Australia Pacific LNG Project

Volume 2: Gas Fields

Chapter 22: Hazard and Risk

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22. Hazard and risk

22.1 Introduction

This chapter of the environmental impact statement (EIS) identifies potential hazards and risks associated with the Australia Pacific LNG Project (the Project) gas fields' construction, operational and decommissioning phases. Measures to mitigate any of the identified potential impacts are also discussed.

Potential hazards and risks for the gas pipeline and LNG facility are addressed in Volume 3 Chapter 22 and Volume 4 Chapter 22 respectively. A summary of the risk assessment process that underpins the EIS is provided in Volume 1 Chapter 4.

This section is largely based on work undertaken by Marsh Pty Ltd and a preliminary Safety Management Study conducted for the high pressure pipelines in the gas fields. Marsh's technical reports can be found in Volume 5 Attachment 47 and Volume 5 Attachment 46.

Australia Pacific LNG has undertaken the preliminary safety management study of the high pressure gas network in accordance with Australian Standard AS 2885.1: Pipelines – Gas and liquid petroleum. A summary of these findings of the preliminary study is provided in Volume 5 Attachment 48.

The process of identifying hazards and risks involved the following:

- Background research on the properties and characteristics of coal seam gas (CSG)
- Review of industry experience of gas field incidents
- Hazard identification workshops specific to the Project
- Review of risks identified within Origin's existing risk registers relevant to the Project.

Hazards were identified and a risk register prepared. The hazards, which are based on abnormal events, natural hazards or accidents are summarised in this chapter. Hazards and risks are presented in four main sections. Section 22.3 outlines the potentially dangerous goods and hazardous substances associated with the project. Section 22.4 outlines the risks to the surrounding environment. These risks are based on Marsh's technical reports, and the section includes a consequence analysis of the relevant hazards. Section 22.5 outlines the hazards and risks based on the preliminarily safety management study. Section 22.6 outlines risks to health and safety.

Australia Pacific LNG's sustainability principles will be applied to the planning, design, construction, operation and decommissioning of the gas fields to ensure associated hazards and risks do not aversely impact people or the environment.

Of the 12 Australia Pacific LNG sustainability principles, the following are most relevant to the gas fields' hazard and risk component of the EIS:

- Adhering to an overriding duty to safety, ensuring operations are carried out in a safe manner and empowering employees and contractors to place safety considerations above all other priorities
- Minimising adverse environmental impacts and enhancing environmental benefits associated with Australia Pacific LNG's activities, products or services; conserving, protecting, and enhancing where the opportunity exists, the biodiversity values and water resources in its operational areas

- Identifying, assessing, managing, monitoring and reviewing risks to Australia Pacific LNG's workforce, its property, the environment and the communities affected by its activities.

The ultimate objective is to design, construct and operate the gas fields to ensure minimal impact on the surrounding environment and community, and no substantial residual risk to public amenity and the safety of those in proximity to the facilities. The strategies outlined in this EIS will demonstrate how these sustainability principles will be addressed.

22.1.1 Scope of work

This section of the EIS discusses the recognised hazards and risks for the gas fields' development, including the gas wells, gas and water gathering networks, gas processing facilities (GPFs) and water treatment facilities (WTFs) and associated infrastructure. A project description of the gas fields is provided in Volume 2 Chapter 3. This section describes the potential hazards and risks including:

- Hazardous substances to be used, stored, processed or produced and the volumes involved
- Potential hazards, accidents, spillages and abnormal events associated with the project (construction, operation and decommissioning)
- Cumulative risk levels to surrounding land uses
- Natural hazards including bushfires, flooding, cyclones, seismic events, wildlife hazards (e.g. snakes) and disease vectors.

Risks to both project and non-project personnel and equipment have been considered with respect to Australian Standard 'AS/NZS ISO 31000:2009: Risk management - Principles and guidelines', which supersedes 'AS/NZS 4360:2004: Risk management'. These risks have been assessed for the construction, operational and decommissioning phases of the Project. Risks have been assessed in quantitative terms where possible and where appropriate for this preliminary planning and design phase.

Possible hazards, accidents, and abnormal events that may arise for the Project, during both construction and in operational phases are described, including events such as:

- Accidental release of hazardous goods or other materials
- Fires associated with incidents arising from project activities
- Vehicle and other transport-related accidents.

An analysis of the consequences of each of these events in regard to safety and environmental damage in the gas fields' area has been conducted. The analysis examines the likelihood of these consequences being experienced, either individually or collectively.

Details of the safeguards that will be employed to reduce the likelihood and severity of hazards, consequences and risks to persons, property, fauna and the environment within and adjacent to the project areas are included. Controls have been introduced to reduce the risk to as low as reasonably practicable (ALARP).

Note that this chapter of the EIS addresses general process hazards and risks and major accident events. Hazards and risks related to aspects involving air emissions including odours and greenhouse gases, dust, noise and vibration, water quality, soil including acid sulphate soil, wastes, and societal hazards and risks are included in other chapters of this EIS. The relevant chapters describe the related hazards and outline controls to reduce the risk, such as Volume 2 Chapter 15 – Noise and vibration.

22.1.2 Legislative framework

Commonwealth and Queensland Legislation

Volume 1 Chapter 2 provides an overview of the general regulatory framework as it applies to the entire project. Current legislation is given in the following sections; but the Project will be undertaken in accordance with the legislative requirements in force over the project life. Legislation relevant to potential hazards and risks associated with the gas fields is listed below. The relevance of these to the Project is then explained.

Commonwealth legislation:

- *Airports Act 1996*.

Queensland legislation:

- *Transport Infrastructure Act 1994*
- *Petroleum and Gas (Production and Safety) Act and Regulation 2004*
- *Dangerous Goods Safety Management Act 2001*
- *Explosives Act 1999*
- *Radiation Safety Act 1999*
- *Workplace Health and Safety Act 1995*
- *Electrical Safety Act 2002*
- Building Act 1975 and Building Fire and Safety Regulation 1991
- *Fire and Rescue Service Act 1990*.

Airports Act

The *Airports Act 1996* regulates the development and operation of airports in Australia, whilst the regulating body, Civil Aviation Safety Authority (CASA), regulates operating procedures in the vicinity of aerodromes in Australia. Part 12 of the *Airports Act 1996* and the Airports (Protection of Airspace) Regulations 1996 establish a framework for the protection of airspace at and around airports.

Any activity that intrudes into protected airspace of an airport is a controlled activity that requires approval. These activities include tall stack sources and buoyant plumes from industrial facilities. The CASA Advisory Circular 139-05(0) (2004) defines the criteria and methodology under which the stack emissions are assessed for potential hazards to aviation safety.

The Project will develop its gas fields in and around the Miles airport and the potential impacts of this development are discussed in Section 22.5.

Transport Infrastructure Act

The *Transport Infrastructure Act 1994* is operated in conjunction with the *Transport Planning and Coordination Act 1994* and the *Transport Operations (Road Use Management) Act 1995*. The *Transport Infrastructure Act 1994* aims to provide a regime for the effective integrated planning and efficient management of a system of transport infrastructure.

The Project may require approvals under the *Transport Infrastructure Act 1994* pertaining to road closures, and the transportation of oversized loads of plant, equipment and materials. These approvals will be obtained on an as-needs basis during the course of the Project's future design and construction phases when the necessary design and construction information required for the permit applications is available. Australia Pacific LNG will comply with all requirements under these Acts with respect to the safe use of roads and other means of transportation.

Petroleum and Gas (Production and Safety) Act

The *Petroleum and Gas (Production and Safety) Act 2004* (PAG Act) regulates the petroleum and natural gas industry in Queensland. It aims to facilitate and regulate responsible petroleum activities and the development of a safe, efficient and viable petroleum and fuel gas industry.

Petroleum activities include:

- Exploration, distillation, production, processing, refining, storage and transport of petroleum
- Distillation, production, processing, refining, storage and transport of fuel gas
- Other activities authorised under the Act for petroleum authorities.

One facet of the Act is to achieve this in a way that minimises land use conflicts and encourages responsible land use management.

The safety obligations contained in the Act apply to its defined operating plant. Specifically, the Act mandates the application of AS 2885, as discussed below, and hence this Australian Standard becomes a legislative requirement under this Act.

Dangerous Goods Safety Management Act

The *Dangerous Goods Safety Management Act 2001* sets out the obligations and requirements relating to the storage and handling of dangerous goods and combustible liquids and the safe operation of major hazard facilities in Queensland. Dangerous goods are defined with reference to the 'Australian Code for the Transport of Dangerous Goods by Road and Rail'.

The *Dangerous Goods Safety Management Regulation 2001* sets out specific obligations for entities who manufacture, import, supply, store or handle stated dangerous goods or combustible liquids; or supply or install equipment for storing or handling those materials.

The Act and Regulation are concerned with protecting against harm or injury to people or damage to property or the environment arising from an explosion, fire, harmful reaction or the evolution of flammable, corrosive or toxic vapours involving dangerous goods; or the escape, spillage or leakage of any dangerous goods. The criteria by which a facility will be classified as a 'large dangerous goods location' or a 'major hazard facility' are also defined. Additional risk minimisation requirements are defined for such facilities before the appropriate licenses to operate are issued.

However, certain parts of the Act and regulations do not apply to:

- Land under the PAG Act is used to obtain, produce or transport petroleum
- Pipes under the PAG Act, other than pipes within the boundaries of a 'major hazard facility' or 'large dangerous goods location'.

Therefore, the gas fields and gas pipeline are not considered as major hazard facilities and will be primarily governed by the PAG Act. Major hazard facilities are administered by the Hazardous Industries and Chemicals Branch within the Department of Justice and the Attorney-General, whilst the gas fields and main transmission pipeline will be administered by the Queensland Mines and

Energy branch of the Department of Employment, Economic Development and Innovation. The Project will obtain the necessary licenses and authorities to operate under the PAG Act.

Explosives Act

The *Explosives Act 1999* provides for the regulation of explosives, including approval to manufacture, possess, sell, store, transport or use explosives in order to ensure the safety of the community from all activities associated with explosives.

If explosives are required, such as for blasting along in-field pipeline routes or down hole in wells, a licence or approval under this Act will be required for the purchase, transportation and use of explosives.

Radiation Safety Act

The *Radiation Safety Act 1999* provides for the regulation of radioactive substances. It is possible radioactive sources will be employed in borehole logging equipment, for weld testing, level instrumentation or another purpose. Australia Pacific LNG will ensure radioactive source users have the required licence and an approved radiation safety and protection plan, detailing radiation protection measures.

Workplace Health and Safety Act

The *Workplace Health and Safety Act 1995* establishes a framework for preventing or minimising workers' exposure to risks by, among other things, imposing safety obligations on certain persons and establishing benchmarks for industry through the making of regulations and codes of practice. The Act does not apply to operating plant, within the meaning of the PAG Act on land the subject of a petroleum authority under the PAG Act or petroleum tenure under the *Petroleum Act 1923*.

The *Workplace Health and Safety Act 1995* will apply for most construction activities.

Electrical Safety Act

The *Electrical Safety Act 2002* establishes a legislative framework for electrical safety in Queensland to prevent people from being killed or injured and property being destroyed or damaged by electricity. The framework imposes obligations on those who may affect the electrical safety of others, and establishes standards for industry and the public through regulations and codes of practice for working with and around electricity.

The Act is relevant to the Project to the extent that electrical work, as defined, will be undertaken.

Building Act and Building Fire and Safety Regulation

The *Building Act 1975* and *Building Fire and Safety Regulation 1991* regulates the safe design and operation of all buildings so as not to endanger persons, property or the environment. These objectives are achieved by appropriate building design and maintenance in compliance with the Building Code of Australia and development of an appropriate safety management system.

Fire and Rescue Service Act and Fire and Rescue Service Regulation

The *Fire and Rescue Service Act 1990 and Fire and Rescue Service Regulation 2001* requires the operator to establish effective relationships with the Queensland Fire and Rescue Service to provide for the prevention of and response to fires and certain other incidents endangering persons, property or the environment and/or for related purposes or activities.

Relevant state planning policies

In addition to and in parallel with the legislation, certain state planning policies are referenced for developments such as these. These include the policies discussed here.

Queensland State Planning Policy 1/03 Mitigating the Adverse Impacts of Flood, Bushfire and Landslide

This State Planning Policy requires that developments should minimize the potential adverse impacts of flood, bushfire and landslide on people, property, economic activity and the environment. The policy has effect when development applications are assessed, when planning schemes are made or amended and when land is designated for community infrastructure.

Queensland State Planning Policy 1/02 Development in the Vicinity of Certain Airports and Aviation Facilities

This State Planning Policy sets out the State's interest concerning development in the vicinity of those airports and aviation facilities considered essential for the State's transport infrastructure or the national defence system. The policy addresses control of development and land use in the vicinity of aeronautical installations and provides guidance to local authorities on how this issue should be addressed when carrying out their planning duties.

Relevant national and international standards

The key standards that apply to hazard and risk assessment for the Project are outlined below.

AS 2885: Pipelines – Gas and liquid petroleum

AS 2885 is the Australian Standard covering gas and liquid petroleum pipelines. This is the primary Australian Standard that will be used as a basis for the design, construction and operation of the Project's pipeline systems. Part 1 of this standard, AS 2885.1-2007: Pipelines – Gas and liquid petroleum – Design and construction, defines the requirements for the design and construction of gas pipelines.

Key requirements of AS 2885 limit the consequence and likelihood of off-site impacts and these requirements will be implemented as part of the Project, including:

- Development of a 'fracture control plan' to ensure selection of pipeline material which is resistant to brittle or ductile fracture
- Provide a level of resistance to penetration of the pipeline to reduce the likelihood of penetration and significantly reduce the likelihood of a full bore rupture
- Prevention of rupture in 'high consequence' class locations
- Maximum tolerable energy release rates. This limits the radiated heat flux generated from a fire.

Guides referred to in AS 2885.1 include SAA HB105-1998 and HIPAP 4 as outlined below.

HB 105-1998: Guide to pipeline risk assessment in accordance with AS 2885.1

This guide forms the basis for the risk assessment of pipelines in accordance with AS 2885.1.

Risk Criteria for Land Use Safety Planning (Hazardous Industry Planning Advisory Paper no. 4)

This 1997 advisory paper, referred to as HIPAP No. 4, which is directed in the terms of reference, outlines the consequences of heat flux and overpressure, which are referred to in the 'Guide to pipeline risk assessment in accordance with AS 2885.1 1998' produced by Standards Australia and in 'Guidelines for major hazard facilities C Systematic risk assessment 2008' produced by the Queensland Government. The paper and associated consultation draft 'Revised planning guidelines for hazardous development, August 2008' provide risk criteria for land uses in the vicinity of hazardous industries.

AS/NZS ISO 31000:2009: Risk management – Principles and guidelines

This Australian Standard provides a framework for evaluating potential hazards and reducing the risk of those hazards. The associated 'Risk management code of practice 2007' and its supplements provide information on how risk management can be achieved. This standard replaces the recently superseded 'AS 4360: Risk management'.

Other standards

Below is an indicative list of other major standards that will be applicable to the Project. It is recognised there are other national standards, codes of practice, advisory standards and guidance notes that of relevance that are not included in this list:

- AS/NZS 1170.2:2002: Structural design actions - Wind actions
- AS 1170.4:2007: Structural design actions - Earthquake actions in Australia
- AS 1210:1997: Pressure vessels
- AS/NZS 1596:2008: The storage and handling of LP Gas
- AS/NZS 1768:2007: Lightning protection
- AS 1885.1:1990: Workplace injury and disease recording standard in the workplace
- AS 1940-2004: The storage and handling of flammable and combustible liquids
- AS/NZS 2022:2003: Anhydrous ammonia - Storage and handling
- AS 2865:1995: Safe Working in a Confined Space (NOHSC:1009(1994))
- AS/NZS 2927:2001: The storage and handling of liquefied chlorine gas
- AS 2958: Earth-moving machinery – Safety
- AS 3780-2008: The storage and handling of corrosive substances
- AS 3814-2009: Industrial and commercial gas-fired appliances
- AS 4024: Safety of machinery
- AS/NZS 4801:2001: Occupational health and safety management systems - Specification with guidance for use
- AS/NZS 60079.10.1:2009: Explosive atmospheres - Classification of areas - Explosive gas atmospheres (IEC 60079-10-1, Ed.1.0(2008) MOD)

- AS IEC61511:2004: Functional Safety – Safety instrumented systems for the process industry sector
- National Standard for Construction Work [NOHSC: 1016 (2005)]
- National Standard for Manual Tasks (2007)
- National Standard for Occupational Noise [NOHSC: 1007 (2000)]
- National Standard for Plant [NOHSC: 1010 (1994)]
- Adopted National Exposure Standards for Atmospheric Contaminants in the Occupational Environment [NOHSC: 1003 (1995)]
- Australian Code for the Transport of Dangerous Goods by Road and Rail, 7th Edition
- Australian Code for the Transport of Explosives by Road and Rail, 3rd Edition
- National Code of Practice for the Control of Workplace Hazardous Substances [NOHSC: 2007 (1994)]
- National Code Of Practice for Induction for Construction Work, May 2007
- National Code of Practice for the Prevention of Falls in General Construction, April 2008
- The National Code of Practice for the Prevention of Musculoskeletal Disorders from Performing Manual Tasks at Work (2007)
- National Code of Practice for the Prevention of Occupational Overuse Syndrome [NOHSC:2013(1994)]
- Mobile Crane Code of Practice 2006
- Plant Code of Practice 2005
- Risk Management Code of Practice 2007
- Traffic Management for Construction or Maintenance Work Code of Practice 2008
- API RP 520, Sizing, selection and installation of pressure relieving devices in refineries
- API RP 521, Guide for pressure-relieving and depressurising systems
- API RP 752, Management of hazards associated with location of process plant buildings
- API RP 753, Management of hazards associated with location of process plant portable buildings.

22.2 Methodology

Australia Pacific LNG, through Origin, has a system of risk management which uses the concepts based on AS/NZS ISO 31000:2009: Risk management – Principles and guidelines. Risk management is considered as the systematic and ongoing process of hazard identification, assessment, treatment and monitoring.

The risk management methodology used by Australia Pacific LNG in undertaking the risk assessment for the EIS stage of the Project is outlined in Volume 1 Chapter 4.

22.3 Hazard and risk assessment

Australia Pacific LNG will design gas wells, gas and water gathering systems, GPFs, WTFs and water transfer stations that are inherently safe. Risk assessment is considered to be an important part of this process. Australia Pacific LNG will use risk assessments throughout the life of the Project to identify and manage the various hazards and risks associated with the Project.

Origin has been operating CSG wells and related processing facilities and transmission pipelines for a number of years. This has contributed to the development and accumulation of extensive risk registers for the construction, operation and decommissioning of gas field infrastructure. These provide a good basis for the evaluation of potential hazards and risks the Project will introduce. Potential hazards range from venomous snake bites through to hazards from constructing, operating and maintaining industrial plant and equipment.

Processing related hazards were identified through a review of Origin's existing risk registers, with reference to initial process designs and a review of related industry hazards. Scenarios were then developed to establish credible events that could conceivably impact persons, property, fauna or the environment. Where hazards were significant and quantifiable, distances to hazard end points were determined.

Some of the risks presented in this volume of the EIS are also covered in Volume 3 Chapter 22 for the gas pipeline.

22.3.1 Properties and potential hazards of CSG

Analysis of CSG from the Walloons gas fields indicates a methane content greater than 97%. Methane is an odourless, non-toxic and non-corrosive gas and is lighter than air at temperatures greater than minus 110°C. The lower and upper flammability limits of methane are 5% and 15% respectively. This means that if the concentration of methane in air is less than 5%, the gas mixture is too dilute to burn and if it is greater than 15% there is not enough oxygen for it to burn. The auto-ignition point for methane is 580°C. This is the minimum temperature required for methane gas to ignite in air without a spark or flame being present.

Methane is also an asphyxiant. Asphyxia is a possibility if the oxygen concentration in the atmosphere being breathed is less than 19.5%.

Methane is compressible and a release of high pressure methane will result in localised sub-zero temperatures due to expansion cooling (Joule – Thompson effect).

22.3.2 CSG release and fire types

When CSG is released there will not necessarily be a fire. The potential outcomes are:

- CSG release without a fire
- Immediate ignition and fire
- Delayed ignition resulting in a flash fire, or vapour cloud explosion if in a confined area, and resultant jet fire.

Boiling liquid expanding vapour explosion and pool fires are not considered in this chapter, as there will not be any liquefied CSG or significant storage of other liquefied hydrocarbons in the gas fields or gas pipeline elements of the Project.

A gas release will not result in a fire if the gas is not exposed to an ignition source.

If an ignition source is present near the release point a fire could occur. If a release of CSG occurs at low pressure and low velocity, any resultant fire would resemble standard combustion. A methane flame is typically quite difficult to see in daylight conditions. A release of CSG ignited and under pressure would result in a 'jet fire'. A jet fire has the shape of a cone.

If a gas release does not ignite immediately, a gas cloud may form which could find an ignition source distant from the point of release. A flash fire or vapour cloud explosion may occur under these circumstances. A flash fire is the term for a slow deflagration of a premixed, truly unconfined, unobstructed gas cloud producing negligible overpressure. Thermal effects are the main hazard.

A vapour cloud explosion is an explosion occurring with the release of a large quantity of flammable gas, which ignites following the formation of a cloud or plume of pre-mixed fuel and air. For a vapour cloud to explode, there is a minimum and maximum ratio of fuel vapour to air within which ignition can occur. This range is 5 to 15% for methane. It is unlikely that there would be enough confined gas in a cloud in the given ratios in a confined space for a vapour cloud explosion to occur. For gas that could ignite, it has a greater prospect of combustion via a flash fire mechanism, which generally does not create a damaging pressure wave and thus a vapour cloud explosion is unlikely to occur.

22.3.3 Hazardous substances

CSG is considered a hazardous substance. It predominantly consists of methane and is a flammable gas and an asphyxiant (refer to Section 22.3.1). Other potentially hazardous substances are described below.

Indicative chemical storage quantities for the gas field facilities (wellhead, gas processing facility and water treatment facility) are given in Table 22.1 to Table 22.3. The quantity of chemicals stored is dependant on the final design. For example, use of electrical drives rather than gas engines or different configurations of screw and reciprocating compressors would change the quantities of lubricating oil stored. Similarly, the large volume of hydrochloric acid stored for water treatment is dependant on the inclusion of an ion exchange unit in the final design.

Gas wells

Chemicals used at gas wellheads during operation are indicated in Table 22.1. Hydraulic fluids, engine oils and biocide will not be stored at the wellhead, but will be used as part of the process and during maintenance of equipment.

Table 22.1 Chemicals at wellhead during operation – indicative quantities

Chemical	Packaging type	Packaging size (m^3)	Typical quantity (m^3)	Notes
Anti-scalant	Drum	0.205	0.205	To prevent build-up of scale and blockage in pipelines - stored in bunded areas
Hydraulic fluids and engine oils	No storage at wellhead	N/A	N/A	For hydraulic well pumps
Biocide	No storage at wellhead	N/A	N/A	For control of sulphate reducing bacteria
LPG	Cylinder	7,500 litres	25,000 litres	For pilot operations until well produces CSG

During the pilot operation, liquefied petroleum gas (LPG) may be used in bottles prior to using CSG as a fuel source. LPG storage during pilot operations may vary with regard to size of vessels and number, but there will up to three 7,500 litres vessels. Consideration is also being given to the use of an alternative fuel for pilot operation.

Gas processing facilities

Up to 23 GPFs are currently proposed for the Project, depending on detailed design. The GPFs will range in size based on 75 terajoules per day (TJ/d) plant modules and will be configured with total capacities of 75TJ/d, 150TJ/d or 225TJ/d. The quantities of chemicals that are typical for these modular plants are listed in Table 22.2. These quantities are based on current operating experience and may change as configurations are reviewed. These are expected to be the maximum quantities that will be either stored or used at the indicative GPF design capacities.

Table 22.2 Chemicals used by GPFs – indicative quantities

Chemical	Packaging type	Packaging size (m^3)	Typical 75 TJ/d GPF (m^3)	Typical 150 TJ/d GPF (m^3)	Notes
Anti-scalant	Bulk	1	3	6	
Biocides	Drum	0.02	0.2	0.3	Process chemical to prevent sulphate reducing bacteria in wells and process.
Flocculants	Bulk	1	4	8	
Hydraulic drive oil	Bulk	25	2x25	3x25	Combustible liquid
Hypochlorite solution	Drum	0.02	0.2	0.4	Class 8, bunded pallets
Triethylene glycol	Bulk	1	3	6	Process chemical – gas dehydration, combustible liquid
Oils	Drum	0.02, 0.205 and 1	4	7	Combustible liquid including hydraulic oils, within bunded sump
Oil collection	Bulk	0.5	2x0.5	3x0.5	Combustible liquid
Dry waste oil	Bulk	25	2x25	2x25	Combustible liquid
Wet waste oil	Bulk	10	2x10	3x10	Combustible liquid
Crankcase lube oil	Bulk	25	2x25	3x25	Combustible liquid
Cylinder lube oil	Bulk	25	2x25	3x25	Combustible liquid
Diesel	Bulk	12.4	2x12.4	3x12.4	Combustible liquid

Additional notes: A range of other chemicals and products including reverse demulsifier, aerosol cans, oxy-acetylene bottles and liquid petroleum gas will be stored and used for associated camp operations and other aspects of the Project's WTFs.

Water treatment facilities

Up to six WTFs are proposed for the gas fields' component of the Project. The WTF are proposed to be constructed based on 20 mega litres per day (ML/d) modules for the reverse osmosis facility with supporting infrastructure, including chemical storage, based on the peak volumes of water. Table 22.3 provides indicative details of chemical storage for a 40ML/d WTF. These values are based on the operation of the existing Spring Gully WTF and on the design of the Talinga WTF.

Table 22.3 Chemicals for a 40ML/d WTF – indicative quantities

Chemical	Packaging type	Packaging size and quantity	Notes
Anhydrous ammonia	Bulk	2x1t tank 0m^3	To prevent biofouling of ion exchange columns depending on whether a chloramination facility will be a part of the design. Class 2.3, Sub Risk (SR) 8
Anti-scalant	Bulk	10.4+2x2.5=15.4m3m	
Biocide	Bulk	2.5m^{3}m	Class 8, PG III
Chlorine (gas)	Bulk	5t. mm.	To prevent biofouling of ion exchange columns depending on whether a chloramination facility will be a part of the design. Class 2.3, Subrisk 5.1 & 8. Two drums on line and 4 on site in storage
Citric acid	Bulk	10.6m3m	
Diesel	Bulk	3m3.00	Emergency generator, combustible liquid
Hydrochloric acid	Bulk	45+2.5=47.5m3m	Class 8, PG II (33%), dependent on whether ion exchange will be part of design
Lubrication oil	Bulk	2.25m3.	Combustible liquid, self bunded tanks
Sodium bisulphite	Bulk	20+2.5=22.5m3m	Class 8, PG III
Sodium hydroxide	Bulk	13.6+5 =18.6m3m	Class 8, PG II
Sodium hypochlorite solution	Bulk	13.6m3m	Class 8, PG III
Waste oil	Bulk	2.25m3.	Combustible liquid, self bunded tanks

Additional notes: More than 30 miscellaneous chemicals and blends of chemicals (reagents) will also be used in small quantities at the WTFs.

Whilst Table 22.2and Table 22.3 list indicative chemicals, the actual types of chemicals used for specific purposes may change. Material safety data sheets will be available for each of these chemicals. In addition, an electronic register will be kept of all dangerous goods or hazardous materials stored at either the wellhead, GPF or WTF.

This register will list all hazardous chemicals and will generally include the product name, material safety data sheets, container type, container size, number of containers and the quantity of chemical in the container.

All spill containment measures will meet the intent of the relevant Australian Standard for each dangerous good. Storage cabinets and bund pallets may be used for chemicals in smaller quantities.

22.4 Gas field hazards and risks

The major hazards identified for the gas wells, gas and water gathering network, GPFs, and WTFs are presented in the following sections. For each the potential hazard, the possible causes, the anticipated consequences, key controls and 'residual' risk are presented in Table 22.4 through to Table 22.11. Residual risk is the risk remaining after controls are in place and includes an estimate of the effectiveness of those controls. These tables are based on numerous risk workshops conducted during the EIS studies, which included relevant experts and experienced project personnel. Potential hazards and risks are described for the drilling, construction, operational and decommissioning phases within the following areas:

- Plant and equipment – gas wells, gas and water gathering network, GPFs and WTFs
- Natural hazards
- Vehicles and traffic.

22.4.1 Plant and equipment

Gas well drilling

Up to 10,000 gas wells will be drilled during the estimated 30-year life of the Project. Potential hazards associated with drilling gas wells include events such as:

- Injuries from the use of rotating equipment
- Musculoskeletal damage associated with heavy lifting, for example, drill pipes
- Falling from height
- Heavy objects falling
- Escape of gas from the wellhead
- Slips, trips and falls
- Potential impact with overhead powerlines
- Potential radiation exposure from geophysical survey equipment.

Table 22.4 indicates the hazards and risks that were assessed to have the potential for external damage, whereas typical workplace health and safety hazards, such as manual handling hazards, are listed and discussed in Section 22.6.

Australia Pacific LNG will source reputable CSG drillers and appropriately designed drilling equipment, and will implement the controls outlined above to reduce the risks associated with drilling and well completion activities. The requirements of the PAG Act including activities such as competency assessments of the drilling contractors will continue to be embraced. Overall, drilling has a low residual risk to people, property and the environment provided the controls are maintained. This will remain a key aspect.

Table 22.4 Potential drilling and gas well construction hazards

Potential hazard	Possible causes	Possible consequences	Proposed controls	Residual risk level
Uncontrolled release at gas well (prior to installation of the wellhead)	Drilling under pressure and encounter conventional gas Mechanical failure of the casing Earthquake Bushfire	Fire Serious injury or fatality	Secured area around wellheads cleared of vegetation Drilling procedures and trained operators Emergency response procedures Sources of ignition suppressed e.g. spark arrestors on exhausts Quality assessment of equipment Design standards for potential earthquake loads	Negligible
Overhead electrical transmission power line damaged	Drilling rig impact Pipeline construction equipment operated by or transported under power lines and making contact with live lines Mechanical impact Crane operations	Interruption to power Electrocution and fatality	Standard operating procedure for drilling Location of drilling rig away from power lines Known height of transmission powerlines Potential use of isolation devices on cranes Vehicle and route selection Licensed operators of equipment that is high or long (e.g. licensed crane operators, drilling rig operators, pipeline constructors etc)	Low
Exposure to radiation	Radioactive sources used for instrumentation e.g. density measurement equipment Too long near source or too close to source Radiation source is dropped or lost	Radiation sickness Fatality	Borehole loggers and other density testing personnel are licensed according to the *Radiation Safety Act 1999* Reputable geotechnical companies used Level instrumentation is installed and operated by licensed companies	Negligible

Wellhead operations

In order to produce gas from a coal seam, in situ water is first pumped from the well at the depth of the coal seam being developed. Once the ground water pressure has been sufficiently reduced, the CSG will begin to be released. The gas flow increases over time until it reaches a maximum and then tapers off to a long duration low. The time scale for production varies from well to well, but durations of 12 to 25 years are typical.

Due to the nature of the well, some water will be present with the gas produced and some gas will be entrained in the water produced. As a result, both water and gas are piped into a small vessel called a wellhead separator, where the mixture is separated into gas and water streams.

Hazards associated with wellhead operations are associated with equipment failure. These failures will be repaired or equipment replaced as necessary. Regular inspections, preventative maintenance programs and auditing of equipment will take place to manage the integrity of well site equipment. Gas wells are essentially stand alone facilities, which require limited maintenance. Typical maintenance activities include regular engine inspections and servicing and other routine repairs. Down-hole pump replacement may become necessary. Inspection and testing of safety devices will also take place as part of a preventative maintenance program. Corrosion inhibitors and anti-scalant additives will be used to minimise corrosion and scaling risks. Hazards that were assessed to have the potential for external damage are further outlined in Table 22.5.

Well sites will be located to ensure an adequate separation distance between the wellhead and any adjacent facilities or dwellings to allow adequate access for work-over rigs. The separation distance also ensures no impact to third parties, persons or property in the unlikely event of an escape of gas or equipment failure. Section 22.4.2 discusses potential radiant heat distances.

Gas flows from CSG wells are typically lower than from 'conventional' natural gas wells, so a greater number of wells are required. A number of wells (approximately 1,200) must be producing gas, prior to the completion of the LNG facility in Gladstone.

Once a well is producing, a total cessation of production (shut-in) may cause the well to return to its pre-dewatered state. This may require re-starting by dewatering or as a worst case an expensive intervention or repair (work-over). A normal shut-in is unlikely to result in risk to persons, property or the environment.

The highest risk associated with upstream operations is due to travel by operators either to or from the facility or inspection of wellhead facilities. This hazard will be addressed by a range of controls, including designing wellheads to minimise the need for inspection, through to specific controls associated with driving hazards ranging from speed controls through to training.

Table 22.5 Potential CSG wellhead hazards

Potential hazards	Possible causes	Possible consequences	Proposed controls	Residual risk level
Rupture of pipeline between the wellhead and separator	Mechanical failure of pipe / flanges / valves Mechanical impact Vehicle impact Earthquake Bushfire	Fire Serious injury or fatality	Quality assurance of installed equipment Inspection and condition monitoring program Secured area around wellheads Areas around wellheads cleared of vegetation Remote monitoring of pressure and flow Isolation downstream of the well Emergency response procedures Sources of ignition suppressed e.g. spark arrestors on exhausts The low pressure at CSG wellhead Design standards for potential earthquake loads	Low
Uncontrolled release of CSG at the wellhead (and ignition)	Mechanical failure of the casing Earthquake Bushfire	Fire Serious injury or fatality	Secured area around wellheads cleared of vegetation Emergency response procedures Sources of ignition suppressed e.g. spark arrestors on exhausts The low pressure at CSG wellhead Quality assessment of equipment Design standards for potential earthquake loads	Negligible
Gas venting at a wellhead	Mechanical failure Control system failure Pressure safety valve (PSV) release Maintenance activity	Flash fire	Design of facilities Redirection of gas to other processing facilities Operations intervention	Low

Gas gathering network

The two streams (gas and associated water) from the wellhead are separated and flow to the low pressure gas and water gathering networks. A pressure adequate to force associated water from the separator to the water gathering system is maintained by a controller on the separator.

The low pressure gas from each of the wellhead separators flows into a buried pipeline, which links the wellhead separator to the nearest trunk line (typically larger buried pipelines), to form the gas gathering network.

The gas gathering network, which will be constructed of high density polyethylene pipe or equivalent suitable construction material, transports the gas to a GPF. The design may include nodal compression and, if so, may include the use of carbon steel pipe-work in some areas.

The potential risks associated with the construction, operation and decommissioning of the gas gathering network are identified in Table 22.6. The gas gathering network will be constructed using trenching and boring techniques. General construction health and safety risks, such as manual handling of pipes, are discussed in Section 22.6.

As the pipelines are buried, they are less susceptible to external damage from, such as being struck by vehicles.

Water gathering network

Significant volumes of associated water will be co-produced from the wells in advance of gas as dewatering activities take place and will continue at lower rates after full well gas production is established.

The associated water from each of the wellhead separators flows into a buried pipeline which is linked to the nearest trunkline (larger buried lines) to form the associated water gathering network. The entire network will typically operate between 200 and 340 kilopascals (gauge) (kPag), depending on terrain, and will be constructed of high density polyethylene pipe or equivalent material. The water flows through several sub-networks (main trunklines), which direct the water to the associated WTF or to a water transfer station. An intermediate water transfer station may be installed at some points to collect water in a pond and pump it to a suitable location.

Gas and water gathering networks will be installed at the same time and in a common trench wherever possible. General construction health and safety risks, such as manual handling of pipes, are discussed in Section 22.6. The gas and water gathering networks will be monitored continuously for pressure changes through the supervisory control and data acquisition (SCADA) system.

There is a potential hazard, given a pipeline fire, that another pipeline in this common trench will also be damaged. This might lead to associated water leakage.

Table 22.6 Potential gas gathering network hazards

Potential hazards	Possible causes	Possible consequences	Proposed controls	Residual risk level
Person, fauna or vehicle falling into open excavations or trenches	Unexpected open excavations	Damage to vehicles Injury or fatality	Boring of pipeline at major road crossings Construction safety management plan Barricades Identification and signage	Low
Slow leak	Small hole in pipeline Minor joint or weld failure	Loss of gas	See below	Negligible
Rupture of pipeline in the gathering network	Pipeline strike by equipment Major joint or weld failure Earthquake decommissioning of pipelines	Jet fire, flash fire or explosion (depending on level of confinement) Flying debris Serious injury or fatality Rupture of other pipelines in trench	Selection and placement of pipeline Materials of construction Design and material properties of pipeline to prevent rupture Design standards for potential earthquake loads Depth of cover Pipeline markers and signage Emergency response procedures Decommissioning of pipelines	Low

Gas processing facilities

The proposed GPFs will be located across the Walloons gas fields, at sites selected to optimise development of the gas reserves. The gas will be collected and piped to a number of compression units where the pressure of the gas will be raised. The final stage for compression is expected to produce a maximum compressor discharge pressure of 15,000kPag. The compressors are likely to be driven by engines utilising a portion of CSG as fuel. The cooled compressed gas will be piped to a dehydration unit to remove most of the water, mainly to reduce the incidence of corrosion, so it can be efficiently transmitted in the main pipeline.

The typical facilities associated with a GPF, in addition to the above, include:

- Power generating facilities (fuelled by CSG)
- Flare facilities for safe combustion during abnormal operations
- Administration, personnel accommodation and maintenance facilities.

Construction of the GPF will involve typical construction activities such as excavation and installation of plant and equipment modules. A typical GPF will be in a secure site, located away from sensitive receptors and there will be separation between the plant and administration offices. General construction and operational health and safety risks are discussed in Section 22.6. Risks with potential for third party damage are outlined in Table 22.7.

Water treatment facilities

WTFs will collect and process the associated water and utilise or dispose of the water and water products. The water will be treated in a water treatment plant to produce a 'clean' permeate water and a high-salt brine effluent. The effluent either will be safely retained in secure plastic-lined management ponds or further processed to recover useful salts. The treated water could be suitable for commercial uses, irrigation, supplementing community water supplies and aquifer injection.

Typical facilities associated with WTFs include:

- Associated water feed ponds
- The water treatment plant
- Chemical storage facilities
- Management ponds for residual brine effluent
- Power generation (using GSG as fuel)
- Pumps
- Associated buildings.

The major hazards and risks for the WTF to third party persons, property and the environment are assessed in Table 22.8. The potential hazards associated with a WTF and ponds also include electrical hazards (discussed in Section 22.6) and chemicals (discussed in Section 22.3.3). Hazards and risks associated with water and water discharges are further discussed in Volume 2 Chapter 9 – Aquatic ecology, Volume 2 Chapter 10 – Groundwater, Volume 2 Chapter 11 – Surface water and watercourses, and Volume 2 Chapter 12 – Associated water.

Construction of the facilities typically will involve earthworks and installation of plant and equipment in modules. Hazards and risks associated with construction are discussed in Section 22.6.

Ponds will be designed to prevent uncontrolled water escape to the environment and pond capacity will be controlled throughout the Project. Considering the controls in place, the risk of a dam failure to persons, property, fauna and the environment is considered as being negligible

Table 22.7 Potential gas processing facilities hazards

Potential hazards	Possible causes	Possible consequences	Proposed controls	Residual risk level
Rupture of high pressure piping	Mechanical failure of pipe / flanges / valves Mechanical impact Earthquake	Fire Flying debris Serious injury or fatality	Quality assurance of installed equipment Pipe design and properties prevent rupture and corrosion Inspection and condition monitoring program Remote monitoring of pressure and flow Remotely operated isolation valves Non-return valves Emergency shut down systems and response procedures	Low
Gas leak into enclosed area (with no ignition)	Faulty valve Faulty flange or seal Enclosed area not allowing for the escape of gas Corrosion of pipeline Earthquake	Asphyxiation	Design of compressor Design of electrical installations Quality assurance of installed equipment Pipe design and properties to prevent rupture and corrosion Inspection and condition monitoring program Gas detection Remote monitoring of pressure and flow Remotely operated isolation at mid line valves Secured area Emergency shut down systems and response procedures	Low
Gas leak into enclosed area (with	Faulty valve	Explosion	Design of compressor	Low

Potential hazards	Possible causes	Possible consequences	Proposed controls	Residual risk level
ignition)	Faulty flange or seal Enclosed area not allowing for the escape of gas Corrosion of pipeline Earthquake	Flying debris Fire Serious injury or fatality	Design of electrical installations Quality assurance of installed equipment Pipe design and properties to prevent rupture and corrosion Inspection and condition monitoring program Gas detection Remote monitoring of pressure and flow Remotely operated isolation at mid line valves Secured area Emergency shut down systems and response procedures	
Operating high pressure gas processing plant and equipment	Operations error	Injury or fatality	Sites work under the umbrella of an appropriate safety management system Ongoing training and awareness Ergonomic system design Standard operating procedure	Low
Loss of tri-ethylene glycol at the GPF	Leak Mechanical failure	Corrosion Sour gas Acute effects: - toxic via ingestion - mildly irritating to the eye and	Design and quality assurance of equipment Area secured SCADA monitoring systems in place Appropriate containment in closed sump	Low

Potential hazards	Possible causes	Possible consequences	Proposed controls	Residual risk level
		skin Chronic effects - defeats the skin and may contribute to dermatitis		
Damage and failure of storage facilities	Poor design leading to failure of vessels Mechanical impact	Contamination Injury chemical exposure	Vessels constructed as per Australian Standards Quality assurance of installed equipment Inspection and condition SCADA monitoring program Secure area around above ground infrastructure Emergency shut down systems and response procedures Standard operating procedures Remote SCADA monitoring of pressure and flow	Low
Accommodation fire	Electrical fault Naked flame Source of fuel and ignition Kitchen fire	Loss of infrastructure Injury or death	Smoke detectors installed and operational Fire fighting equipment installed and operational Separation of certain infrastructure and chemicals in storage Emergency response procedures Ongoing education and training of persons	Low

Table 22.8 Potential water treatment facilities hazards

Potential hazard	Possible causes	Possible consequences	Proposed controls	Residual risk level
Dam failure or subsidence	Insufficient buffers in storage ponds and bunding Placement of fill or cut Incorrect sizing or construction type of structures Overtopping Embankment failure Seismic activity Liner breach	Release of contaminants to waterways (mainly suspended solids) Release of contaminants to land Inundation of property and assets Health and safety risks to people and animals Crop damage Scour and erosion (loss of vegetation and soil) Overland flow Property and infrastructure damage	Engineering design of dams Gathering geotechnical information Monitoring and maintenance Capacity control procedures	Negligible
Dam overflow	Overtopping Insufficient buffers in storage ponds and bunding	See above	See above	Negligible
Drowning and hazard to fauna	Boat accident Potential fall into the pond	Injury Fatality	Engineering design of dams Controlled access Adequate signage	Negligible

High pressure gas pipelines

The dried compressed gas from each of the GPFs is routed to the high pressure gas pipeline network. The buried steel pipeline network will link all of the GPFs and connect to the main gas transmission pipeline through to the LNG facility on Curtis Island. The pipeline will be designed for a significantly conservative maximum allowable operating pressure, which is expected to be 15,000kPag.

Potential hazards associated with the construction and operation of the high pressure gas pipelines are similar to those for the main gas transmission pipeline, which are discussed in Volume 3 Chapter 22. The hazards with potential for external damage applicable to the high pressure pipeline are given in Table 22.9. Additional hazards for the high pressure pipelines are related to the compressor outlet, that is, the potential for a rupture of the pipe at a compressor or GPF discharge. This hazard is outlined in Table 22.7 and analysed in Section 22.4.6

22.4.2 Natural hazards

Natural disasters

Potential hazards related to natural disasters for the gas fields' area are presented in Table 22.10. The likelihood of any damage in the event of a natural disaster will be significantly reduced through the design of equipment and facilities. Emergency response plans will be developed for at least the following scenarios and adhered to in any disaster. These will include procedures for evacuation of personnel, containment of equipment and protection of the environment. The proposed controls will reduce the risk to acceptable levels.

Climate and climate change is further discussed in Volume 2 Chapter 4, while emergency response plans are included in Section 22.7

Wildlife and disease vectors

In the project area, personnel will be exposed to potentially hazardous wildlife, including snakes and spiders, and disease vectors, such as mosquitoes, rats and flies.

Venomous snakes and spiders are known to inhabit the gas fields' area. Project personnel will be alerted to the hazards of snakes and other venomous animals and the areas where they are commonly found, such as in long grass and under rocks. First aid training and treatments will be provided.

Mosquitoes are able to transmit viruses such as dengue fever or Ross River fever. Australia Pacific LNG will control mosquito breeding at ponds and other water areas. The potential for malaria, which has been eradicated from Australia, and disease vectors for other exotic diseases that might be entertained as a result of migration or climate change will be further assessed, if the risks became credible.

The control of disease vectors such as insects and rodents is necessary for the maintenance of health and hygiene in any location. Controls are via items such as screen doors, as well as hygienic practices, covered waste disposal, sanitation and sewerage systems. Accommodation and office areas will be treated to minimise exposure in these environments. Controls will be monitored for effectiveness, verified by means such as audits and inspections or, where appropriate, microbiological sampling of environment and food contact surfaces will be undertaken. These controls will be regularly reviewed and adapted to reflect changed circumstances.

Table 22.9 Potential high pressure pipeline construction and operation hazards

Potential hazard	Possible causes	Possible consequences	Proposed controls	Residual risk level
Mid line rupture	Excavation Earthquake Corrosion	Fire Injury or fatality	Selection and placement of pipeline easement Design standards for potential earthquake loads Pipeline designed to prevent full bore rupture Depth of cover Pipeline markers and signage Remote monitoring of pressure, flow and leaks Remotely operated isolation at mid line valves Corrosion inhibitor and cathodic protection Emergency response procedures	Low
Damage to infrastructure during construction	Excavation Use of explosives Vehicle impact	Interruption to community or business Injury or death	Identification of infrastructure Surveys Standard operating procedures for explosives Reputable pipeline construction contractors Construction safety management plans	Low
Person, fauna or vehicle falling into open excavations or trenches	Unexpected open excavations	Damage to vehicles Injury or fatality	Boring of pipeline at road crossings Construction safety management plan Barricades Identification and signage	Low

Potential hazard	Possible causes	Possible consequences	Proposed controls	Residual risk level
Overhead electrical transmission power line damaged	Boring and trenching operations Pipeline construction equipment operated by or transported under power lines and interfering/ making contact with live lines Mechanical impact	Interruption to power Electrocution and fatality	Standard operating procedure for equipment Pipeline route Height of transmission powerlines Potential use of isolation devices	Low
Damage to data cables	Excavation Use of explosives	Loss of service Electrocution and/or fatality	Standard operating procedures for explosives Dial before you dig Cable locating	Low

Table 22.10 Potential hazards related to natural disasters

Potential hazards	Possible causes	Possible consequences	Proposed controls	Residual risk level
Geology and geomorphology	Earthquake Landslide Subsidence	Pipeline rupture Property and equipment damage Environmental harm Injury to person	Design of plant and infrastructure to withstand such events Location of plant and infrastructure away from vulnerable areas Ongoing monitoring and inspections of equipment Emergency response plans	Negligible
Floods (natural)	Excessive rain River flows breaking banks	Environmental harm Release of contaminants to waterways (mainly suspended solids) Inundation of property and infrastructure Drowning Health and safety risks to people and animals Crop damage Scour and erosion (loss of vegetation and soil)	Construct bridges and other infrastructure above maximum flood levels Construct buried infrastructure (pipes, power or telecommunications cables) to avoid scour and potential rupture Observe weather forecasts, warnings and updates from the Bureau of Meteorology Emergency response plans Install flood gauges and close roads as necessary Avoid remote locations, wells and ponds during heavy weather Journey management plans Consider the provision of a dedicated	Negligible

Potential hazards	Possible causes	Possible consequences	Proposed controls	Residual risk level
			elevated area for a helipad at key facilities	
Drought	Lack of rain Lack of retention of water	Agricultural losses Death of livestock Desertification of land	Water management, including re-use and water restrictions Ongoing monitoring and inspections of water systems Opportunity for the Project to provide water to wildlife and livestock	Negligible
Heat wave	High temperatures Climate change	Equipment and infrastructure damage Heat stroke or death of vulnerable persons Cancer from sun exposure	Education and training Management of persons Heat stress emergency response procedures Design equipment and utilities for high temperatures and increased demands Use of personal protection equipment, sunscreen and shade	Negligible
Storms	Wind Rain Dust	Equipment damage Environmental harm Injury or death of people	Observe weather forecasts, warnings and updates from the Bureau of Meteorology Design of equipment for storm events Emergency response plans	Low
Bushfire	Sources of ignition	Property damage	Observe weather forecasts, warnings and	Low

Potential hazards	Possible causes	Possible consequences	Proposed controls	Residual risk level
	Lightning Accidental or deliberate fire	Environmental harm Injury or death of fauna and/or livestock Injury or death of people	updates from the Bureau of Meteorology Observation of total fire bans for high risk days / seasons Education and training Emergency response plans Bushfire breaks (maintain clearance around wellheads) Smoke detection systems at the camps Fire prevention during construction Maintain contact with and obtain advice from rural fire services Recommendations to fire services which dams can be used for fire water	
Lightning	Storm weather Lightning attractors	Damage to equipment or buildings Explosions Injury or death of people	Observe weather forecasts, warnings and updates from the Bureau of Meteorology Lightning protection for at risk structures Cessation of certain activities during lightning, e.g. explosive activities, standing near/under attractors Emergency response plans	Negligible

22.4.3 Vehicles and traffic

The potential hazard and risk aspects of road transport and traffic will be managed across the Project through the three elements of road design, vehicle design and behaviour management of drivers and pedestrians. Potential vehicle and traffic hazards are outlined in the Table 22.11. Traffic and transport impacts and their management are further outlined in Volume 2 Chapter 17.

The increase in heavy and light vehicle traffic is considered to have a high residual risk rating despite the application of controls to as low as reasonably practicable and the application of controls beyond those required on, such as public roads. Due to the potential fatal consequences of a vehicle accident and the fact that the likelihood related to the background risk of a vehicle accident is high, the residual risk of a vehicle accident to persons and fauna remains high.

Australia Pacific LNG fleet vehicles and hire vehicles used by project personnel will be fitted with an in-vehicle monitoring system. Drivers will be required to comply with a corporate local transport directive, which makes journey planning mandatory.

It is difficult for Australia Pacific LNG to reduce the residual risk further as the designs of public roads and the behaviour of other road users is beyond its control. However, Australia Pacific LNG will actively engage with the relevant authorities to identify particular risks and participate in ongoing campaigns to reduce the likelihood and consequences of vehicle accidents.

22.4.4 Cumulative risk levels to surrounding land uses

The gas fields are primarily located within rural areas, and include areas of remnant vegetation. There are numerous small towns and rural dwellings within the gas fields' area. Key project infrastructure will be located away from sensitive receptors to ensure the hazard end points for an explosion or CSG fire do not impinge upon dwellings.

Traffic and transport risks are likely to increase with concurrent construction and operation activities undertaken by multiple projects. Australia Pacific LNG will work with local authorities, the Department of Transport and Main Roads, and discuss issues with other project proponents to manage traffic and transport-related risks.

A fire started for any reason by any of the proposed project activities could spread to surrounding vegetation and become a bushfire. Bushfires threaten people, property and the environment. Controls for the prevention of bushfire, such as work procedures and maintaining clearings around wellheads and other gas processing facilities are outlined in Section 22.4.2. The risk of such fires increases with concurrent construction and operation activities undertaken by multiple projects.

Where any pipeline crosses any other pipelines, or is adjacent any facilities or infrastructure, then the requirements of AS 2885 will be applied. As the 'off-site' risk from fire radiation or explosion imposed by any of the proposed facilities is very small, other site selection criteria such as the need for access ensures that cumulative safety risks are minimised.

There is a potential environmental impact (e.g. spills) associated with the increased transport of fuel, hazardous materials and other chemicals by all of the projects in the region. The use of reputable transport contractors and appropriately designed containers in line with legislative requirements will minimise the risk.

Cumulative hazards and risks are discussed in more detail in Volume 2 Chapter 25.

Table 22.11 Potential vehicle and traffic hazards

Potential hazards	Possible causes	Possible consequences	Proposed controls	Residual risk level
Increased heavy and light vehicle traffic	Quantity of materials required to construct and install gas field and pipeline facilities Movement of large numbers of construction and operation staff at shift changes Addition of high volumes along previously low trafficked routes Need to supply road construction material and water to remote road construction sites	Elevated risk of serious or fatal motor vehicle accidents Increased risk in areas outside of regular emergency services contact Increased risk of fauna injuries and deaths	Driver fatigue monitoring Enforced speed limits on project vehicles Use of buses to move people - minimise private vehicles on site. Restricted access to public in work areas Ongoing education and training of drivers and pedestrians in road hazards Journey management plan Vehicles fitted with in-vehicle monitoring systems Consultation with councils and Department of Transport and Main Roads regarding high risk intersections and sections of road	High
Rail and road crossings	Increased traffic at uncontrolled rail crossings	Injuries or fatalities Collisions and disruption of rail services	Liaison with councils and Department of Transport and Main Roads in consideration of high risk rail and road crossings	Medium

Potential hazards	Possible causes	Possible consequences	Proposed controls	Residual risk level
			Mandatory stop at railway crossings monitored by in-vehicle monitoring system	
Diesel fire involving mobile fuel tanker	Vehicle engine fire as an ignition source to the fuel tank Naked flame Collision	Fire Environmental harm Serious injury or fatality	Suitably qualified fuel transport operator (giving consideration to vehicle maintenance, driver training and procedures) Properties of diesel (difficult to ignite) Clean up procedures as part of emergency response plan	Negligible
Air transport safety	Increased traffic on airstrips (both fixed wing and rotary wing aircraft) Flaring and exhaust plumes causing turbulence affecting Miles aerodrome	Threatened operation of aircraft Aircraft crash, injuries or death	Modelling of plume rises Location of plant outside controlled air space Consultation with relevant local government authorities and CASA	Negligible

22.4.5 Consequence assessment overview

The purpose the consequence assessment is to illustrate the impacts of scenarios where there is a significant hazard represented at the wellhead, gas and water gathering networks, high pressure pipelines, GPFs and WTFs during construction, operations and decommissioning. This applies to hazards which have the potential to impact persons, property or the environment by heat radiation or explosion overpressure.

All hazards, including those with the potential for catastrophic consequences, will be managed via design and ongoing safety management to reduce the likelihood of an incident to as low as reasonably practicable. While safety management procedures and emergency management plans are important with respect to the holistic approach to the management of risk, design of facilities are the critical first steps in the overall hierarchy of controls. The hierarchy of controls including, eliminate, substitute/transfer, engineer, administration and personal protection equipment, and the risk management methodology for the control of risks is presented in Volume 1 Chapter 4.

The hazards have been assessed in terms of the potential worst credible consequences of scenarios. This has been done in order to assess the outermost limits of the potential impacts. The limiting scenarios are presented and assessed to ensure that the hazards are inherently limited by design. Where it is shown that the limiting scenario meets design criteria, then other lesser potential impacts are also likely to meet design criteria.

HIPAP no. 4 contains guidelines for comparing the consequences of heat flux and overpressure. These are used to identify appropriate hazard end points to be considered. Hazard end points for heat radiation levels were obtained for 4.7 kilowatts per square metre (kW/m^2), 12.6kW/m^2 and 23kW/m^2 in order to assess the risk of serious injury and the risk of fatality. Similarly, hazard end points were obtained for explosion overpressure levels of seven kilopascals (kPa) and 70kPa.

The consequence assessment is available in the technical report in Volume 5 Attachment 46.

Plant and pipeline incidents

Natural gas has been safely handled for many years. There has never been a death or injury recorded in connection with damage to a pipeline in Australia (Tuft 2009). The industry is not without its incidents and accidents, but it maintains an excellent safety record as a result of the high standards adopted in the design and management standards of present day pipelines and facilities.

An analysis of pipeline incidents performed by Tuft (2009) of the Australia Pipeline incident database shows a breakdown of all damage incidents recorded. For example, the number of recorded incidents from external interference is 118; six from construction defects; five from earthmoving; five from lightning, and three from corrosion.

In comparison, an analysis of pipeline incidents by the European Gas Pipeline Incident Data Group (EGIG) has been categorised into six different causes. External interference is similarly identified as the leading cause of gas pipeline incidents resulting in a gas leak, with an overall percentage of 49.6. Corrosion and construction defects/material failures are again the next most common cause of the failures at 16.5 and 15.5% respectively.

The predominant cause of pipeline incidents, no matter which data source is considered, is external interference. AS 2885 contains guidelines for protecting pipeline against such threats, on the basis of the location class (i.e. additional controls for high consequence locations). For example, thicker wall pipes may be used in sensitive areas to reduce the risks of material failure, gouging, deformation and corrosion. The preliminary location classifications found when assessing the high pressure pipeline route, as part of the safety management study are further outlined in Volume 5 Attachment 48.

In addition to the major events identified above, gas leaks from pipelines and associated infrastructure resulting in minor fires have been known to occur in the industry. The impact of these events is usually limited to plant infrastructure and the hazard promptly handled by plant personnel (CH-IV International 2006). The effective response to gas leaks is a culmination of the practices equating to a good approach to process safety management. This includes the development of pipeline and plant safety management plans including emergency response plans, which outline the response to gas leaks and fires.

22.4.6 Gas fields' hazard scenarios

The following gas fields' hazard scenarios have been analysed:

- Uncontrolled release of gas at the wellhead
- Rupture of pipeline between wellhead and separator
- Rupture of pipe in gas gathering network
- Rupture of gas outlet header from compressor
- Uncontrolled detonation of explosives
- Gas flaring
- Process and exhaust gas plume rise assessment
- Gas leak from pipeline infrastructure
- Diesel fire involving mobile fuel tanker
- Pipeline gas explosion.

Details of the modelling, consequences, likelihood and risk assessment for each scenario are presented in Volume 5 Attachment 47 and Volume 5 Attachment 46. The key findings from this analysis are summarised below.

Uncontrolled release of gas at the wellhead – prior to installation of the wellhead

An uncontrolled release of CSG at a wellhead and subsequent fire is considered to be very unlikely, given the controls in place, and to have a low consequence due to comparatively low pressures of CSG. Therefore, it is given a negligible residual risk rating.

Rupture of pipeline between wellhead and separator

Whilst the release rate and emissive power of a pipeline rupture between the wellhead and separator are less than for uncontrolled release of gas at the wellhead, the distances to the hazard end points are greater due to the momentum of a horizontal release superimposed with the effect of wind speed.

The distances to the hazard end points based on the most conservative estimates are 31m for a thermal flux of 4.7kW/m^2 (potential injury), 29m for a thermal flux of 12.6kW/m^2 (chance of fatality) and 28m for a thermal flux of 23kW/m^2 (likely fatality).

Rupture of pipe in gas gathering network

This scenario assumes a full bore rupture of the largest pipe in gathering network prior to the gas processing facilities. The CSG is at low pressure, the pipeline will be buried and the pipeline will be designed to prevent a full bore rupture. Thus, this scenario is considered to be extremely unlikely. Nevertheless the scenario has been modelled to show the hazard it represents.

For a 600mm pipe diameter, the distances to the hazard end points based on the most conservative estimates are 127m for a thermal flux of 4.7kW/m^2 (potential injury), 77m for a thermal flux of 12.6kW/m^2 (chance of fatality) and 57m for a thermal flux of 23kW/m^2 (likely fatality).

Rupture of gas outlet header from compressor

This scenario considers a full bore pipe rupture of the gas outlet header from a compressor at a GPF, which is at high pressure. Although the pipe is designed to prevent a full bore rupture, it is possible that rupture could occur due to mechanical impact or earthquake because this section of pipe is above ground.

The modelling results indicate distances to the hazard end points, based on the most conservative estimates, of 130m for a thermal flux of 4.7kW/m^2 (potential injury), 118m for a thermal flux of 12.6kW/m^2 (chance of fatality) and 114m for a thermal flux of 23kW/m^2 (likely fatality).

Uncontrolled detonation of explosives

Australia Pacific LNG's use of explosives during construction or operations of the gas fields will be minimal. Explosives may be used during drilling and construction, such as when hard rock sections require blasting. An uncontrolled detonation of explosives could lead to injuries or fatalities or damage to surrounding fauna, property, including pipelines or state forest. Australia Pacific LNG will use accredited, experienced, contractors to meet legislative requirements.

Gas flaring

Over the life of a well and a GPF, there will be occasions when gas is flared. At a wellhead there may be drilling rig flares and flare pits. At a GPF there will be flaring associated with combusting gas released by pressure relief valves during unplanned over-pressuring. Flaring is avoided where possible, such as by redirecting gas, reducing gas flow rates and/or selling gas to other persons. Flaring may be expected a few times a year.

A consequence analysis has been performed on a flame out scenario to calculate the hazard end point associated with the lower flammable limit. Methane is flammable only over a narrow range of concentrations (5 to15%) in air. The lower flame limit is the lower concentration (5%) at which the CSG is flammable. The modelled scenario is for a situation where the flare is extinguished resulting in a vapour cloud which leads to a flash fire, if subsequently ignited. This is a worst credible case.

The modelling shows the hazard end point for flaring at a GPF. The lower flammable limit is 18m from the point source. Since the flare stack will be approximately 46m high (the final height to be determined during detailed design), the flame will not reach ground level.

Flares may potentially impact air traffic. Miles landing strip and Chinchilla aerodrome are located near the gas fields. A GPF flare stack may potentially be located near the Miles landing strip. It is remotely possible that the emissions from the flare stack could impact the flight paths of small aircraft or helicopters flying in the vicinity by creating air turbulence or pilots may be confused by the flames from the stacks. Plumes from process and exhaust gas are further assessed below.

Process and exhaust gas plume rise assessment

One of the proposed GPFs will potentially be 2.2km north east of Miles aircraft landing area. There are currently no commercial flights serviced by the landing strip. The landing strip is primarily used by the Royal Flying Doctor Service and private aviation such as Western Downs Flying School. However, the development plan indicates that the authorities may consider commercial aviation in the future. The circuit surrounding the landing strip is used for training and landing approaches and can be anywhere from 1.8 to 3.6km from the runway.

The Civil Aviation Safety Authority (CASA) states that an approach circuit to a landing strip for a light aircraft can be anywhere up to three nautical miles (5.6km) from the landing strip. Aircraft typically overfly on the approach at 1,500ft (457m) and are at a height of 1,000ft (305m) on the downwind leg. They further descend on the base leg until the final approach. The actual heights and distances from the landing strip may differ, as they depend on the size of the aircraft and the capabilities of the pilot.

The obstacle-free area in civil aviation means there should be no wires or any other form of obstacles above the approach and takeoff areas, runways, runway strips, flyover areas or water channels. The obstacle-free area was considered to extend to a distance of 1,350m west of the proposed GPF. CASA requires the proponent of the facility with an exhaust plume which has a vertical velocity of greater than 4.3m/s at a height of 110m or higher to assess the potential hazard to aviation operations.

The modelled effect of flaring plumes on nearby aviation operations are presented in Volume 5 Attachment 47. The assessment consists of two scenarios, an emergency high speed flaring event and air emissions from normal operations. Using data collected from the two scenarios, the resulting plumes were modelled based on meteorological data over a one year period.

With respect to proximity of the plume and the aircraft it was found that the location of the plume will be 2.25km from the runway, 1.35km from the obstacle free area and 1km from the flight path of an aircraft. However, both flaring operations and normal operations exceed the limitation height of 110m at over 4.3m/s. Plume heights during normal operations have a probability of 1.7% of being above 110m. Emergency flaring events, which are infrequent, have a probability of exceeding 110m, 20% of the time (0.18% of a year). This probability is relatively low. If this is combined with the probability of an aircraft being in the vicinity at the same time then the probability of interaction is even less likely.

CASA must be notified if the universal obstacle limitation surface of 110m is at risk of being breached by an exhaust gas plume. CASA may then request information regarding the breach of height and may also need to assess the height of the stacks. CASA will then determine the effect on aircraft safety and whether or not the plume should be classified as a hazardous object.

Australia Pacific LNG will discuss plans for the proposed GPF near Miles aerodrome with CASA and the local government authority. Australia Pacific LNG will endeavour to design the facility to meet both CASA and local government requirements.

Gas leak from pipeline infrastructure

Gas leaks from pipeline and plant infrastructure resulting in minor fires have been known to occur in the industry. The impact of these events is usually limited to plant infrastructure and the hazard usually promptly handled by plant personnel (CH-IV International 2006). An effective response to gas leaks is a culmination of practices, which will be managed via risk management. Australia Pacific LNG is committed to establish and maintain risk management practices throughout the Project.

Modelling was undertaken of a gas leak within an enclosure (e.g. a turbine compressor) which could result in an ignition and explosion. Whilst this situation is very unlikely, the modelling found that the distances to the hazard end point for an explosion pressure of 7kPa (probability of injury is 10%) is 33m, and less than 10m for an explosion pressure of 70kPa (100% chance of fatality), which are within the nominated boundary of the GPF. Australia Pacific LNG will install gas detection and flame detection devices in the enclosures and will utilise flash proof electrical installations to further reduce the risk of this scenario.

Diesel fire involving mobile fuel tanker

Mobile fuel tankers will be used to supply diesel to site and to refuel heavy construction equipment. A fire involving a mobile fuel tanker could lead to fatalities, environmental and property damage. The transportation of fuel will comply with the Australian Code for the transport of dangerous goods by road and rail. It is considered that the selection of travel routes and suitably qualified fuel handling operators is fundamental to achieving an acceptable level of risk. Australia Pacific LNG will ensure that contractors involved in the handling of fuel are suitably qualified and are compliant with legislative requirements.

Pipeline gas explosion during decommissioning

During decommissioning, if sections of any pipeline (including gas gathering network and high pressure gas pipelines) are not correctly purged and hot work is introduced there is a remote possibility of a pipeline gas explosion. In the event that the pipeline is filled with a mixture of gas and air within the flammability limits, an overpressure explosion could occur. This risk has been assessed for the gas pipeline and is presented in Volume 3 Chapter 22. Proposed controls to manage this risk include a decommissioning safety plan, pigging the pipeline before purging, and correct purging of the pipeline.

22.4.7 Consequence assessment summary

A summary of the results from the consequence assessment are presented in Table 22.12

Table 22.12 Summary of consequence assessment for the gas fields

Scenario	Thermal flux (kW/m^2)	Effect	Distance to hazard end point (m)
Uncontrolled release of CSG at the wellhead – prior to installation of the wellhead	4.7	Pain in 15 to 20 seconds and injury after 30 seconds	25
	12.6	Significant chance of fatality after extended exposure, effects on wood and steel	16
	23.0	Likely fatality, effects on wood and steel	12
Rupture of pipe from wellhead to the separator	4.7	Pain in 15 to 20 seconds and injury after 30 seconds	31
	12.6	Significant chance of fatality after extended exposure, effects on wood and steel	29
	23.0	Likely fatality, effects on wood and steel	28
Rupture of gas	4.7	Pain in 15 to 20 seconds and injury after 30	127

Scenario	Thermal flux (kW/m^2)	Effect	Distance to hazard end point (m)
		seconds	
gathering network pipeline	12.6	Significant chance of fatality after extended exposure, effects on wood and steel	77
	23.0	Likely fatality, effects on wood and steel	57
Rupture of gas outlet from compressor – horizontal release	4.7	Pain in 15 to 20 seconds and injury after 30 seconds	130
	12.6	Significant chance of fatality after extended exposure, effects on wood and steel	118
	23.0	Likely fatality, effects on wood and steel	114
Rupture of gas outlet from compressor – vertical release	4.7	Pain in 15 to 20 seconds and injury after 30 seconds	100
	12.6	Significant chance of fatality after extended exposure, effects on wood and steel	64
	23.0	Likely fatality, effects on wood and steel	43
Gas flaring – flame out	Lower flame limit		18
Gas leak from pipeline into enclosure – explosion of stoichiometric mixture	7kPa	Probability of injury 10%, repairable damage	33
	70kPa	100% chance of fatality, complete demolition of houses	<10

Australia Pacific LNG will design, construct, operate and decommission facilities and pipelines in accordance with the mandatory regulations, standards and codes of practice. This includes taking into consideration the distance to hazard end points and designing facilities to present a minimum risk with respect to the surrounding land uses.

22.5 Safety management study

The EIS terms of reference require a risk assessment in accordance with AS 2885 be conducted on the gas pipeline from the gas processing plant(s) to the LNG facility on Curtis Island. Such risk assessment is identified in AS 2885 as a safety management study. This section summarises the Project's activities to date in conducting the assessments, and discusses the high pressure network in the gas fields' area. The technical report is available in Volume 5 Attachment 48.

These safety management studies have been preliminary only, as some design decisions have not yet been made, and results of some ongoing field studies are not yet available.

The objectives of the AS 2885 safety management study process are different from, but complementary to, those addressed by the previous sections based on the Marsh report. The objective of the safety management study process is to ensure as far as possible that the pipeline is designed and installed in a manner that will protect the pipeline against any conceivable events which may arise generally or at particular locations in future. The risk assessment in the above section is based on the threats to the surrounding area by the presence of the pipeline and other gas field facilities.

Location classification analysis

The safety management study includes a location classification analysis. From the start of the pipelines to the beginning of the Callide Range, the route was defined as R1 (land that is unused, undeveloped or is used for rural activities) with local R2 (land that is occupied by single residence blocks typically in range 1ha to 5ha) around Miles and Camboon. The route is almost entirely rural with very low population density. With more detailed alignment design, these classifications will be further detailed.

Threat analysis

A significant factor associated with damage to buried pipeline is external activities, which inadvertently contact and cause damage to the pipeline. AS 2885 requires certain controls be put in place as external interference protection, and further defines acceptable physical and procedural controls as outlined in Table 22.13.

Table 22.13 Physical and procedural controls for external interference protection

Physical controls	Methods
Separation	Burial (depth of cover) Exclusion (fencing, access prevented) Physical Barrier (crash barrier, concrete slabs/coating)
Resistance to penetration	Wall thickness (if adequate to prevent penetration) Barriers preventing penetration
Procedural controls	**Methods**
Pipeline awareness	Landowner / third party liaison Community awareness program One call service (Dial before you dig) Marker signs or marker tape Activity agreements with other entities
External interference detection	Planning notification zones Patrolling Remote intrusion monitoring

Examples of proposed mitigation measures which will be implemented to protect the pipeline against the potential threats include:

- Road and rail crossings:
  - Extra depth of cover across the entire road or rail easement
  - Extra wall thickness if required by potential loading

  - Concrete slabs in the areas of future table drain maintenance
  - Marker tape for the entire road or rail easement
  - Liaison with road or rail authorities
- Watercourse crossings:
  - Extra depth of cover
  - Concrete mechanical/weight protection if warranted by stream scour potential
  - Careful rehabilitation of banks to prevent future erosion
- Corrosion (internal and external):
  - Full time gas quality monitoring
  - Periodic intelligent pig for metal loss
  - Quality external coating
  - Periodic DC voltage gradient inspection
- Landslip, subsidence, floods, scour and so on:
  - Routing to avoid potential slip, subsidence, flood prone or scour prone locations
  - Routine patrols to observe movement
  - Liaison with mining /gasification companies
  - Buoyancy control in flood prone areas
  - Extra depth of cover in water courses
  - Concrete protection in scour-prone locations
- Electrical effects (induced voltages, fault currents, lightning and power failures):
  - Design of earthing systems
  - Procedures and training during construction and during operations
  - Procedures to stop work during lightning activity
  - Surge arrestors
  - Back-up battery systems
- Operations and maintenance activities (repairs, dig ups, equipment maintenance):
  - Design of over-pressure protection systems
  - Monitoring and alarm via SCADA system
  - Training to ensure bypass is prevented
  - Procedures and training for repair dig ups
  - Accurate location prior to excavation.
  - Regular audits of equipment condition
  - Application of recommended equipment programs

- Potential construction defects:
  - For coating damage – approved handling procedures, backfill specification, holiday detection on installation
  - For failed field joint coating – qualified coating application procedure approval, design selection of system, holiday detection after completion
  - For dents and wrinkles – qualified bending procedures approval, visual and internal gauge inspection
  - For weld quality – qualified weld procedures approval, non-destructive testing inspection, hydrostatic pressure and leak test
  - For backfill quality – backfill quality inspection, inspection during construction, dc voltage gradient inspection
  - For blasting procedures – qualified blasting procedures, licensed personnel for design and implementation of blast programs, exclusion zones.
- Potential design defects:
  - For stress corrosion cracking – engineering design and metal specification, high quality coating, temperature control, periodic intelligent pig inspection for cracking
  - For wall thickness deviations – engineering design quality assurance and audit procedures, inspection, hydrostatic pressure test
  - For inadequate functionality – operations and maintenance input into engineering design, hazardous operations studies, pre-commissioning inspection and testing
- Potential material defects:
  - Engineering design, quality assurance, inspection and test plans
- Intentional damage:
  - Markers and warning signs
  - Security fencing and locks where necessary
  - Routine patrols
  - Surveillance at critical facilities
  - Employee background checks
  - Human resources management.

Threats at specific locations

Three specific areas were considered as potentially representing different threats and these were:

- The Fairview to Spring Gully loop, as the pipeline is parallel and adjacent to an existing operating pipeline
- The surface facilities
- The eastern section of the existing pipeline. Proposed changes involving new connections to this existing pipeline could prevent integrity monitoring by intelligent pig under some conditions.

Failure and consequence analysis

The failure and consequence analysis, undertaken according to AS 2885, determined the following preliminary parameters for the main transmission pipeline:

- The critical defect lengths
- The wall thicknesses required to prevent penetration
- Radiation contours for full bore ruptures.

This information will be used to assist in the design of the sections of the high pressure pipeline with corresponding pipe thicknesses (standard wall, heavy wall and bends) and separation distances to reduce the risk of potential threats. Results were determined for the range of diameters (12, 16, 20, 24, 30 and 36 inch) proposed for the gas pipeline in the safety management study (refer to Volume 5 Attachment 48 for the results).

22.6 Health and safety

The health and safety of the community and employees of the Project is to be maintained through the design of safe facilities and by development and implementation of health, safety and environmental (HSE) management plans.

Australia Pacific LNG's approach to health and safety contains several key elements including identification and management of hazards, education and training, management of contractors and subcontractors, emergency preparedness and providing for recreation.

22.6.1 Community health and safety

Australia Pacific LNG recognises that it has an obligation to reduce the risk of injury and incidents affecting health, safety and environment to as low as reasonably practicable. Australia Pacific LNG has incorporated Origin's health, safety and environment policy, which requires it to 'identify and manage risks to as low as reasonably practicable where they have the potential to cause an accident, injury or illness to people, or unacceptable impacts on the environment or the community' (Origin Energy 2009).

Mitigation for the major health and safety risks to the community are outlined in Sections 22.3, 22.4, 22.5 and 22.6. It is expected that the level of potential health and safety risks to the community posed by the Project will be minimal due to the distances of project infrastructure from sensitive receptors.

Locations of sensitive receptors

The gas fields are primarily located within rural areas and include areas of remnant vegetation. There are numerous small towns and rural dwellings within the general area of the gas fields. The principle urban centres are: Chinchilla and Miles, with much smaller communities at Condamine, Kogan, Drillham and Dulacca. A description of the public services and amenities available within the gas fields is presented in Volume 2 Chapter 22.

Due to the large geographic spread of the gas fields over approximately 570,000ha and the proposed ongoing development over the proposed 30-year life of the Project, it is not possible to provide detailed information of all sensitive receptors that could be affected by project activities in the current documentation. Australia Pacific LNG will design, locate and operate all plant, infrastructure and equipment to minimise impacts to the community's health and safety.

Cumulative risks

Discussion of cumulative hazards and risks is presented in Section 22.4.4 and in Volume 2 Chapter 25. The gas fields are primarily located within rural areas. Project infrastructure will be located away from sensitive receptors as far as practicable, such that there is unlikely to be any cumulative impact with respect to health and safety of persons associated with the activities undertaken at these locations.

22.6.2 Health and safety of persons on site

Health and safety for site personnel will be regulated to meet industry standards, codes of practice and relevant statutory provisions, particularly the PAG Act. Health and safety management will include:

- A health and safety policy
- Identification of hazards associated with construction and operation of the Project
- Assessment of the level of risk of each hazard
- Development of control measures to avoid or minimise the risk
- Implementation of corrective actions on an ongoing basis to avoid or minimise hazards
- Monitoring and review of the effectiveness of the control measures and corrective actions to maintain continual improvement.

The potential health and safety risks and associated mitigation measures for both construction and operations for the gas fields are summarised in Table 22.14. Australia Pacific LNG personnel and all construction contractors and operators will implement the safety management plan and relevant environmental management plans to reduce the risk of the potential hazards.

Table 22.14 Potential health and safety hazards for persons onsite

Potential health and safety hazard	Mitigation measures (included in safety management plan)
Injuries from moving plant and vehicles	Appropriate signage Driver training Vehicle speed limits Use of designated roadways and walkways Exclusion areas around vehicles (e.g. cranes)
Dropping heavy loads e.g. pipes during unloading of trucks and other heavy construction work	Prescribed work procedures Equipment maintenance Regular certification of lifting equipment Competent certified operators (riggers and doggers)
Operation of drilling equipment	Detailed planning for the operation of drilling rigs Trucks and related transport operations

Potential health and safety hazard	Mitigation measures (included in safety management plan)
	Ongoing training and awareness Periodic risk analyses and safety meetings prior to drilling Emphasis on fatigue management Crew change and tag out of equipment
Working with rotating machinery	Guarding over rotating or moving parts of machinery Operator training
Working at heights and falling from heights	Fall arrest and restraint equipment will be worn when working at heights Exclusion zones whilst working adjacent to excavations Controls to prevent persons from working off vehicles at height (e.g. back of utes, top of drill rigs and from bonnets) and provision of elevated work platforms where necessary Guardrails will be fitted where necessary Vehicle access design and requirements assessed
Falls, slips and trips	Appropriate signage Designated walkways Footwear that reduces the risks of slipping with respect to muddy and uneven field surfaces
Trench collapse and rock falls	Operating procedures in and around trenches Personal protection equipment, including hard hats
Working in confined spaces	Confined space procedures complying with Australian Standards
Continual working with airborne contaminants (including dust)	Dust suppression, road watering Appropriate vehicle and machine maintenance
Hearing impacts from prolonged noise exposure	Specification of equipment that meets noise level requirements Personal protection equipment and signage
Vibration impacts from prolonged exposure	Monitoring for possible damaging vibration (e.g. prolonged vibration as a result of operating an excavator) Assessing whether activities or equipment is creating a nuisance vibration
Heavy lifting, awkward postures and manual handling	Manual lifting guidelines (avoid heavy lifting and awkward postures) Provide information related to appropriate handling of items
Eye, respiratory or other damage from	Personal protection equipment, including masks worn during sand

Potential health and safety hazard	Mitigation measures (included in safety management plan)
sandblasting	blasting
Burns and fumes from welding and other hot work	Procedures for welding in open spaces No welding activities will be undertaken in enclosed spaces Personal protection equipment, including gloves and masks.
Pressure testing	Standard operating procedures including restriction of personnel in the vicinity of the pipeline during pressure testing
Injuries from handling hazardous substances/chemicals	Signage Material safety data sheets and associated spill clean up equipment for chemicals Personal protective equipment
Working with electricity	Electrical equipment will be regularly checked Isolation procedures
Heat exhaustion, dehydration and/or sunburn and skin cancer from continual working in the sun.	Training and awareness Provision of sun protection and personal protective equipment Measures to identify signs of heat stress and actions to avoid and treat
Fire and explosions resulting from the presence of combustible gases and liquids, oxygen and ignitions.	Isolation procedures See Section 22.3.2 and Section 22.4.6
Snake, mosquito and other animal bites	See Section 22.4.2 and Section 22.7
Natural disasters (bushfire, landslides, floods and so on)	See Section 22.4.2 and Section 22.7
Lighting	Assess lighting level to determine if it is in accordance with Australian Standards for night time work Direct lighting away from dwellings
Water quality	Potable water quality Water quality is further discussed in: • Volume 2 Chapter 10 – Groundwater • Volume 2 Chapter 11 – Surface water • Volume 2 Chapter 12 – Associated water management
Mental and physical health	Provide amenity, recreational and health programs that support a workforce which is fit for work, enjoys a healthy work-life balance and transfers these values into the home or community

Potential health and safety hazard	Mitigation measures (included in safety management plan)
	Standards for the health and fitness for work of employees, including first aid, medical examinations and rehabilitation Initiatives to promote and encourage a healthy lifestyle

Planning and management during construction, operations and decommissioning will be undertaken in accordance with regulatory requirements. This will include the following:

- Safety management plans
- Systematic risk assessments
- Emergency response plans and procedures
- Education and training
- Incident reporting and investigation
- Rehabilitation planning.

Australia Pacific LNG will develop and implement a robust safety management plan that will apply to all personnel, including contractors and operators. Tools used to develop and implement this plan include the following:

- Statutory acts and regulations
- Safety standards and codes of practice
- Internal safety procedures and safe work standards
- Health and safety objectives, targets and key performance indicators
- Competency and training, including induction
- Hazard assessment and risk management
- Risk register and mitigating action plans
- Hazardous materials management
- Subcontractor management
- Safety management system planning and development and improvement
- Job hazard analysis
- Communications including daily pre-start meetings
- Personal protective equipment
- Emergency response
- Incident investigation and reporting
- Health and safety issues/resolutions
- Health and safety auditing
- Communication and organisational learning.

22.6.3 Mitigation and management

Australia Pacific LNG employs a hazard and risk management procedure which provides a risk assessment process for personnel, facilities, the public, customers and the environment, and includes a regular review process. This risk and opportunity assessment process has been utilised to identify key potential hazards and controls for the Project. Plans will be developed for the gas fields, pipeline and LNG elements of the Project as a part of this whole-of-life risk management and safety management.

Induction and training programs will be used to ensure personnel have the required skills and training to competently perform their work in a safe and environmentally sound manner. Subcontractors will be subject to pre-qualification, auditing and inspection by Australia Pacific LNG with respect to their health and safety standards.

Australia Pacific LNG's emergency response plans will describe emergency response procedures including drills, involvement of emergency services, adjacent neighbours and any emergency equipment that may be required. In addition, Australia Pacific LNG will keep documentation of potential emergency situations and impacts and will update its emergency response plan as new information becomes available.

Australia Pacific LNG has standards for the health and fitness of employees, including first aid, medicals, and rehabilitation. It will undertake initiatives to promote and encourage a healthy lifestyle. This might include recreational activities or the provision of recreational facilities.

Health and safety hazards to the local community have been assessed in the risk and opportunity assessment process. Matters of community health and safety will be regularly communicated through a range of channels including Australia Pacific LNG's community shop-front and consultation sessions that allow for regular two-way dialogue.

In particular, Australia Pacific LNG will strive to improve the standard of health and wellbeing for Indigenous people through, for example, implementing a community partnership program and celebrating and supporting Indigenous cultural values amongst the project workforce.

22.7 Emergency management

Australia Pacific LNG will maintain a state of emergency preparedness as a commitment to employees, contractors, customers, neighbours, communities and shareholders in providing a safe, healthy and environmentally responsible working environment. While prevention will be the first defence against any incident, Australia Pacific LNG will be prepared to respond to potential incidents, regardless of how large or complex.

Emergency response is a component of Origin's current safety management system. It is a corporate expectation that emergency response plans will be developed for all business units. Australia Pacific LNG is liaising with other CSG and LNG participants with a view to establishing an emergency response capability that permits initial medical care of injured personnel within one hour of mobilisation and primary medical care with four hours of mobilisation.

Origin has emergency response plans for existing facilities. These plans include emergencies at gas wells, gas and water gathering networks, GPFs, WTFs, high pressure pipelines and transmission pipelines. Australia Pacific LNG will utilise these as the basis for their emergency response plans.

22.7.1 Contents of the emergency response plans

The current Origin emergency response plans will be updated to reflect the scale of the Australia Pacific LNG project. It is anticipated there will be a number of individual emergency response plans to meet the different requirements of the individual facilities. These will all meet the overall Australia Pacific LNG requirements.

The emergency response plans will contain necessary information that could be readily accessed during an emergency. Australia Pacific LNG will conduct drills on a regular basis to train personnel with respect to responses to credible emergency scenarios. The plans will describe emergency response procedures including drills, involvement of emergency services and adjacent neighbours. These plans provide for the identification of crisis and emergency situations and impacts, identify emergency equipment to be provided, responsibilities of personnel, and indicate when regular simulations including relevant stakeholders are conducted. The relevant sections of the emergency response plan will use the State Planning Policy 1/03 'Mitigating the Adverse Impacts of Flood, Bushfire and Landslide' for reference.

The emergency response plans will be developed using the latest standards, and updated to account for any learnings where appropriate. The following is a guide to their contents:

- Guidelines for the use of the plan
- Document control
- General information – this section may include:
  - Responsibilities
  - Emergency alarm
  - Interaction with emergency services
  - Interaction with community
  - Helicopter use
  - Emergency response plan preparedness
  - Emergency equipment
  - Contact with relatives
- Emergency organisation structure – this will outline the organisation to handle an escalation of an incident. This section will include different levels of organisation for different magnitudes of emergency, and may include:
  - Emergency control organisation
  - Emergency awareness
  - Emergency response centre
  - Emergency response locker contents
- Roles and responsibilities - this will outline the roles and responsibilities of persons in the event of an incident. This section may include the roles and responsibilities of:
  - First person at the scene of an incident
  - Emergency coordinator

  - Site emergency response personnel
  - Safety advisor
  - Logistics support officer
  - Incident record keeper
  - Duty manager
  - Emergency services
- Emergency contact numbers – the list of emergency contact numbers may include:
  - Contact numbers in the event of a wellhead, GPF, WTF or pipeline emergency
  - After hours contacts
  - Emergency services numbers including Emergency Management Queensland, Queensland Ambulance Service and Queensland Fire and Rescue Service
  - Government contacts including the hazardous industries and chemicals branch and the department of community safety
  - Nearby operating companies
  - Nearby landowner contact numbers
  - Equipment hire or contractor/s contacts
- Spill contingency plans - this section will contain the spill contingency plans. This may include information regarding:
  - Assessment of spill type and spill risk
  - Selection of field response techniques
  - Recommended field response techniques
  - Spill on ground
  - Location of material safety data sheets or recommended spill clean up procedures for different substances
  - Procedures with respect to the inadvertent release of contaminants
- Emergency shut down – this section will contain information concerning the safe shut down of a well, GPF, WTF or pipeline in the field
- Gas leak without fire – this section will contain procedures to follow in the event of a gas leak, which has not been ignited. This will include elimination of potential sources of ignition, safely locating the leak, any necessary isolation of sections of pipe or equipment and repair or replacement of the offending parts
- Fire – this section will contain the procedures to follow in the event of a fire. These might be different depending on the location and nature of the fire. For example, there may be plans for the following fire situations:
  - Pipeline rupture and subsequent jet flame fire
  - Field fire

  - Wellhead fire (including fire as a result of a gas leak at the wellhead)
  - Production separator
  - Wire-line unit or hydraulic pumping unit
  - Fire in workshop or stores
  - Encroaching bushfire
  - Fire at chemical or flammable goods storage
- Explosion - this section will contain the procedures to follow in the event of an explosion. This may include:
  - Pipeline rupture
  - Uncontrolled detonation of explosives
  - Explosion related to bomb, sabotage or terrorism
- Bomb threat, sabotage and terrorism – this section will contain the procedures to follow in the event of a bomb threat, sabotage and terrorism at facilities and pipelines and will be consistent with Queensland's counter-terrorism and critical infrastructure policies
- Medical emergency – this section will contain the procedures to follow in the event of a medical emergency. This could include a fatality, musculoskeletal injury, disease event, an amputation, heat stress (hyperthermia) or other injury
- Missing worker(s) – this section will include general assistance regarding how to locate a missing person especially in remote locations. This may include the use of a helicopter
- Environmental emergency – this section will include general information about what to do in the event of an environmental emergency, such as, a pond wall collapse, potential contamination and/or the death of wildlife
- Unauthorised entry – this section will contain the procedure to follow if an unknown person enters a secure facility or exclusion zone
- Natural disasters – this section will contain the procedures to follow in the event of a natural disaster, such as a flood, storm or landslide
- Lightning strike – this section will provide assistance in the event of a lightning strike
- Wildlife and disease vectors – this section will provide assistance in the event of:
  - A snake bite
  - Illness after a rodent bite
  - Illness after a mosquito bite
  - Illness after an insect bite
- Emergency response for the WTF – this section will be dedicated to emergency response at the WTF and will include an:
  - Assessment of spill type and spill risk
  - Chemical spills at the water treatment plant

- Shift changeover procedure in an emergency – this section will deal with shift changeover, which can be critical in an emergency
- Termination of emergency – at the end of an emergency, order may need to be returned to a facility or area. This section may include procedures for:
  - Return to control of a facility from emergency services
  - Reporting and investigation
  - Recovery and restoration
  - Debrief
- Reports and forms – this section will include standard reports, forms and checklists. Typical forms will include:
  - Emergency report form
  - Log sheet
  - Change over check
  - Change over brief
  - Debrief report
  - Bomb threat checklist.

Australia Pacific LNG will use emergency procedures, which have been developed for and used in gas fields, GPFs, WTFs and gas pipelines in Queensland. These contain the typical emergencies that might be encountered in the gas fields. Australia Pacific LNG will update or add to the emergency response plan with new information and any new emergency that is a credible threat.

22.8 Conclusion

22.8.1 Assessment outcomes

Controls that manage the risk of the hazards for the gas fields' facilities, as outlined, would reduce the risk of incident for the Project. Hazards will be managed such that they present a risk that is as low as reasonably practicable. Most hazards are considered to be able to be managed, such that they present a negligible or low risk to persons, property, fauna or the environment.

Table 22.4 through to Table 22.11 summarise the hazards and risks of the following:

- Drilling and gas well construction
- CSG wellhead operations
- Construction and operation of the gas and water gathering network
- Construction and operation of the GPFs
- Construction and operation of the WTFs
- Construction and operation of the high pressure gas pipelines
- Natural hazards (seismic events, bushfire, floods, venomous animals and disease vectors)
- Traffic and transport activities for all phases of the Project.

Each table identifies the potential hazards, possible causes and consequences, proposed control or mitigation measures and the assessed residual risk level after the controls are implemented.

The following environmental values are applicable to each one of these hazard and risk categories:

- Life, health and wellbeing of people
- Diversity of ecological processes and associated ecosystems.

Similarly, the relevant sustainability principles are also applicable to each one of these hazard and risk categories:

- Adhere to an over-riding duty to safety, ensure operations are carried out in a safe way and to authorise employees and contractors to place safety considerations above other priorities
- Minimise adverse environmental impacts, enhance benefits associated with its activities, products or services; maintain, and enhance where the opportunity exists, biodiversity values
- Identify, assess, manage, monitor and review risks to its people, property, the environment and the communities affected by its activities.

22.8.2 Commitments

In order to minimise the potential risk to people property and the environment from abnormal events or accidents associated with its gas fields activities, including from exposure to natural hazards, Australia Pacific LNG will:

- Operate the gas field under a formal safety management plan in accordance with the requirements of the *Petroleum and Gas (Production and Safety) Act 2004*, to be updated as required during operations
- Maintain an up to date traffic management plan which will include: driver fatigue monitoring, driver education and training, enforced speed limits for project vehicles, use of buses to reduce private vehicle use, public access restrictions to work areas; and use of in-vehicle monitoring systems
- Initiate and participate in ongoing community campaigns to reduce the likelihood and consequences of vehicle accidents
- Consult with Civil Aviation Safety Authority and the Western Downs Regional Council on plans for the proposed gas processing facility near Miles aerodrome.

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