the HSE requirements for the construction and commissioning phases will also be prepared, including identifying the main risks associated with these phases. The emergency response plan, including medical emergency response, will also be developed

The third (construction and commissioning) phase includes the preparation of the security risk assessment and activity matrix during pre-construction, construction and following completion of the construction phase; pre-start-up technical safety reviews; and updating of any detailed design documentation and studies conducted in the FEED phase. Performance standards and assurance tasks for safety critical elements/equipment are developed and the detailed HSE Activity Plan for construction and commissioning is implemented.

During construction, non-routine tasks, hazardous activities (such as confined space entry) will be managed by performing appropriate risk assessments, developing detailed method statements, and executed under the permit to work system appropriate for the activities.

The fourth (operational) phase includes implementation of the HSEMS, HSEMS performance reviews, and technical HSEMS reviews. Again, non-routine tasks will undergo specific job hazard analysis and appropriate method statements will be developed. Non-routine operational activities and maintenance activities will be executed under the operations phase safe (permit to work) system. Other measures include isolation activities during maintenance, systems to control over-rides, modifications (same process as design), and major shutdown management (e.g., detailed planning, permitting, and simultaneous operations safe work practice (SIMPOS) assessments).

The fifth (decommissioning) phase includes the preparation of detailed HSE plans for decommissioning, including one or more hazard identification exercises and health hazard risk reviews, and the update of HEMP studies (conducted in the design phase). At this stage, a decommissioning HSE case would be established.

Analysis of other Hazards and Risks

This section outlines additional hazards and risks not captured through the analysis of key risks above, as identified in the preliminary hazard and risk assessments undertaken for the project.

Workplace Risks

During construction, the key health and safety risk to workers relates to working at heights or under a heavy load. To minimise the risk of worker injury, the HEMP for Construction and Commissioning will include specific requirements for JSEAs for all work at height or under heavy load so that key hazards can be identified and steps taken to minimise the risk of them occurring.

During operation, the key health and safety risks to workers relate to being exposed to a gas leak, fire or explosion from a loss of containment of flammable gas or LNG. As outlined above, the preliminary quantitative risk assessment found that the layout of the LNG plant will not expose personnel or contractors to undue risk.

To minimise the risk of worker injury during operation, the LNG plant will be designed and constructed in accordance with applicable codes and standards. Arrow's HSEMS which includes a range of standard operating procedures will also direct how works are to be undertaken on site to ensure that a high level of workforce safety is maintained.

Bushfire

Appendix 26, Bushfire Hazard and Risk Assessment, found that there were low to medium bushfire risks associated with the project. A range of treatments will be adopted to further reduce these risks to an acceptable level including the use of firebreaks, operational and suppression preparedness and adequate access and training.

A firebreak of at least 30 m will be maintained around all buildings and facility structures during all phases of the project, in accordance with SPP 1/03 requirements. The width of this firebreak will prevent an upper limit of 15 kW/m^2 radiant heat flux on the metal outer surface of an LNG tank in accordance with the European standard EN 1473:2007.

Other Natural Events

Preliminary analyses have been undertaken into the prevalence of natural events such as cyclones, earthquakes, tsunami and flooding in the project area and the associated risks to the LNG plant and workers.

The overall frequency of cyclones off the east coast of Australia is expected to decrease slightly by 2070 while the number of long-lived and severe cyclones (Category 3 to 5) is projected to increase, potentially by up to 140%. Cyclone development is also projected to shift southward in the coming century, exposing the Central Queensland region to greater cyclone impacts (see Chapter 10, Climate and Climate Change Adaption). Weather events such as cyclones could increase wind shear stress on LNG plant infrastructure and lead to inundation of low-lying areas of the LNG plant site.

Overall, average annual rainfall is expected to decrease with climate change, while severe short-term, high-rainfall events i.e., associated with cyclone activity, are expected to increase. The portion of the project area located on Curtis Island is not impacted by river floods; however, the proposed mainland launch site 1 is located at the mouth of the Calliope River, which has experienced numerous floods. Gladstone and surrounding areas are expected to experience storm surge tide rises as a result of climate change.

The Detailed Seismic Hazard Assessment (Arup, 2010) undertaken for the project identified four faults crossing the project site, which were inactive during the Quaternary period. No fatal flaws within the project site were identified by the study. Modelling by Geosciences Australia (2011) indicates that the tsunami hazard for the east coast of Queensland is low.

The following mitigation measures will be put in place to manage potential risks associated with these natural events:

- The LNG plant will be designed and constructed in accordance with current Australian standards addressing climatic factors including wind, bushfires and sea level rise for maritime structures.
- Where it is considered necessary, project infrastructure will be sited to avoid flood risk areas or protected from flood inundation.
- A design storm tide maximum level of 4.06 m AHD will be adopted and consideration given to implementing flood and storm surge immunity strategies should any project premises be situated below 4.06 m AHD e.g., mainland launch site 1 and TWAF7 (see Chapter 15, Coastal Processes).
- The LNG plant will be designed to comply with EN 1473:2007 (in lieu of an Australian standard with design criteria for hazardous facilities such as LNG tanks) and Shell's Earthquake Design and Engineering Practice Manual for Onshore Facilities (Shell, 2008) for the management of seismic hazards.

Terrorist Activities

Arrow Energy will undertake detailed security planning in consultation with Emergency Management Queensland to ensure compliance with Queensland policy on counterterrorism and the protection of critical infrastructure.

As outlined in Section 29.6.1, a range of security controls will be in place to safeguard the LNG plant and its staff. These controls will comply with major hazard facility and Queensland counterterrorism policy requirements.

A maritime security plan will be developed in accordance with the Maritime Transport and Offshore Facilities Securities Act, should the Port of Gladstone be declared a security operated port and Arrow Energy a port facility operator.

Road Transport

The safety of all road users will be a key consideration in the final choice of haulage routes and access points for the project. Only qualified fuel transport operators will be utilised on the project and Arrow's 12 Life Saving Rules, which include requirements on safe driving, will be adopted.

A detailed traffic management plan will also be developed in consultation with the Department of Transport and Main Roads and Gladstone Regional Council prior to construction commencing. The plan will detail measures to ensure public safety at project sites, avoid obstruction to other road users, address seasonal weather influences on transport arrangements, and manage issues such as driver fatigue. The traffic management plan will also address the movement of oversized loads.

Aviation Hazard

Potential aviation hazards were assessed in the plume rise assessment (Appendix 15, Plume Rise Impact Assessment) in accordance with the CASA (2004) Guidelines for Conducting Plume

Rise Assessments. The assessment identified that the exhaust plumes from the power generation stacks were likely to exceed the Procedures for Air Navigation Services – Aircraft Operational Surfaces (PANS-OPS) above the project site during routine operations and from the cold dry gas flare during non-routine operations.

During routine operations there is a potential for five of the power generation gas turbine exhaust plumes to merge, with the consequent enhanced buoyancy, causing the plume vertical velocity to exceed the 4.3 m/s threshold at the PANS-OPS. The critical plume height of the five merged power generation gas turbine exhaust plumes is predicted to be 373 m AHD, while the critical plume extent is predicted to be 80 m.

Plumes associated with the power generation gas turbines are likely to cause the vertical velocity to be greater than 4.3 m/s threshold at and above the PANS-OPS for an average of 17 hours per year or 0.2% of the time. Plumes associated with the compressor gas turbine drives are not predicted to exceed the PANS-OPS at any time.

During upset conditions at the LNG plant, a release from the cold dry gas flare is predicted to generate a plume with a vertical velocity that exceeds the 4.3 m/s threshold at the PANS-OPS under all meteorological conditions (i.e., all hours of the year for all five years assessed). The critical plume height of the cold dry gas flare plume is predicted to be 2,385 m AHD while the critical plume extent is predicted to be 1,613 m.

Due to this likely exceedance of the PANS-OPS, Arrow Energy will be required to submit an application for operational assessment of a proposed plume rise to CASA. Arrow Energy will liaise with CASA to ensure that all relevant requirements are met and appropriate management measures adopted. This will include implementation of a maintenance program to keep equipment in good working order and minimise the need for flaring where possible.

Environmental Pollution

Activities requiring the use of fuels, oils and chemicals within the vicinity of watercourses and drainage lines have the potential to result in accidental spills and pollution of waterbodies and associated loss of aquatic communities. Stormwater may also become contaminated with hydrocarbons or chemical residues in storage facilities such as bunds. In severe storm events, bunds may overflow, potentially releasing contaminated stormwater.

The risk of environmental pollution from a spill at the LNG plant is considered low with the range of proposed controls in place. All fuels, oils and chemicals will be stored and handled in accordance with the relevant Australian Standard (e.g., AS1940-2004 and AS 3780-2008) and Arrow's Chemical Management Procedure. Chemicals will be stored in bunded storage facilities at least 100 m from watercourses and refuelling will not be carried out within 100 m of waterways (see Chapter 13, Surface Water Hydrology and Water Quality). A risk assessment will be carried out for discharges from bunded areas and additional controls such as instrument protection or manual inspections adopted at any bunds considered to be of a high risk. Appropriate spill prevention and response plans and personnel training will also be undertaken to manage potential risks associated with spills.

Spills that occur in process areas will drain to the controlled discharge facility where the first flush will be monitored and either diverted to the effluent treatment plant or discharged to the marine outfall depending on the quality of the effluent. Contaminated stormwater will be captured for treatment or diverted to the marine discharge outfall if water quality meets specified discharge criteria. Chapter 13, Surface Water Hydrology and Water Quality, and Chapter 31, Waste Management, provide additional information on the management of spills and stormwater runoff.

Wildlife Hazards

Mosquito numbers on Curtis Island are high, placing workers at a high risk of being bitten by mosquitoes. The project will increase the potential for the breeding of biting insects such as mosquitoes through, for example, water pooling at construction sites and the presence of wheel ruts, which provide breeding grounds for these insects.

With appropriate management measures in place, the significance of any increase in mosquitoes and biting midges as a result of the project has been assessed as low (see Chapter 18, Freshwater Ecology). The risk of workers contracting a mosquito-borne disease such as Dengue fever, Ross River or Barmah Forest virus during construction or operation has been assessed as low assuming appropriate controls are in place. Similarly, the risk of the general population being infected by Dengue fever or Ross River or Barmah Forest virus as a result of the project has been assessed as low to very low.

Key management measures to be adopted include:

- Designing the LNG plant and construction camp to meet the requirements of AS/NZS 3500.3:2003 Plumbing and Drainage – Stormwater Drainage, to ensure that workers and members of the public do not become susceptible to vector-borne disease.
- Minimising stagnant pools of water on site during construction.
- Undertaking earthworks and rehabilitation activities in a manner that facilitates adequate drainage and reduces the potential for standing water to accumulate.
- Introducing operational mosquito management systems and vector-borne disease management to reduce the risk of mosquito or other vector borne diseases during the operation of the LNG plant.

Personnel on the project could be exposed to potentially hazardous wildlife such as snakes, crocodiles and spiders. In accordance with Arrow Energy's Wildlife and Stock Management Guidelines, all practical steps will be taken to prevent hazardous wildlife from entering the workplace (such as fencing and screen doors). Personnel will receive training on the risks associated with hazardous wildlife and areas where they are commonly found.

Decommissioning Hazards

The hazards and risks associated with decommissioning largely mirror those for the construction phase of the project. In addition, there is the potential that soil within the project area will have become contaminated from spills during construction and operation, and workers could be exposed to contaminated soil during rehabilitation.

In accordance with Arrow Energy's Rehabilitation Procedure, a contaminated land assessment will be undertaken of the project area prior to any rehabilitation works commencing. A preliminary risk assessment will then be carried out to identify potential environmental and human health hazards and risks arising from exposure to any hazardous contaminants and control measures to be adopted.

29.4.2 Feed Gas Pipeline and Tunnel

This section describes the key hazards and risks associated with the proposed feed gas pipeline and proposed tunnel.

Threat Identification and Analysis

In accordance with AS 2885.1-2007, a series of potential threats were identified across the construction, operation and decommissioning phases of the feed gas pipeline and tunnel. Table 29.6 outlines key threats, typical design and safety controls to be applied and the residual risks that remain. The detailed risk assessment is contained in Appendix 25, Preliminary Safety Management Study. With the application of design and safety controls, risks have been reduced to low, negligible or as low as reasonably practicable (ALARP).

Table 29.6 Feed gas pipeline and tunnel threats and safety controls

Potential Threat	Typical Design and Safety Controls	Residual Risk
Construction		
Damage to storage vessels, hoses or pipes results in a release of flammable or combustible material and leads to injury, destruction of property or environment.	AS1940-2004 requirements on the storage and handling of flammable and combustible liquids will be complied with. Personnel will be trained in hazardous materials handling procedures and safeguards to be adopted. An emergency response plan will be developed.	Low
Loss of containment of hazardous or environmentally pollutant materials leads to environmental damage.	Material safety data sheets will be made available for all chemicals used on site. Personnel will be trained in hazardous materials handling procedures and safeguards to be adopted. Dedicated cargo handling and storage area to be provided. Emergency response procedures will be adopted.	Negligible
Health and safety threats to workers in pipeline - working at heights in confined spaces, near electrical equipment leads to injury or death.	A construction management plan will be developed and include requirements on personnel training and safe working procedures. A JSEA will be conducted prior to all hazardous or non-routine operations. All work will be required to comply with the permit to work system. Work will only be carried out by trained and qualified personnel. Emergency response procedures will be adopted. An appropriate earthing system will be adopted and include measures to limit induced voltage.	Low – intermediate
Health and safety threats to workers in tunnel – work in confined spaces, near electrical systems and/or tunnel flooding leads to injury or death of workers.	All work will be required to comply with the permit to work system. Specialist training will be provided to personnel working in the tunnel. The tunnel will be constructed using a specialised tunnel boring machine incorporating a range of safety features. JSEAs will be conducted for all hazardous or non-routine operations (including any confined space work). Emergency response procedures will be adopted.	Intermediate
Use of heavy machinery and vehicles or access track leads to erosion, dust, weeds and increases bushfire risk.	Track selection to avoid sensitive environmental areas. Vehicles to be restricted to designated tracks and designated speed limits. Vehicles to be equipped with a fire extinguisher.	Low

Table 29.6 Feed gas pipeline and tunnel threats and safety controls (cont'd)

Potential Threat	Typical Design and Safety Controls	Residual Risk
Operation		
Generic threats to the pipeline (e.g., corrosion, fault, mechanical damage, terrorism) leads to injury, destruction of property and/or environment.	The feed gas pipeline will be designed and operated in accordance with AS 2885-2007 standards. All materials and manufacturing methods associated with the pipeline will comply with recognised standards. A fracture control plan and pipeline integrity plan will be prepared during detailed design to determine the fracture toughness requirements for the pipeline in accordance with AS 2885.1-2007 requirements. Preventative maintenance and inspection programs will be implemented including the use of intelligent pigging for planned periodic inspections. The control room will be manned 24 hours a day all year round to ensure that immediate notification is provided in the event of a fault in the pipeline.	Intermediate
Health and safety of workers in tunnel - loss of containment of gas, working in excessive heat, tunnel flooding or collapse leads to injury or death of workers.	Access to the tunnel will be restricted at all times. All work will be required to comply with the permit to work system. The design of the tunnel will incorporate seismic risks. JSEAs will be conducted all hazardous or non-routine operations. Automated inspection systems will be utilised where possible to avoid personnel entering the tunnel. Emergency response procedures will be adopted. The ventilation system will be appropriately designed and maintained.	Intermediate
Natural event such as land subsistence, cyclone, storm, earthquake damages tunnel and/or pipeline leading to a loss of containment, injury and/or destruction to property, environment	The feed gas pipeline will be designed and operated in accordance with AS 2885-2007 standards. The tunnel and pipeline will be designed to incorporate risks associated with natural events. Pipeline will be located in a tunnel under Port Curtis making the threat from heavy waves negligible.	Intermediate
Flooding of the tunnel results in a loss of containment, injury and/or destruction to property, environment.	An investigation will be undertaken into the need to clamp or secure the pipeline to ensure that it does not become buoyant in the event of flooding of the tunnel. The application of such technical solutions will be determined through a formal risk assessment.	Low
Failure to properly purge pipeline with inert gas prior to operational start-up results in ignition of flammable gas and air present in pipeline, injury and/or destruction to property, environment.	Appropriate start-up, maintenance and shutdown procedures will be adopted. Start-up and maintenance procedures will include requirements for purging air from pipeline or purging with an inert gas where required, continuous monitoring and the establishment and enforcement of an exclusion zone. Gas will be vented through the LNG plant flare system.	Low

Table 29.6 Feed gas pipeline and tunnel threats and safety controls (cont'd)

Potential Threat	Typical Design and Safety Controls	Residual Risk
Decommissioning		
Failure to purge pipeline with inert gas prior to shut down and isolation leads to ignition of flammable gas and air present in pipeline, injury and/or destruction to property, the environment.	Shutdown procedures will include requirements for purging gas from the pipeline with an inert gas, continuous monitoring and the establishment and enforcement of an exclusion zone. Gas will be vented through the LNG plant flare system. All work will be required to comply with the permit to work system.	Low
Health and safety threats to workers who work near electrical systems, undertake manual handling, and operate equipment leading to injury or death of workers.	Safe work procedures will be documented in a decommissioning plan. JSEAs will be conducted all hazardous or non-routine operations. All work will be required to comply with the permit to work system. Works will only be carried out by trained and qualified personnel. Emergency response procedures will be adopted. An appropriate earthing system will be adopted and include measures to limit induced voltage.	Low - Intermediate

Analysis of Key Risks

As outlined in Table 29.6, construction and decommissioning hazards (threats) have generally been given a low to intermediate risk ranking. The key hazards (threats) and risks relate to the operation of the feed gas pipeline and tunnel. In particular, an intermediate risk ranking has been given to generic threats to the feed gas pipeline and natural events leading to a loss of containment, injury and or the destruction of property and the environment. Risks to the health and safety of personnel working in the tunnel were also assessed as intermediate. All risks have been reduced to ALARP, as evaluated in the Preliminary Safety Management Study undertaken for the feed gas pipeline in accordance with AS 2885.1-2007 (Appendix 25, Preliminary Safety Management Study).

This section provides further detail on the key risks associated with the feed gas pipeline and tunnel and the design and safety controls to be adopted. Safety hazards and risks will be managed through the application of engineering and site selection controls during design wherever possible. These controls will be based on the requirements of relevant regulatory requirements and Australian and international standards. Design and safety controls incorporate engineering and site selection controls in the first instance, followed by behavioural controls and then any specific site controls where required.

Loss of Containment

The undetected corrosion of the feed gas pipeline leading to a full bore rupture is considered to be the worst conceivable event that could occur if all threat mitigation measures failed. Should this occur, the consequence distance for a loss of containment has been calculated. The consequence distance is the measurement length (the distance from the centreline of the pipeline to radiation contour for a full bore rupture that may cause injury) of full bore rupture as follows:

- Distance to 4.7 kW/m^2: 1.5 km (for a 1,220-mm diameter pipeline) or 1.8 km (for a 1,422 mm diameter pipeline).

- Distance to 12.6 kW/m^2: 0.9 km (for a 1,220 mm diameter pipeline) or 1.1 km (for a 1,422 mm diameter pipeline).

The risk ranking given to this event was intermediate given the high level of design safety that has been incorporated into the pipeline design and high standard of safety controls to be adopted.

In accordance with AS 2885.1-2007 requirements, the entire pipeline will be designed for *no rupture*, such that rupture of the pipeline will not be a credible failure mode. Key design safety controls to be applied to the pipeline include:

- Locating the pipeline within a concrete tunnel as it travels under Port Curtis.
- Burying the majority of the pipeline under a minimum cover of 750 mm to 900 mm.
- Restricting access by locating all valves and above ground sections within locked and fenced off areas.
- Manufacturing the pipeline from high tensile steel of known quality that is subjected to quality control inspections to ensure it meets an acceptable standard.
- Use of corrosion protection measures such as removing the occurrence of corrosive soils near the pipeline, externally coating the pipeline with fusion bond epoxy or equivalent and ensuring that it is cathodically protected when buried.
- Use of specific hot-tapping controls.

Natural Events

There is an intermediate risk that a natural event such as an earthquake, land subsidence, cyclone, or waves, could damage the feed gas pipeline and/or tunnel and result in the loss of containment of flammable gas. This in turn could result in injury to people nearby or the destruction of adjacent property or the environment. The preliminary analyses undertaken into the prevalence of these natural events in the project area found no fatal flaws associated with active faulting, liquefaction potential, seismic induced slope instability or tsunami hazard within the project site (Arup, 2010).

The severity of cyclones off the east coast of Australia is projected to increase. Further detail on the risks associated with these natural events impacting the project site is provided in Section 29.4.1 and in Chapter 10, Climate and Climate Change Adaption.

The design of the tunnel and feed gas pipeline will incorporate measures to manage seismic risks and the risks associated with cyclones and major storms. Steel pipelines have been shown to be very resistant to failure in these circumstances. The seismic risk to the pipeline will be assessed further during detailed design.

Workplace Risks

During operation, the key risks to workers' health and safety relate to working in or on the pipeline or in the tunnel and being exposed to a gas leak, fire, excessive heat or flooding.

To minimise the risk of worker injury, the pipeline and tunnel will be designed and constructed in accordance with applicable codes and standards. Arrow's HSEMS, which includes a range of standard operating procedures, will also direct how works are undertaken on site to ensure that safe work practices are adopted.

29.4.3 Shipping

This section outlines potential hazards and risks associated with shipping activities for the Arrow LNG Plant, as identified in preliminary risk assessments undertaken for the project.

Potentially Hazardous Incidents

Table 29.7 outlines potentially hazardous incidents associated with the shipment of LNG based on the preliminary risk assessment undertaken. Typical design and safety controls and residual risks are also outlined.

Table 29.7 LNG shipping hazards and safety controls

Potential Hazard	Typical Design and Safety Controls	Residual Risk
LNG carrier transport – damage to LNG carrier (e.g., collision, allusion, grounding) leads to loss of containment and injury and/or pollution of the receiving environment	Relevant international and Australian industry standards and legislative requirements will be complied with. Channels will be designed in accordance with Permanent Association of Navigation Congress and International Association of Marine Aids to Navigation and Lighthouse Authorities recommendations and tested by extensive marine simulation. Procedures developed by the Curtis Island LNG proponents and the Regional Harbour Master (Gladstone) will be complied with.	Medium
Berthing and LNG carrier loading and unloading – accident or mechanical failure leads to an uncontrolled release of LNG and injury and/or pollution of the receiving environment	Materials will be selected and designed in accordance with the requirements of relevant codes. Controlled material transfer activities will be adopted, including a pre-start protocol, permanent on-site presence by personnel representing the carrier ship and LNG plant and communication requirements. Gas and fire detectors with alarms will be installed to detect any upset operating conditions. Operators of LNG carriers, Arrow Energy staff and contractors will comply with the Port Procedures Manual, which details LNG operating parameters. Emergency response procedures will be adopted. An emergency shutdown system will be adopted which automatically stops loading in the event of an emergency. Requirements detailed in the Queensland Counter-Terrorism Strategy the Maritime Transport and Offshore Facilities Securities Act will be adhered to.	Medium

Analysis of Key Risks

This section provides further detail on the key risks identified in Table 29.7 and the design and safety controls to be applied.

LNG Carrier Transport

A key risk associated with LNG carrier transport is that a breach of a cargo tank could lead to a loss of containment and injury and/or pollution of the receiving environment. The preliminary hazard identification (HAZID) study on LNG navigational risks associated with the project (ELP, 2010a) identified the following key potential scenarios and risks from an accidental breach of LNG cargo tanks:

- Collision with another vessel in transit. A collision between two LNG carriers or an LNG carrier and another vessel in the channel was considered to be highly unlikely because of strict no passing and separation rules that apply in the Port of Gladstone.

- Allision of a vessel with a carrier at berth (i.e., a collision with a static object). An allision between an LPG carrier and an LNG vessel at the Arrow LNG jetty was considered to have a low probability of occurring due to the significant distance between the channel and the berth, the travel speed of the impacting vessel and presence of the tugs.
- Grounding. Simulations have shown that there is a low likelihood of an LNG carrier grounding, either because of engine or rudder failure, as tugs have been able to control the carrier. There is also a low likelihood of an LNG carrier grounding due to human error as the vessel will be piloted and have four tugs in attendance (ELP, 2010b).

A number of operating parameters and safety controls will apply to LNG vessels to manage potential hazards and risks associated with a breach of an LNG cargo tank. These are detailed in full in Chapter 28, Traffic and Transport, and summarised below:

- The operation of LNG carriers within the Port of Gladstone will comply with industry standards as agreed by Maritime Safety Queensland and the requirements of the Port Procedure Manual (MSQ, 2010).
- The operation of LNG carriers and smaller marine vessels utilised during construction will comply with Arrow Energy rules for LNG operations. These will be based on the above requirements and address issues such as crew competencies, approvals process for LNG vessels, scheduling and quality assurance requirements.
- A 250 m exclusion zone will extend forward and aft of an LNG carrier when it is operating in the shipping channel (Figure 28.1). The exclusion zone will be reduced to a 250-m-radius circle centred on the LNG loading manifold when the LNG carrier is moored at the berth for loading (see Figure 6.10). All non-project vessels will be prohibited from entering the exclusion zones or performing any operations within this zone, including fishing and other recreational activities.
- LNG vessels en route to Arrow Energy's LNG jetty will give advance notice of arrival dates and will time vessel arrivals for scheduled entry into the port. Forecast LNG vessel arrival times are very accurate, and these vessels have the advantage of being able to enter the port on all tide conditions, which also aids overall port scheduling.
- All pilots and tug masters will undertake simulation training prior to the arrival of the first LNG carrier.

The four LNG proponents on Curtis Island (GLNG, QCLNG, APLNG and Arrow Energy) are in discussion with Maritime Safety Queensland, the Regional Harbour Master (Gladstone), Gladstone Ports Corporation and Gladstone Regional Council regarding the development of a joint LNG maritime safety management plan. This plan will set out a range of issues such as operational procedures, incident reporting, and crew requirements.

Berthing, Loading and Unloading

The individual fatality risk contours associated with LNG carrier loading and unloading are presented in Figure 29.2 and described in Section 29.4.1. The risk criteria for each of the land uses were found to be met.

Risks associated with an uncontrolled release or spill of LNG during loading and unloading will be controlled through a range of measures including compliance with the Port Procedures Manual (MSQ, 2010), relevant legislative requirements and industry standards as agreed by Maritime

Safety Queensland. An emergency shutdown system will also be put in place and will activate automatically in the event of a loss of containment.

Environmental Pollution

In the unlikely event of a collision, allusion or grounding, there is the potential for a spillage of LNG, oil or chemicals. As outlined above, a number of operating parameters and safety controls will apply to LNG vessels to manage potential hazards and risks associated with a breach of an LNG cargo tank. Most LNG carriers are double hulled.

With the range of controls in place, the risk of an accident resulting in a spill to the marine environment has been assessed as very low.

There is a low risk that the transport of LNG will introduce pest species and pollute the marine environment from poor antifouling practices and the release of ballast water. These risks are outlined in detail in Chapter 31, Waste Management, and Chapter 19, Marine and Estuarine Ecology, and summarised below.

Project vessels will be required to comply with a range of antifouling protocols and requirements (e.g., International Convention for the Prevention of Pollution from Ships (MARPOL) ; Chapter 19, Marine and Estuarine Ecology).

Project vessels will also be required to comply with international, national and state government ballast water management systems requirements, including the Australian Quarantine and Inspection Service's Australian Ballast Water Management Requirements (AQIS, 2008). The discharge of high-risk ballast water from ships is prohibited anywhere inside Australia's territorial sea. Ballast water will be exchanged in international waters prior to entering the Great Barrier Reef Marine Park (Chapter 31, Waste Management).

Impacts on other Operational Port Activities

There is a low risk that LNG shipping activities associated with this project will affect other operational activities in the port. During construction, marine traffic associated with the project will be managed by an LNG maritime movement scheduling authority. During operation, simulation modelling has shown that the existing channel infrastructure is likely to be sufficient to maintain existing port performance subject to management of port movements (see Chapter 28, Traffic and Transport).

29.5 Cumulative Risks

This section outlines potential cumulative risks associated with the key hazards identified during the construction, operation and maintenance, and decommissioning of the Arrow LNG Plant. Projects that meet the criteria for inclusion in the cumulative impact assessment are defined in Chapter 9, Impact Assessment Method, and are shown in Figure 9.2.

Potential cumulative risks include the following:

- Incident at the LNG plant causes a knock-on effect at a neighbouring facility. There is a low risk of this occurring due to the separation between each site. The injury and propagation risk calculations also showed that the risk of knock-on effects from the LNG plant or an LNG carrier complied with the most stringent criteria for maximum acceptable risk at neighbouring industrial facilities.
- Multiple projects create a greater risk of Dengue-carrying mosquitoes breeding and a Dengue fever outbreak, compared with a single project. Each of the projects would need to be located

in close proximity to a residential population for transference of the virus to occur and it is not considered that a combination of construction projects will significantly increase the incidence rate of Dengue fever in the event of an outbreak.

- Multiple projects increase the risk of bushfire ignition. The potential for ignition may increase with the number of people and the development and increased access to bushland. The cumulative impact will be mitigated by contemporary bushfire protection design associated with the project. An increase in people will also improve bushfire detection and response times and effectiveness of suppression.

29.6 Emergency Management Planning

Emergency management planning for the project will be undertaken in accordance with the requirements of the National Standard for the Control of Major Hazard Facilities (NOHSC: 1014(2002)), the National Code of Practice (NOHSC: 2016(1996)) and the Dangerous Goods Safety Management Act.

All emergency management planning will be undertaken in consultation with relevant Queensland government authorities and emergency services organisations. In particular, the Department of Community Safety and Emergency Management Queensland, which includes the Queensland Ambulance Service, Queensland Fire and Rescue Service and Emergency Management Queensland, will be consulted.

A wider program of consultation will be undertaken to inform the development of emergency response plans. It is envisaged that representatives from the Curtis Island LNG projects, the LNG Incident Response Group Captains, Maritime Safety Queensland, Regional Harbour Master (Gladstone), Gladstone Ports Corporation, Queensland Police Service, Queensland Fire and Rescue Service and Queensland Ambulance Service will be consulted on the development of these plans.

29.6.1 Emergency Management Systems

This section describes the emergency management systems and procedures that will be adopted on the project.

Emergency Shutdown Systems and Procedures

An emergency shutdown and detection system will be in place to initiate automatic transfer shutdown actions in the case of a significant LNG leak.

Security and Terrorist Activities

Prior to construction commencing on the project, Arrow Energy will liaise with Emergency Management Queensland on an appropriate response to the potential for security and terrorist incidents.

The Arrow LNG Plant will be fenced and access controlled. Security systems will be in place to safeguard the LNG plant and its staff from unauthorised access. These systems will comply with major hazard facility and Queensland counterterrorism policy requirements.

The LNG plant and associated LNG carrier loading and sea transport will adhere to strict protocols for safeguarding against terrorism and other intentional acts of vandalism. This includes complying with the requirements set out in the Queensland Government's (2007b) Counter-Terrorism Strategy and the Maritime Transport and Offshore Facilities Securities Act.

Marine Collision

Protocols will be developed in consultation with Marine Safety Queensland and Gladstone Ports Corporation to minimise the likelihood of marine collisions and ensure compliance with relevant maritime safety requirements (e.g., the MSQ (2010) Port Procedures and Information for Shipping – Gladstone).

Natural Disasters

The requirements of SPP 1/03 (Mitigating the Adverse Impacts of Flood, Bushfire and Landslide) will be complied with in the management of natural hazards. A bushfire management plan will be developed and include procedures to prevent and manage potential risks associated with bushfires.

Leak Detection/Minimisation

A leak detection system with alarms will be installed within the space between the primary and secondary LNG tanks to detect any potential accumulation of LNG. The system will activate an alarm in the control room if an LNG spillage is detected.

Gas detectors will be installed throughout the LNG plant near the most probable leak sources. An audible and visible alarm, clearly recognisable as a fire and gas alarm system, will be installed at the outer edge of each LNG train area.

29.6.2 Emergency Response Plans

Emergency response plans will be developed to detail areas of responsibility, procedures and the facilities and equipment in place to prevent emergencies and safely manage emergency incidents should they occur. This section provides an outline of the key plans to be developed.

Fire

A detailed fire response plan will be developed which outlines the systems and procedures in place on the project to prevent and protect against fires. These will align with Arrow Energy's Fire Prevention Procedure and include:

- Fire safety philosophy for the project.
- Training requirements and specific roles for personnel in the event of a fire.
- Fire prevention and protection measures at the LNG plant.

The following fire protection facilities and equipment will be made available to the project and detailed in the fire response plan:

- Fire prevention systems (e.g., ventilation, drainage system, which limits potential travel distance of spills).
- Passive fire protection system (e.g., suitable epoxy-based intumescent coating shall passively protect the discharge system of the compressor from the condenser down to the accumulator).
- Active fire protection system (e.g., water spray system, sprinkler system).
- Fire water system (including storage and pump).
- Fire detection facilities.
- Exposure protection (e.g., firewater monitors).
- Gaseous extinguishing systems.

- Equipment in plant buildings (e.g., flammable gas detectors, ultra-sensitive smoke detection system).
- Fire station and emergency control centre.

Spill Prevention and Control

A spill prevention and control plan will be developed and link in to the relevant national or local oil and chemical spill response plan. The plan will include the following key features:

- Training requirements for personnel.
- Spill prevention and response procedures.
- Spill response equipment available on site.
- Notification and reporting requirements.

Medical Emergency Response

A detailed medical emergency response plan will be developed which outlines key areas of responsibility for personnel on site and the medical emergency facilities and resources available.

A range of medical emergency facilities and resources will be made available in accordance with the minimum standards set out in the Shell (2005) Exploration and Production Medical Emergency Response Guidelines. These will be detailed in the medical emergency response plan and include:

- An appropriately designed onsite medical facility.
- Trained medical personnel.
- First aid equipment.
- An appropriate method of transport from facility to shore.
- Remote medical support.

A detailed medical emergency response study will be undertaken prior to construction commencing to assess transport times between the LNG plant and the mainland and determine whether required response times can be met.

Arrow Energy will also contribute to a common Curtis Island local emergency response strategy being developed by the various stakeholders involved in the Curtis Island LNG projects.

Maritime Security Plan

Should the Port of Gladstone be declared a security operated port and Arrow Energy a port facility operator, the company would be required to prepare a maritime security plan in accordance with the Maritime Transport and Offshore Facilities Securities Act. This plan will outline security measures and procedures to be implemented as a part of the project to protect against any unlawful interference with maritime transport or offshore facilities. The plan will be developed in consultation with the Marine Safety Queensland and Gladstone Ports Corporation.

29.7 Commitments

The measures (commitments) that Arrow Energy will implement to manage hazards and risks are set out in Table 29.8.

Table 29.8 Commitments: Hazard and risk

No.	Commitment
C29.01	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.
C29.02	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.
C28.01	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. Common with Chapter 28, Traffic and Transport.
C28.09	Develop a shipping activity management plan in consultation with Gladstone Regional Council, Gladstone Ports Corporation, Maritime Safety Queensland and all contractors operating within the Gladstone Port. Common with Chapter 28, Traffic and Transport.
C28.11	Ensure that operators of project vessels, Arrow Energy staff and contractors comply with the LNG Marine Operations Maritime Safety Management Plan if/when this plan is agreed between Maritime Safety Queensland, Gladstone Ports Corporation and the other LNG proponents. Common with Chapter 28, Traffic and Transport.